SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

FOOD SCEINCE AND NUTRITION RESEARCH DIRECTORATE (FSNRD)

1st PROCEEDINGS OF 2021-2023, SoRPARI's FSNRD RESEARCH REPORTS



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Jigjiga Ethiopia

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Year, 2015 E.C

Tel: 0257753123|757097|757049

Fax: 0257753122

P.O.Box: 398, Jigjiga, Ethiopia

Contributors

1. Abdulkarim Mohammed Ali
2. Mohammed Dol Ateye
3. Hooda Mohammed Jama

Prepared and Compiled by: ***Abdulkarim Mohammed Ali (FSNRD Director)***

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Message from Director General



Mr. Mohammed Sharif Ali

Director General of SoRPARI

Research is an advanced stage of study undertaken to discover or establish facts or principles. The research can solve problems encountered by agricultural producers with tangible benefits. For instance, low production of crops, livestock, fish and different natural resources can be overcome by turning to newly developed varieties and breeds. Or better nutrition and food sufficiency can be attained by diversifying diets. Yet in many developing countries, the connection between this research and agricultural development is weak. There is little investment in agriculture-focused research as the immediate impacts are easy to overlook. Therefore, it is important to establish an institute which engaged in research activities and link stakeholders and end user to the different agricultural technologies.

Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) was established in 2002 G.C, and effective since 2011 G.C, with objectives of changing the livelihood of

pastoralists and agro-pastoralists by introducing, adapting, generating, popularizing and disseminating livestock, forage, crop, natural resource and related technologies. By mid-years of its working experience, the institute had faced a lot of challenges which reached up to risking the existence of the institute. Since the reform that happened by 2018 G.C. in our country particularly our region, the institute has been getting the usual support from government and different partners which help it to restore. As part of the benefit from the reform and expanding its research service to pastoral and agro-pastoral community, the institute has open the Food and Nutrition research at program level by mid-2020 and promote it to directorate level by the mid 2021 G.C.

It is known that, one of the burning issue that worries the global community is malnutrition. Malnutrition, in all its forms, includes under nutrition (wasting, stunting, underweight), inadequate vitamins or minerals, overweight, obesity, and resulting diet-related non-communicable diseases. According 2021 World Health Organization report, 1.9 billion adults are overweight or obese, while 462 million are underweight. Globally in 2020, 149 million children under 5 were estimated to be stunted (too short for age), 45 million were estimated to be wasted (too thin for height), and 38.9 million were overweight or obese. Around 45% of deaths among children under 5 years of age are linked to under-nutrition. These mostly occur in low- and middle-income countries. At the same time, in these same countries, rates of childhood overweight and obesity are rising. The developmental, economic, social, and medical impacts of the global burden of malnutrition are serious and lasting, for individuals and their families, for communities and for countries. As part of the global community, the above mentioned figures and facts also represent or by far represent the pastoral community as these community are mostly affected both by natural and man-made disasters which enhance the problem of malnutrition than other area. As institute, in solving malnutrition problem, we believe it should be supported by data and evidence which need research.

Although the Food and Nutrition research directorate of our institute is at its young stage and has very limited research facilities (Laboratory and budget), the staffs conducted nine research works which support the evidence the institute look for in fulfilling the full information packages on some crop commodities adapted by the institute and grown in the region. The nine researches mainly focus on cereals, legumes, oils seeds and animal products. The evidence from these research works will help government, NGOs, concerned UN agencies and other stakeholder as baseline information and for better partnerships with our institute. Therefore, I kindly request all stakeholders to enjoy reading the proceeding. Finally, I want to thank and appreciate the food and Nutrition Research Director and his staffs for their commitment and being role model in preparing the first ever proceeding in the history of our institute at directorate level and let all other directorates take lesson from it.

Thank you

Message from Deputy Director General



Jimaale Yusuf,
Deputy Director General of SoRPARI

Somali Regional State is endowed with huge natural resources like rivers, vast rangelands, suitable land for crop and forage production, diversified forests and wild live. Most of the population depends on livestock production, crop farming and small-scale trade. Camel, cattle, sheep and goats are the major domestic animals that provide food and income to this pastoral and agro pastoral communities of the region. For the effective utilization of these and other natural resources, the research institute plays great role to improve the livelihoods of pastoral and agro-pastoral communities.

The Somali Region Pastoral and Agro pastoral Research Institute (SoRPARI) was established in 2002 by **proclamation number 31/2002** to coordinate agricultural research system in the region. SoRPARI has become effective since by, delivering agricultural technologies (through developing/adapting) and coordinate/support regional research networks. From 2002 FY SoRPARI in collaboration with its various stakeholders (mainly EIAR) has succeeded in the selecting/developing various **technological options/alternatives, Information and knowledge** that are crucial for improving the pastoral and agro-pastoral production & food security in the region. In doing so, the institute has achieved for the delivery of **159 technologies and information** to pastoral and agro-pastoral communities of the region.

Food insecurity is among the most formidable challenges that the third world countries are facing. An estimated 26% of the world's population experienced hunger or did not have regular access to nutrient-rich and sufficient food in 2019 according to FAO and its collaborators. Ethiopia has been facing significant problem of nutrition insecurity under nutrition (Stunting, wasting and micronutrient deficiencies (anemia) and over nutrition (overweight, obesity & related non-communicable diseases (diabetes, high blood pressure).

Despite remarkable progress in the last decade, the burden of malnutrition in Ethiopia is still high.

- In Ethiopia, the estimated national annual cost of under nutrition US$55.5million which is 16.5 percent of Ethiopia's GDP (Global Panel, 2016).
- Reducing child under nutrition rates to half the current levels by 2025 could reduce losses by ETB 70.9 billion.
- Therefore, the growing concern for nutritional and food security and great emphasis on consumer needs as well as stiff competition in food marketing has opened a host of challenges and opportunities

According to Ethiopian Demographic and Health Survey (EDHS, 2019) on Regional distribution of Stunting in Ethiopia, Somali Regional State is one of the regions that has the highest nutrition stunning rates; 30.5 among all regions of the country. Major causes of this stunning nutrition in the country as well as the region is Inadequate production/productivity, limited availability of diversified foods, high price for nutrient dense food and poor handling system and Inadequate food processing technologies. The region is one of the most vulnerable areas for both natural and manmade disasters which affect the food and nutrition security of the pastoral and agro-pastoral community. As a research institute, all forms of interventions to fight malnutrition should be supported by data and evidence which need research.

Ethiopian government has developed strategies; National Nutrition Program I & II, Nutrition Sensitive Agriculture Strategy, National Food Security Strategy, National Food Fortification Strategy, Nation School Health and Nutrition Strategy and Sekota Declaration - end child under nutrition by 2030 in Ethiopia.

To succeed these policies and strategies, a lion's share contribution is expected from the agriculture sector, particularly from the agricultural research systems at National and Regional as well.

- Accordingly, contribution from the Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI) will be huge as it has a Regional mandate to coordinate research related to nutrition sensitive agriculture and food.
- SoRPARI established the Food and Nutrition Research Directorate (FSNRD) in 2022 with the objective of strengthening food science and nutrition research among the pastoralist and agro-pastoralits communities in the region and to conduct food science

and nutrition researches especially some of the basic food commodities such as maize, rice, sorghum and sesames

- The directorate has developed a research strategy emphasizing on improvement of food processing technologies, food enrichment, value addition, reduction of postharvest loss, and enhancement of food quality and safety.

The food and Nutrition research directorate is established to conduct research on food and Nutrition areas which either on those commodities tested by our institute or major current global, national and regional issues related to malnutrition. The directorate has conducted nine researches on cereals, legumes, oil seeds and animal product like meat. As part of disseminating research information, they prepared the first ever proceeding in which nine manuscripts have been compiled. The data and facts from these researches will help concerned stakeholders as base line information for their plan in designing projects and creating partnerships with our institute.

Finally, I would to appreciate the Food and Nutrition Research Directorate Director and his staffs for valuable role model job in leading and coordinating (as a technical advisory chair) the first research proceedings published by Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI).

I thank you,

Jimaale Yusuf,

Deputy Director General,

Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI)

Message from FSNRD Director



Mr. Abdulkarim Mohammed Ali

Food Science and Nutrition Research Directorate Director (FSNRD)

Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) was established in 2002 G.C, and effective since 2011 G.C, with objectives of changing the livelihood of pastoralists and agro-pastoralists by introducing, adapting, generating, popularizing and disseminating livestock, forage, crop, natural resource and related technologies. SoRPARI conducted a wide range of researches both introduced and tested of intensive crops and forages rangelands over many years and released various suitable technologies, others introduced and adapted, (for both riverine and rain fed farming systems).

The areas of food technology and nutritional research in agriculture has not been given due attention in the regional research institutes. Consequently, agricultural researchers of the country have focused most of their attention on improving the production and productivities of the crops and livestock. However, in any major crop/livestock improvement program, attention must not

only be given to the quantitative aspect of production but also nutritional considerations, processing quality and consumer acceptance be considered in order to bridge the gaps between nutritional needs and food supply.

According to EDHS report, Ethiopia has experienced a steady reduction in the prevalence of stunting over the past two decades from 58 per cent in 2000 to 34 per cent in 2022. Early initiation of breastfeeding (initiation of breastfeeding within 1 hour of birth) has shown a slight improvement from 72 per cent (in 2019) to 77 per cent in 2022, and exclusive breastfeeding has increased from 59 per cent in 2019 to 61 per cent in 2022. This is a result of the Government and partners' ongoing commitment to end malnutrition in all its forms through creating policy space, expanding service delivery platforms, and capacity-building initiatives.
Despite the progress, Ethiopia is amongst the countries with the highest number of stunted children under five in the world. The average prevalence of stunting in developing countries is 25 per cent. In addition, only 8 per cent of children aged 6 to 23 months consumed the minimum recommended 5 out of 8 food groups. Overall, 47 per cent of children were in severe food poverty, meaning they consumed 2 or fewer food groups a day contributing to an observed high prevalence of wasting at 11 per cent.

SoRPARI as part of playing its role in efforts to fight all forms of malnutrition and to support it through evidence, it establish the "***food science and Nutrition research***" at program level in 2013 E.C. and Now "***Food Science and Nutrition Research Directorate***" Since end of 2014 E.C. Hence, the Food Science and nutrition Research Directorate of SoRPARI is established for the purpose of working to improve the safety and quality of the food supply from the farm to the table by providing high quality research and services to public and the food industry.

As part of disseminating finalized research works to stakeholders and end users, the directorate has been collected different manuscripts from the researches done since 2013 E.C to prepare the 1st proceeding. In this particular proceeding, nine research manuscripts done on rice, maize, sorghum, sesame, haricot bean, soybean, wheat, different meat sources, and product development from peanut and sorghum are included.

Lastly, the directorate is always grateful to the top management and all other staffs for their help and insightful contribution in the research works. I wish you to enjoy reading of the proceeding and using as baseline data for your future research work and keeping your cooperation as usual.

Thank you

Abdulkarim Mohammed Ali

Food Science & Nutrition Research Director

FOOD SCIENCE AND NUTRITION RESEARCH DIRECTORATE

About SoRPARI

Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) has been undertaking various applied research programs that have been fundamental for food security and poverty reduction in the region since its establishment in, 2002 G.C. This is undertaken across its 7 research centers and subcenters which address various agro-ecologies of the region working on Crop, Livestock, Natural Resources, Agricultural engineering and Agricultural Extension and socio-Economics. Currently, SoRPARI is almost on the virtue of starting the operation of Food Science, Nutrition and with its Laboratory to undertake applied research on the agricultural products (food crops and livestock products- including fishery and honeybee products). This is aimed at integrating the quantitative research to the qualitative approach with the generated technologies from various disciplines of agricultural research at different agro-ecology-based research centers being organized under SoRPARI.

To undertake this research, SoRPARI built a Food Science and Nutrition directorate/program and plan to its Laboratory with the necessary facilities and cutting-edge Laboratory equipment in its head quarter compound. The establishment of Food Science came at a time when the country is urgently demanding competent laboratories to support the implementation of activities set under the 10 years plan to ensure food safety, quality and nutritional content. The Laboratory is the first of its kind in the region under SoRPARI management that can undertake quality research and generate technologies for the community of the region as well as the country. Hence, it will contribute to filling the gap in the link between production in the development and production of safe, nutritious and wholesome food. Furthermore, it could help the region as well as the country boost its export by providing testing services for exporters locally and can encourage the food processing industries by relying on their proved quality.

Once it established, the SoRPARI Food Science Research Laboratory will be capable of undertaking a wide variety of micro-biological, chemical and physical tests on food products. The establishment of this Food Science Research Directorate and its Laboratory at SoRPARI

head quarter will have a positive impact on the agricultural research and development program, which has not been given considerable attention for several years, by creating a competitive environment.

The Need for the establishment of Food Science Research Directorate and its Laboratory

Food Science is a field of integrated study of basic sciences and the application of science and engineering to the production, processing, distribution, preparation, and evaluation of food. Furthermore, it is the study of the transformation of biological materials into food products acceptable for human consumption. This requires studying diverse scientific disciplines related to food, including Chemistry, microbiology, biochemistry, toxicology, biotechnology, Nutritional science, engineering technology for the development and management of food resources; and effectively applying the industrial and practical aspects to product development, food processing, preservation, and marketing.

The areas of food technology and nutritional research in agriculture has not been given due attention in the regional research institutes including SoRPARI in the previous time. Consequently, agricultural researchers of the country have focused most of their attention on improving the production and productivities of the crops and livestock. However, in any major crop/livestock improvement program, attention must not only be given to the quantitative aspect of production but also nutritional considerations, processing quality and consumer acceptance be considered in order to bridge the gaps between nutritional needs and food supply. Hence, the Food Science and nutrition Research Directorate and its Laboratory of SoRPARI is established for the purpose of working to improve the safety and quality of the food supply from the farm to the table by providing high quality research and services to public and the food industry.

Vision and Mission

Vision

- The vision of Food Science & Nutrition research directorate is to become a leading research entity with center of excellence to significantly contribute to food and nutrition security in pastoral and agro-pastoral area of horn of Africa by 2030.

Mission

- Deliver and popularize Food science & Nutrition technologies, knowledge and information in participatory and integrated way for all the pastoral and agro-pastoral communities of the Somali Region, in particular, and communities of the other regions with similar agro-ecologies, in general to reduce malnutrition.

To attain the above mission:

- Develop different new products through utilizing both modern and indigenous knowledge (Value addition)
- Conducting specific research on different thematic areas
- Establishing and furnishing standardized different food laboratories and providing full laboratory services

Objectives

- To access and identify food related problems, generate and adopt/ adapt food science & Nutrition and related technologies in relation to production, processing and product development which is suitable, nutritious, safe and acceptable to human consumption and industrial uses
- To transfer food science and Nutrition technologies through service provision, various standard protocols, quality assurance, food regulation formulation, and play leading role in environmental issues for policy makers and strengthen stakeholders' interaction to enhance the development of food industries in the pastoral and agro-pastoral of Somali region as well as the country.

Required facilities, infrastructure and technology inputs

Laboratory building and necessary facilities and infrastructure to undertake the Food Science and nutrition research will be going to be established in the SoRPARI head quarter compound or some other place here in Jigjiga. The building and infrastructure design and therefore, the completed construction, will include more or less all necessary facilities required for the research activities. However, considering the quality and quantities of research to be carried out, and

above all to discharge the mission of the SoRPARI's Food Science and nutrition Laboratory, it requires technical and administration backups, day to day energetic follow-ups and considerations in order to have "enthusiastic for the purpose" Laboratories as opposed to generic Laboratories to enable the Institute to discharge the technology generation, innovation and transfer mandates.

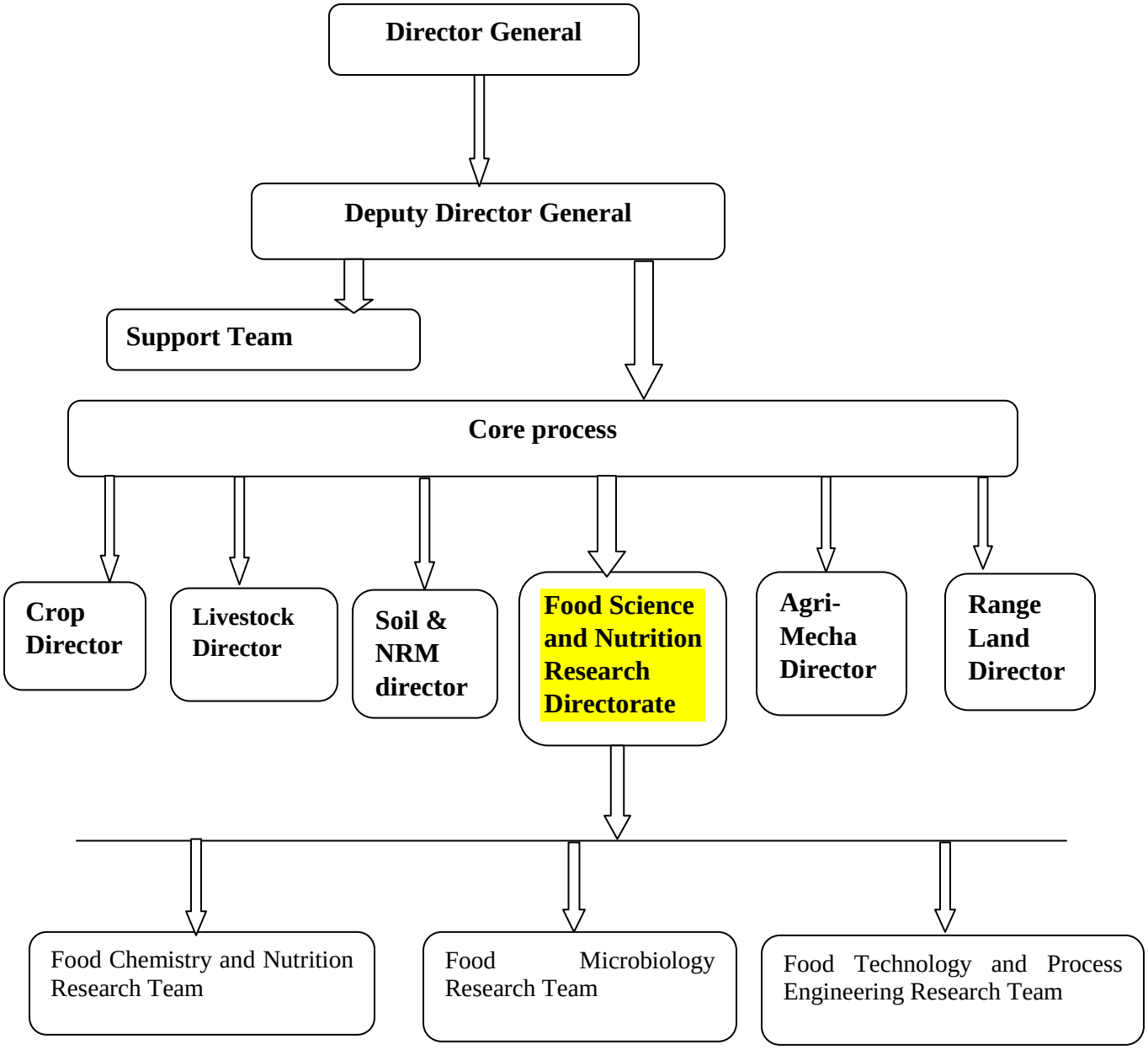
Putting enabling organizational structure in place

Organizational structure of the new Food Science Research Directorate study was newly developed at the end of 2014E.C. adopting some basic ideas and principles from the organizational structure of existing sister research Institutes in the country and from best examples in the world. For considerations, a number of nationally and internationally known Food Science research centers, Institutes and Universities are thoroughly need to be visited physically and also explored through internet benchmarking. We need to visit to some of the Food Science Laboratories in Universities (such as Addis Ababa University, college of natural science, center for Food Science and Nutrition, and research institutes, such as EIAR, Agricultural and Nutritional Research Laboratories Directorate, Oromia Agricultural Research Institute with the Agricultural Quality Research Laboratory of the country). Until physical visit to be made soon, we have visited their experience from these institute websites. Accordingly, it is realized that the following three disciplinary teams are vital in the establishment of SoRPARI's Food Science and Nutrition Research Directorate:

1. Food Chemistry and Nutrition Research Team

2. Food Microbiology Research Team

3. Food Technology and Process Engineering Research Team



These Laboratory and the respective research activities undertaken in each team are coordinated by the structurally organized Directorate of Food Science Research Director. Furthermore, Research team heads are assigned and will be reporting to the coordinator/ Director. Each team has at least three to four research components under which numbers of qualified researchers and Laboratory technicians will be assigned. Accordingly, a total of 15 human powers will be

proposed and the number can be improved based on the condition at a time and will be approved by the concerned bodies of the Somali region.

Components under each research teams

1. **Food Chemistry and Nutrition Research Team**
    A. Food Analysis
    B. Food Assessment and Nutrition Analysis
    C. Food Chemical Safety and Toxicology
2. **Food Microbiology Research Team**
    A. Food Pathology
    B. Food Probiotics
    C. Food Biological Safety and Toxicology
3. **Food Technology and Process Engineering Research Team**
    A. Food Biotechnology
    B. Food Processing and Product Development
    C. Food Marketing and Value Chain
    D. Food Processing and Environmental safety

These Research components under respective teams will going to be organized to undertake Food Science and nutrition research activities accordingly and researchers having pertinent professions will be recruited.

This Food Science and nutrition Research Directorate will be established at the end of 2022 G.C. or 2014 E.C. Never the less, the required budget (for administration work/ human resource recruitment and research activities) is allocated in the end of 2022 G.C. or mid of 2014 E.C. to start the operation, One Director for the Food Science Research Directorate and three Team leaders and two researchers (qualified professionals in food science) are required; while two junior researchers will be newly needed too. The source of this human capital will be from SoRPARI staffs and from market through vacancy. These Teams will be going to undertake a lot of activities to make the actual work and Laboratory operational as soon as possible. Furthermore, the existing staffs of food science and nutrition program have already prepared number of research Proposals related to Food Science and nutrition waiting some for budget approval while some others for review meeting by internal and external evaluators.

Strategic issues of Food Science Research by Thematic Areas

1. **Food Microbiology**

    A. **Food Pathology**

- Assess food items collected from different areas for their health and microbial pathogens by the use of indicator microorganisms.
- Assess indigenous food items collected from different areas for their health and microbial pathogens by the use of indicator microorganisms.
- Identification of important pathogens and spoilage microorganisms in foods, their distribution and the conditions under which they grow
- Identify the conditions under which the important pathogens are commonly inactivated, killed or made harmless in foods.
- Assessing different traditional food preservation technique.
- Understand the role and significance of microbial inactivation, adaptation and environmental factors (i.e., aW, pH, temperature) on growth and response of microorganisms in various environments.

1.2Food Beneficiary Microbiology

- Identification, Characterization, and classification of beneficial microorganisms in food system (Such as probiotics used mostly in dairy product, fermentative which mainly used in food processing) and those used in food preservation will be studied.
- Using identified microbes and microbial products, studies regarding processed product quality, health benefit their production mechanisms will be studied.

1.3 Food Microbial Safety and Toxicology

- The economic significance and distribution of Microbial toxins in foods and the etiology of toxin production and subsequent accumulations will be studied.
- protect the public health through microbial hazard identification, hazard characterization, exposure assessment and risk characterization. (HACCP Implementation).

2. Food Chemistry and Nutrition

2.1 Food Analysis

- Determination of those properties that are important characteristics of safe, high-quality foods,

- Study of physical, chemical and bio-chemical properties of foods as they relate to stability, cost, quality, processing, safety, nutritive value, wholesomeness, and convenience.
- Composition and properties of raw agricultural products and processed food and the chemical changes it undergoes during handling, processing, and storage will be studied

2.2 Nutrition assessment and Analysis

- Provide Nutrition information though identification and characterization of most vulnerable or affected individuals or groups, as a screening tool to identify malnourished individuals needing special assistance and contribute to designing of food, health and other development policies.
- Facilitates analysis of socio-economic factors, demographics, food security and cultural aspects of a population.
- Nutrient composition, the chemicals in food that are necessary for life, their chemistry of locally as well as raw agricultural products, and how the body uses them will be studied

2.3. Food chemical and Biochemical safety and Toxicology

- Characterization of food items for allergenic substance composition and support food manufacturers address potential cross-contamination in the manufacturing environment and provide appropriate labeling of potential allergenic components in food
- Distribution of nonnutritive bioactive chemicals, ant-nutritional, antioxidant compounds and their mechanisms of interaction with dietary toxicants in Agriculturally produced, locally prepared and industrially processed, with their ramifications in assuring safety of complex mixtures in our diet will be studied.

3. **Food technology and process engineering**

3.1. ***Food processing and product development***

- Formulation of new food which is a type of fortified plants & animals' part or product by changing their natural nutritive value for greater variety, improved nutritional value, stable shelf life, consumer acceptance and convenience
- Evaluation of the effects of processing and added chemicals on wholesomeness and nutritive value cost, quality, variety, convenience, and deals with the physical, chemical, and biological properties of foods as they relate to stability, cost, quality, safety, nutritive value, wholesomeness, and convenience

3.2. ***Food Value chain and marketing***

- Understand the source and variability of raw food material and their impact on food processing operations
- Understand the properties and uses of various packaging and storage materials in affecting final value chain
- The role of each and every stakeholder in food value chain will be identified

3.3. ***Food Biotechnology***

- Testing the new line/ advanced line/ commercial varieties of food and livestock and their products for nutritional/ processing quality and consumer acceptance and participate in early selection gene modification
- Identification and characterization of biological materials beneficial in food production and processing (eg. Single cell proteins, enzyme producing microbes and other useful microbial extracts) recommendation for end users.

3.4. ***Food and Environmental Safety***

- Study on naturally and manmade environmental pollutants with respect to food production, preparation & processing & contaminations carried out in the environment and give support advice for program management (planning, implementation, monitoring and evaluation) in many sectors including food security (agriculture & livestock), health, water and sanitation, education and environment.
- Characterize & identify the accumulation of hazard and toxic substances in aquatic and terrestrial plants and animals in the food chain & influence responsible to protect the environment for healthfulness of the population

DIFFERENT RESEARCH MANUSCRIPTS OF FOOD SCIENCE NUTRITION RESEARCH DIRECTORATE

1. PROXIMATE AND MINERALS CONTENT ANAYSIS OF DIFFERENT MEAT SOURCES IN JIGJIGA CITY

Abdulkarim Mohammed Ali[1], Mohammed Dol Ateye[2], Hoodo Mohamed Jama[2],

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com***
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***Ateye069@gmail.com*, *hoodoqali042@gmail.com***

Abstract

Meat is a good source of protein and different micronutrient that widely consumed by Somali community. The study was conducted in Jigjiga City Somali Regional state with objective to analyze macronutrient and micronutrient/minerals of different meat sources in different part of the city. Four different types of meat samples from camel, cattle, goat and sheep with total of eight (8) samples were collected from different part of Jigjiga city. The collected meat samples were individually grounded packed in air tight polyethylene plastic bags and were stored at -15°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, different minerals like Calcium, Iron, Zinc, sodium, magnesium and Potassium were determined by AOAC. Based on the result obtained the moisture, ash, protein and fat are in the range of 71.97% (SheMH02) -75.94% (GoaMH), 0.99 %(CamM01) -1.57% (CatM02), 19.12% (CamMH) -23.32% (SheMH02) and 3.01% (GoaMH) -5.25% (CatM01) respectively and most of them are statistically different at $P<0.05$. The minerals content is also in the range of 18.20 (CatM02) – 33.33mg/100g (CamM01), 15.78 (GoaMSH) – 59.16mg/100g (CamM01), 8.97 (CatM01) – 21.84mg/100g (CamM01), 30.59 (CamM01)-31.40mg/100g (GoaMSH), 660.93 (CamM01) – 992.32mg/100g (SheMH02) and 59.59 (CatM02) – 198.43mg/100g (Ca,M01) for calcium, iron, zinc, magnesium, potassium and sodium respectively and more or less they were statistically different at $P<0.05$. Overall, from the finding we conclude that, sheep is better in protein content followed by cattle, goat and camel. Species difference, breed difference, livestock management, pre and post slaughter handling practice and some other reasons might be the factor for their different in their nutritional content.

Key words: Meat, camel, cattle, goat, sheep, Nutrition, minerals.

1. INTRODUCTION

The general increasing human population in the world leads to the movement of people from rural areas to urban. This will increase the demand for food of livestock origin [1]. Human beings consume protein-rich foods to fulfill their nutritional requirements, mainly of animal origin, such as meat (cattle, camel, sheep, goat, poultry, pig, fish, and seafood/shellfish), milk, and eggs [2]. Meat and meat products are most valuable livestock products and sources of high-quality protein due to their amino acid composition. They are also the major source of iron and some vitamins in the B group. So, meat consumption can alleviate several nutritional deficiencies [3].

Consumers often consider meat quality based on organoleptic properties and microbiological quality. However, meat quality can be evaluated in a more unbiased way by evaluating its chemical composition and physical proprieties. Livestock meat applies a crucial role in human nutrition. Besides, it represents an important constituent of a balanced and healthy diet due to its essential components such as amino acids, long-chain n-3 polyunsaturated fatty acids, and microelements, namely, iron, selenium, zinc, and copper different quality traits of red meat are influenced by several factors, that is, genetic, environmental and management factors. meat composition varies from breeds, from animals, and from one muscle to another in the same animal [4].

Meet is the best source of animal proteins, micronutrients, and B-complex vitamins in the human diet. The chemical composition of meat is an important factor determining both its nutritional value and its suitability for processing meat products [5]. The amount of fat in beef is the source of juiciness and marbling which are some of basic parameter that determines the eating qualities of meat.

The chemical composition and physical properties of meat determined the quality of meat (pH, color, water holding capacity, hardness, thermal treatment losses, nutritional value of meat proteins, digestibility, etc.). These characteristics are influenced by animal species, breed, individual characteristics, sex, age, rearing technologies, and fattening, as well as other factors such as meat production procedure (feeding, transporting, and slaughtering condition) and

processing (storage time or temperature condition) [6]. Composition, texture of the muscle, and some biochemical processes that take place during slaughtering, fabricating, and storing carcasses essentially affect tenderness, while the flavor, which is influenced by the fat content, can be manipulated by genetic methods, growth performance control, and dietary supplementation [7].

There are no any studies that were conducted to evaluate nutritional qualities of Meat in Somali region and people uses different mythologies to slaughter animals and local traders are selling in different areas and not protecting sunlight, and mostly its open areas, also the hygiene of the meat looks poor. However, the qualities of these meats were not examined or investigated. The minerals composition and profile on the quality of meat and a healthy diet are not well documented. Food security is more critical than food safety among both rural and urban poor [8]. The lack of vigorous surveillance of food pathogens in Somali region meat and meat products presents a challenge for food hygiene trainers, as it becomes difficult to demonstrate the magnitude of contamination with these pathogens. Therefore, the aim of this study was analyze the macro and micro-nutrient content of different meat sources in Jigjiga City.

2. MATERIALS AND METHOD

2.1. Materials and Equipment

Meat samples from different livestock sources were collected from the different establishments in Jigjiga city. The meat sources were camel, cattle, goat and sheep. Two samples were collected from each source of meat which makes the total samples 8. All necessary precaution was taken to ensure hygienic and sanitation during sample collection and on the occasion of storage. Further, after bringing to the laboratory, meat samples were size reduced until it suitable for utility, packed in airtight polyethylene plastic bags and were stored at -15°C until further analysis.

2.2. Determination of Proximate Composition

Samples from L. dorsi muscle were thawed for 24 - 48 hours at 4˚C - 8˚C. All exterior muscles, connective tissue and external fat was removed leaving only the Longissimus thoracis muscle. Samples were cubed, submerged in liquid nitrogen for rapid freezing, placed in a blender (VITA-MIX Corp, Cleveland, OH; model # VM0100A) and ground to form beef homogenates.

Grinded/powdered samples were double packed in VWR sample bags (BPR-4590 VW1, Radnor, Pennsylvania) and stored at −40˚C for subsequent analysis [9]. For each parameter approximately 5 g of lean meat was taken from Longissimus dorsi muscle (eye rib area).

Fat content

Soxhlet method of solvent extraction of fat was determined according to AOAC standard procedure [10]. About 2 g milled samples were measured into an extraction thimble lined with fat free cotton. Then the thimbles with the samples were attached to the extraction apparatus. The aluminum cup with a boiling cheap was placed in the oven at 100˚C for 30 minutes and cooled to room temperature in the desiccators for 30 minutes then the cup weight was measured using a digital balance and recorded as W1 (weight of cup), then 50 ml of diethyl ether was added into each cup, after which set up of the extraction apparatus was done.

The samples contained in the thimbles were soaked for about 1 hour by lifting the thimble down into the cup, started from the apparatus hot plate temperature reached 55˚C, after soaking the thimbles will be lifted up and the extraction process takes place for 5 hours. Then the recycling process made by the diethyl-ether was stopped to let the solvent evaporate from the aluminum cup with the extract, in the process the evaporated solvent was recovered in the apparatus. Then aluminum cup and the content were dried in the oven for 30 minutes at 100˚C to evaporate the remaining solvent in the cup. After drying, it was removed from the oven and cooled in the desiccators for 30 minutes then weighed and recorded as W2 (cup + fat).

The percentage of fat will be calculated using the following formula

$$\text{Fat\%} = \frac{(W2-W1)*100}{\text{Sample weight}}$$

Moisture Content

The chemical composition was performed by employing the classical procedures of the Association of Analytical Chemists [11]. For moisture content, the samples were dehydrated in a hot air oven at 125°C until obtaining two successive.

Ash

Ash was determined according to the AOAC standard procedure [10]. Two-gram ground meat sample will be placed into a dried crucible with known weight. The crucible was placed inside a

muffle furnace at 150˚C. Temperature will be increased gradually till it reached 600˚C and heated at that temperature for 3 hrs. Then the crucible will be taken out, cooled into a desiccator and weighed. The ash percentage was calculated as

$$\text{Ash \%} = \frac{\text{(Crucible weight containing incinerated meat- Empty crucible weight)} * 100}{\text{Meat sample weight before incineration}}$$

Crude protein

For determination of crude protein Kjeldhal method of AOAC standard procedure [10], Crude protein was obtained by multiplying the amount of nitrogen by 6.25. The sample was weighed in a Kjeldhal flask. Half a tablet of catalyst mixture (10 parts) of K2SO4 to 1 part of CuSO4 was added (10 ml). 25 ml Concentrated H_2SO4 was added. The content of the flask was digested under boiling at maximum heat for 2 hours. The flask was cooled and transferred to the distillation unit. The sample was distilled using 40% NaOH solution and received in 4% Boric acid. The content was titrated against 0.1 M HCl.

$$\%\text{Crude protein} = \frac{\text{(mlHCL for sample-mlHCLfor blank)}*0.1*14*100}{\text{Weight of sample}}$$

2.3. Mineral analysis

A total of 5 gm of the well-mixed sample was introduced inside porcelain crucibles, then ashing of the sample by using muffle furnace. The obtained ash was dissolved in 1.5% nitric acid and then completed with distilled water up to 100 ml. The sample was filtrated and the trace elements were determined using a spectrophotometer (Unico-UV-2100 spectrophotometer, USA), and the wavelength was 623, 630, 578, 560, 578, and 630 nm for iron, magnesium, calcium, zinc, potassium, and sodium, respectively [12]

2.4. Statistical analysis

All the analysis will be performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained will be analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using Genstat version 18.0. The level of significance will be considered at $P < 0.05$.

3. RESULT

3.1. Macro-nutrient content different meat sources

Table 1: Proximate composition of different Meat sources

Sample Code	Moisture	Ash	C.Protein	C.Fat
CamM01	75.14±0.74^{e}	0.99±0.01^{a}	20.55±0.24^{d}	3.32±0.08^{b}
CamMH	75.37±0.78^{f}	1.5±0.02^{ab}	19.12±0.17^{a}	4.01±0.12^{d}
GoaMH	75.94±0.81^{g}	1.31±0.02^{bc}	19.74±0.21^{b}	3.01±0.05^{a}
GoaMSH	74.97±0.67^{d}	1.42±0.02^{c}	20.06±0.22^{c}	3.55±0.09^{c}
CatM01	73.25±0.54^{c}	1.06±0.03^{c}	20.44±0.24^{d}	5.25±0.15^{f}
CatM02	73.26±0.55^{c}	1.57±0.04^{c}	20.48±0.24^{d}	4.69±0.14^{e}
SheM01	72.91±0.46^{b}	1.4±0.03^{c}	21.74±0.29^{e}	3.95±0.11^{d}
SheMH02	71.97±0.41^{a}	1.57±0.05^{c}	23.32±0.34^{f}	3.14±0.06^{a}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
Cam: Camel, Goa: Goat, Cat: Cattle and She: Sheep

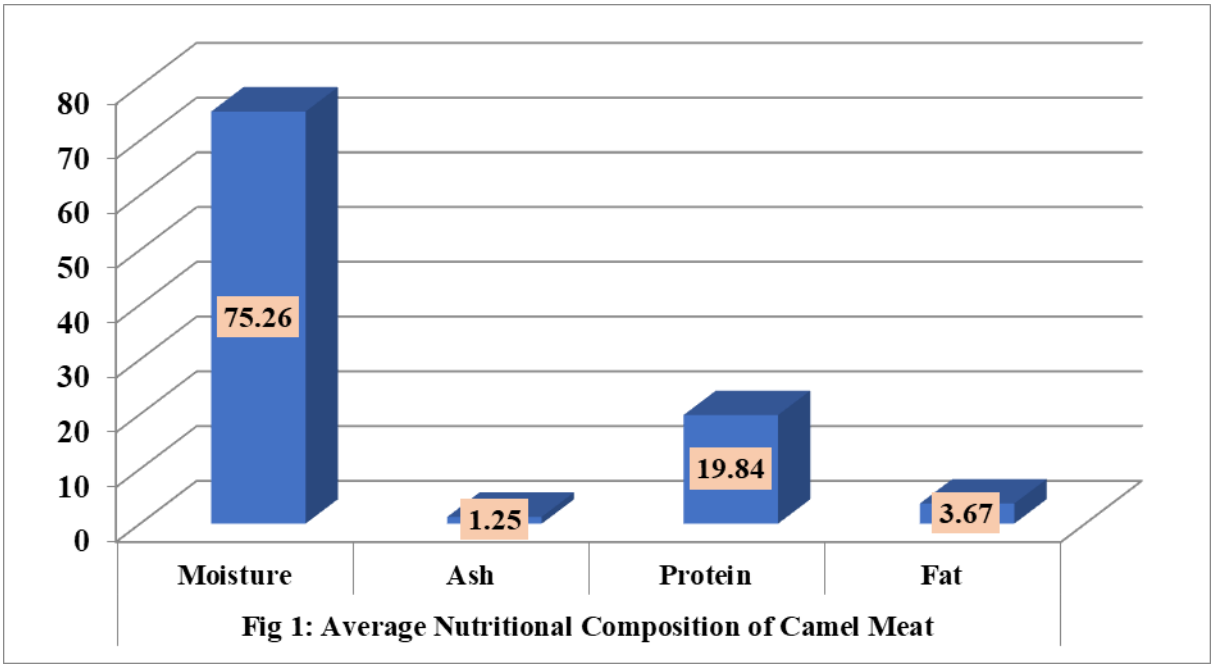


Fig 1: Average Nutritional Composition of Camel Meat

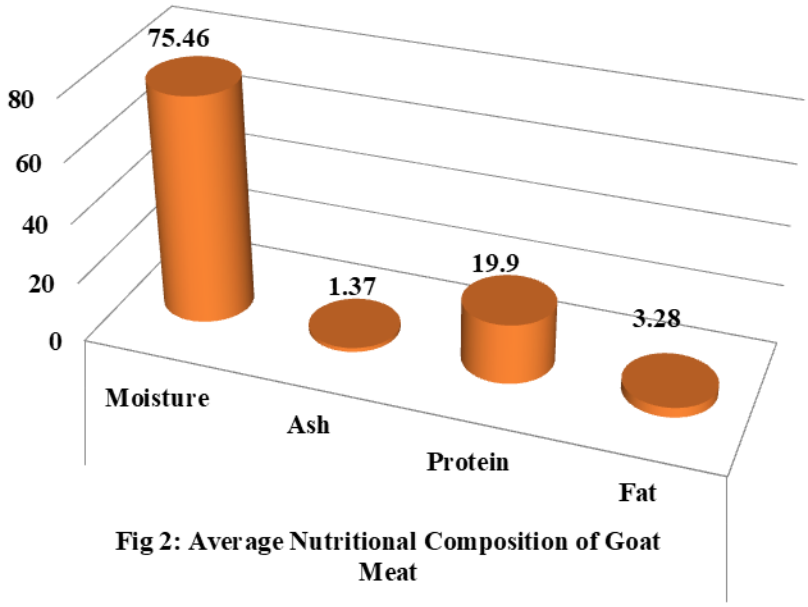


Fig 2: Average Nutritional Composition of Goat Meat

The proximate composition of different meat of camel, cattle, goat and sheep are indicated in table 1. The moisture content is in the range of 71.97% (for SheH02) to 75.94% (for GoaMH). Statistically significant different were observed at $p<0.05$ in moisture content of different meat sources. Significant differences were also observed within same species of meat sources. This not only true for the cattle where there no difference in moisture content as shown in table 1 above which is 73.25% and 73.26% for Cat01 and Cat02 respectively.

When it comes to ash content, CamM01 has the lowest while CatM02 (0.99) & and SheMH have the highest which 1.57%. CamM01 ash content is significantly different from all others samples such as GoaMH, GoaMSH, CatM01, CatM02, SHeM01 and SheMH02 which were 1.31%, 1.42%, 1.06%, 1.57%, 1.40% and 1.57% respectively. On the other hand, the ash content is not statistically different among GoaMH, GoaMSH, CatM01, CatM02, SHeM01 and SheMH02 which were 1.31%, 1.42%, 1.06%, 1.57%, 1.40% and 1.57% respectively.

CamMH has the lowest in protein content (19.12%) while SheMH02 has the highest in protein content which is 23.32%. Statistically there is no significant different in protein content among CamM01 (20.55%), CatM01 (20.44%) and CatM02 (20.48%). The protein content is significantly different among CamMH, GoaMH, GoaMSH, SheM01 and SheMH02 which are 19.12%, 19.74%, 20.06%, 21.74% and 23.32% respectively. These samples protein content are

significantly different with that of the above mentioned samples protein content which are CamM01 (20.55%), CatM01 (20.44%) and CatM02 (20.48%).

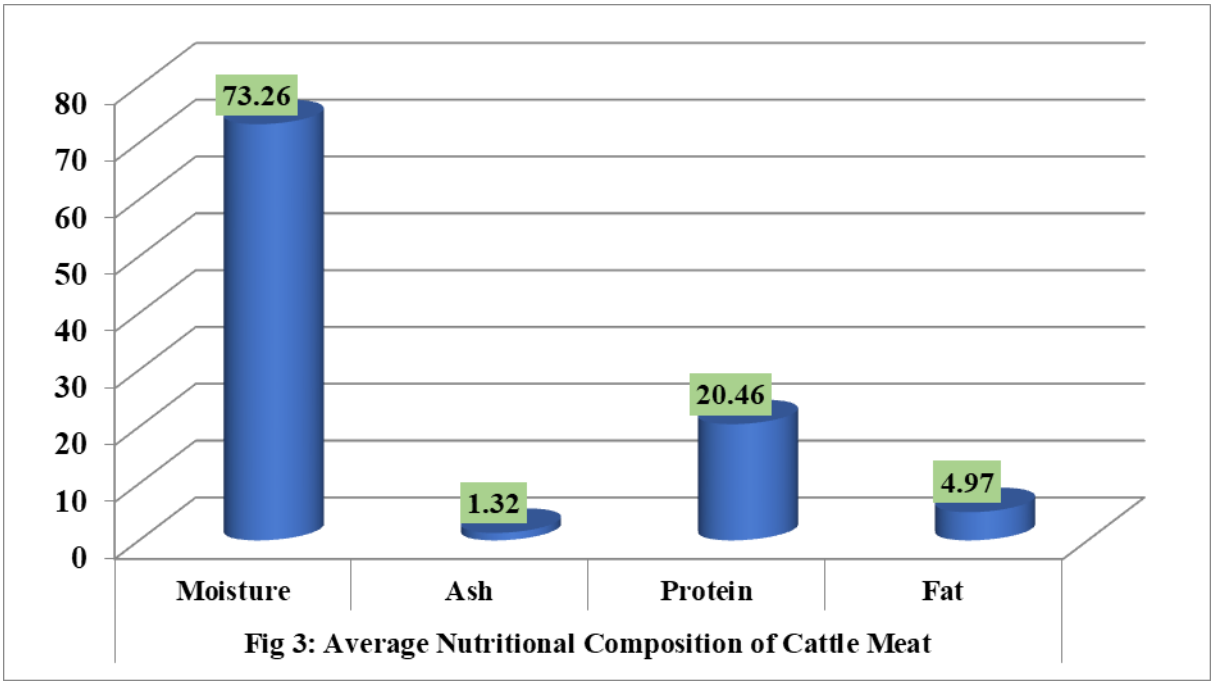


Fig 3: Average Nutritional Composition of Cattle Meat

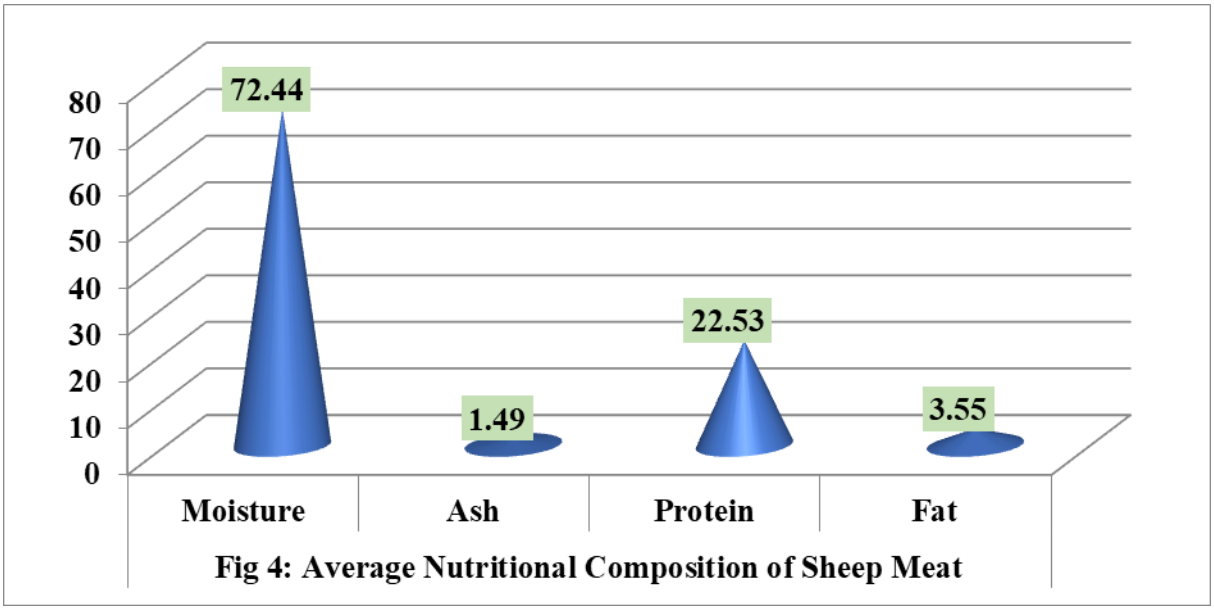


Fig 4: Average Nutritional Composition of Sheep Meat

When it comes of fat content, it is in the range of 3.14% (SheMH02) and 5.25% (CatM01). No significant difference were observed among SheMH02 (3.14%) & GoaMH (3.01%) and also among SheM01 (3.95%) and CamMH (4.01%). The fat content is statistical difference among CamM01, GoaMSH, CatM01, CatM02 which are 3.32%, 3.55%, 5.25% and 4.69% respectively. The average macronutrient composition also indicated in fig 1, 2,3 and 4 for each commodities.

3.2. Micro-nutrient content different meat sources

Table 2. Mineral's content of different Meat Sources

Sample Code	Result in (mg/100g)					
	Calcium (Ca)	Iron (Fe)	Zinc (Zn)	Magnesium (Mg)	Potassium (K)	Sodium (Na)
CamM01	33.33±0.32^{f}	59.16±0.55^{e}	21.84±0.21^{e}	30.59±0.32^{a}	660.93±0.69^{a}	198.43±0.98^{c}
CamMH	21.20±0.21^{c}	42.73±0.42^{d}	15.56±0.15^{d}	30.83±0.26^{d}	818.75±0.81^{cd}	72.78±0.74^{a}
GoaMH	22.20±0.22^{c}	16.98±0.14^{a}	13.84±0.13^{c}	31.16±0.29^{b}	703.07±0.71^{ab}	77.86±0.77^{a}
GoaMSH	23.80±0.28^{d}	15.78±0.12^{a}	14.98±0.34^{d}	31.40±0.30^{cd}	777.44±0.79^{bc}	80.99±0.81^{ab}
CatM01	25.23±0.25^{e}	18.96±0.18^{ab}	8.97±0.09^{a}	31.13±0.28^{b}	756.54±0.76^{bc}	76.12±0.76^{a}
CatM02	18.20±0.18^{a}	22.46±0.22^{b}	11.33±0.11^{b}	31.35±0.30^{bc}	900.61±0.91^{d}	59.59±0.61^{a}
SheM01	19.40±0.15^{bc}	16.45±0.13^{a}	11.86±0.12^{b}	31.23±0.31^{bc}	850.69±0.86^{cd}	95.88±0.93^{ab}
SheMH02	17.37±0.17^{ab}	34.40±0.32^{c}	12.84±0.32^{b}	31.20±0.27^{bc}	992.32±1.99^{e}	112.49±0.99^{b}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
Cam: Camel, Goa: Goat, Cat: Cattle and She: Sheep

Tables 2 indicate the minerals content different meat sources. Six different minerals were considered in this study. CatM02 has the lowest in calcium content while CamM01 has the highest in calcium content. There is no significant difference in the calcium content among CamMH, GoaMH and SheM01 which are 21.20mg/100g, 22.20mg/100g and 19.40mg/100g respectively at $P>0.05$. The same true when it comes to the calcium content for CatM02 and SheMH02 which are 18.20mg/100g and 17.37mg/100g respectively. Statistically significant

difference were observed among CamM01, GoaMSH, CatM01 at P<0.05 which are also true with the above mentioned samples calcium content.

Iron is also the 2nd minerals considered in this study. No significant differences were observed among SheM01 (16.45mg/100g), GoaMSH (15.78mg/100g), GoaMH (16.98mg/1006) and CatM01 (18.96mg/100g) at P>0.05. Statistically significant difference were observed among meat samples of SheMH02, CamMH and CamM01 which are 34.40mg/100g, 42.73mg/100g and 59.16mg/100g respectively which are also significantly different from the above mentioned samples at P<0.05.

The zinc content of different meat samples are indicated in the table 2 above. It is in the range of 21.84mg/100g for CamM01 and 8.97mg/100g for CatM01. No significant difference were observed for the samples SheMH02 (12.84mg/100g), SheM01 (11.86mg/100g) and CatM02 (11.33mg/100g) at P>0.05. The same is true for samples GoaMSH and CamMH which are 14.98mg/100g and 15.56mg/100g respectively at P>0.05. But statistically significant difference were observed in meat samples CatM01, GoaMH and CamM01 which are 8.97mg/100g, 13.84mg/100g and 21.84mg/100g respectively at P<0.05 which are also significantly different with the above mention meat samples.

CamM01 has the lowest in magnesium content (30.59mg/100g) while CamMH has the highest in magnesium content (30.83mg/100g) as shown in table above. Except these samples of the same species, no significant difference were observed among all samples when it comes to magnesium contents of the different meat samples at P>0.05.

When it comes to potassium content, it is in the range of 992.32mg/100g for SheMH02 and 660.93mg/100g as shown in table 4.2. No significant difference were observed among CatM01, GoaMSH, GoaMH and SheM01 which are 756.54mg/100g, 777.44mg/100g, 703.07mg/100g and 850.69mg/100g respectively at P>0.05. The same is true for meat samples SheM01 and CamMH which are 850.69mg/100g and 818.75mg/100g respectively at P>0.05. But statistically significant difference were observed among CamM01, CatM02 and SheMH02 which are 660.93mg/100g, 900.61mg/100g and 992.32mg/100g respectively at P<0.05.

Lastly, the sodium content of different meat samples was indicated in table 2. The sodium content of different samples are in the range of 59.59mg/100g (CatM02) to 198.43mg/100g (CamM01).Statistically, significant difference were observed among CamM01 samples which

are 198.43mg/100g with the rests of the other meat samples in one way other at P<0.05. But, significant difference were observed among CamMH, GoaMH, CatM01, CatM02, GoaMSH, SheM01 and SheMH02 which are 72.78mg/100g, 77.78mg/100g, 76.12mg/100g, 59.59mg/100g, 80.99mg/100g, 95.88mg/100g and 112.49mg/100gm respectively at P>0.05.

4. DISCUSSION

4.1. Macronutrients

The amount of ash, crude fat (CF) and crude protein (CP) were significantly different between breeds. Similarly, a study had reported the presence of significant difference in protein, fat, ash and moisture content of beef across the breeds [13]. The moisture content of the different meat sources are in the range of 71.97-75.94% as shown in table 1. The difference in moisture content might be due to species difference, breed difference, handling practice before and after slaughter and some other reasons. The moisture content obtained in agreement with Ante Kasap, et.al. [14]. This result is also in agreement with a Spanish study on three lamb genotypes [15] where breed did not show a significant effect on dry matter ($p > 0.05$). Our results were higher than those reported by Liu et al. [16] and Berrighi et al. [17], respectively, for Chinese (23–25%) and Algeria lambs (18%).

The protein content of different meat sources are in the range of 19.12%-23.32% as indicated in table 1. The result obtained for protein analysis is comparable with study done on cattle breed based on their age in Ethiopia [18].The result of the present study in respect to CP implied that sheep are better for red meat production as the percentage protein decreased with advance in age. The obtained results were comparable to those reported by Addis et al. [19] for Agnello di Sardegna lambs, while they were lower than those reported by Liu et al. [16][25] for Oula lambs. The difference in crude protein content among these meat samples is due to species difference, breed difference, management of those species before slaughter, handling practice after slaughter and some other reasons.

The fat content of different meat sources are from 3.14 to 5.25% as shown in table 1. The result obtained for fat analysis is lower than with study done on cattle breed based on their age in Ethiopia [18] but higher than the study done by [14]. The CF content of beef of all the breeds under the study can

be considered as a good contributor to palatability of the beef as minimum of 3% fat is suggested to ensure acceptable palatability of beef [20]

4.2. Micronutrient

After protein and fat, meat is an essential source of several other nutrients, such as minerals [21]. It is defined as poor food in calcium and rich in potassium (K), phosphorus (P), iron (Fe), sodium (Na), and zinc (Zn) [22]. Its consumption can respond qualitatively or quantitatively to the human needs for mineral elements. Fe and Zn were most abundant microelements which much higher than the result obtained by some other research [14, 23]. The Zn content is the range of 8.97-21.84mg/100g as indicated in table 4.2. Meat is a major source of total iron (Fe) and heme iron [24] and thus might help reduce major public health problem worldwide [22]. The iron content depends on the breed, muscle, and animal's age [25][24]. Under this study, the iron content of the meat is in the range of 16.45 to 59.16mg/100g.

When it comes to other minerals, Potassium is the most abundant one followed by sodium, magnesium and calcium. The potassium content is in the range of 660.93-992.32mg/100g. The obtained results were higher than those reported by Osorio et al. [26] in suckling lambs of Churra breed and by Polidori et al. [27] for Fabrianese breed meat. In comparison with the literature, the tested meats presented a high content of major mineral elements [14, 26, 27]. The natural feeding condition-based pasture in phosphocalcic soils rich in phosphorus, sodium, magnesium, and calcium could explain the high levels recorded in the studied meats [28]. The magnesium and calcium contents of the meat sources are in the range of 30.59 to 31.40mg/100g and 18.20 to 33.33mg/100g respectively. The result might be influenced by bread type, breed type, nature of pasture livestock used, handling management of the livestock and some other reasons. In general, all meat types have good sources of both micro-minerals and macro minerals.

5. CONCLUSION

Eight different samples of meat were used for this study. The meats were used from camel, cattle, goat and sheep from different place in Jigjiga city. Based on the laboratory analysis, the moisture content is in the range 71.97-75.94% which makes sheet meat to be lowest in moisture content while camel to be the highest averagely. Meat from camel has lowest in protein content (19.12%) while meat from sheep has highest in protein content (23.32%). When it comes to fat

content, meat from cattle has highest in fat content (5.25%) while meat from goat has lowest in fat content which is 3.01%. six types of minerals were considered in this study. All meat sources are highest in minerals content. Based on their order, potassium, sodium, magnesium, calcium, iron and zinc considered to be from highest to lowest level.

6. RECOMMENDATIONS

Based on the data available and identified gaps, the following recommendations are forwarded;

- Further research should be done for some missed parameters such as type of fatty acid or fatty acid characterization.
- Special research should be done under control condition to further analyze the effect of different factors on meat nutritional quality.
- Research should also be done on the effect of post slaughter process/factors on meat nutritional quality.

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CONFLICT OF INTEREST

- This is to confirm that, there is no conflict of interest between authors for this study

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2. NUTRITIONAL, ANTI-NUTRITIONAL AND PHYSICO-CHEMICAL PROPERTIES OF DIFFERENT HARICOT BEAN VARIETIES ADAPTED UNDER SoRPARI's DIFFERENT RESEARCH CENTERS

Abdulkarim Mohammed Ali[1], Mohammed Dol Ateye[2], Hoodo Mohamed Jama[2],

1) Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com***
2) Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***Ateye069@gmail.com, hoodoqali042@gmail.com***

Abstract

Haricot bean one the legume crop that widely consumed in Somali community. The study was conducted in Somali Regional state with objective to analyze macronutrient, micronutrient/minerals, antinutritional content, functional and physical of different haricot bean varieties adapted by Somali region pastoral and Agro-pastoral Research Institute. Six different types of samples such as *Awash mittin, Awash 2, Seri 119, Seri 125, Adi* and D Control as control with total of fifteen (15) samples were collected from three different research center namely Dolo-Ado, Fafan and Kelafo. The collected haricot samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Zinc and Potassium were determined by AOAC. The Anti-Nutritional content such as tannins and phytate, functional and physical properties were also determined by different standard procedures. Based on the result obtained the moisture, ash, crude fiber, protein and fat are in the range of 7.915 (K-Seri 119) -11.533% (F-Adi), 4.218 (F-Awash-2) -5.606% (K-Seri 125), 2.230 (F-Seri 125) -4.480% (F-Awash - 2), 16.210 (K-Seri 125) -22.180% (D-Awash mittin) and 0.540 (D.Seri 125) – 2.250% (D-Awash -2) respectively and most of them are statistically different at $P<0.05$. The minerals content is also in the range of 65.96 (F-Adi) – 108.07mg/100g (D-control), 126.0 (D-Seri 119) – 152.0mg/100g (K-Seri 125), 3.092 (K-Awash 2) – 4.798mg/100g (D-Awash 2) and 4.306 (K-Seri 119)-6.571mg/100g (D-control) for calcium, potassium, zinc and iron respectively and more or less they were statistically different at $P<0.05$. Regarding the anti-nutritional content, the tannins and phytate content is in the range of 0.30 (F-Adi and F-Awash 2) -34.95mg/g (D-Seri 119) and 2.193 (K-Seri 119) – 4.05mg/g (D-Seri 119) for tannins and phytate respectively and statistically different for tannins content at $P<0.05$. The functional and physical properties of different haricot bean varieties under study were more or less statistically different at $p<0.05$. Overall, from the finding we conclude that, adapted haricot bean varieties have better in nutritional content especially, ash and fiber and protein content especially varieties with D-Awash mittin. Varietal difference, agro-ecology, nature of soil, farming management and some other reason might be the factor for their different in their nutritional content. Haricot bean is reached in protein, minerals and other important nutrient and therefore, we recommend that, it can be used either alone or mix with those staple cereals as part of fighting against malnutrition and in the preparation of different recipe.

Key words: Haricot bean, macro-nutrient, minerals content, Anti-nutritional content, Functional Properties, Physical property.

1. INTRODUCTION

Grain legumes occupy an important place in human nutrition, especially in the dietary pattern of low-income groups of people in developing countries. Legumes, considered as poor man's meat, are generally good sources of nutrients [1]. They are an important and inexpensive source of protein, dietary fiber and starch for a large part of the world's population, mainly in developing countries [2]. Among the commonly consumed food legumes, haricot beans (Phaseolus vulgaris L.) occupy an important place in human nutrition in East and Great Lakes regions of Africa [3]. Beans are also one of the best non-meat sources of iron, providing 23–30% of daily recommended levels from a single serving [4].

Ethiopia is one of the poorest countries in the world with 85% of its population living in the rural parts of the country and employed in agriculture sector. The agriculture sector is very important in the Ethiopian economy that it accounts for roughly 46% of the country's Gross Domestic Product (GDP) and 90% of exports [5]. Agriculture is the core component and driver for Ethiopia's growth and long-term food security. Agriculture directly employs 80 percent of the total population, 43 percent of gross domestic product (GDP), and over 70 percent of export value [6]. Despite the considerable progress made in the sector, ensuring commercialized production remains one of the major challenges facing millions of people.

Haricot bean (Phaseolus vulgaris L.) has been an export pulse crop for Ethiopia for more than 50 years and probably been grown as food crop for a much longer period in the low and mid land altitude areas of the country [7]. The crop is widely grown in areas between 1400-2000 m.a.s.l. The main production areas include the East Hararghe, West Wellega, East shewa, West Arsi, Sidama, Wolayita, Wollo and East Gojam [8]. The crop is grown either as a sole crop and/or intercropped with either cereal or perennial crops [9]. There are a wide range of haricot bean types grown in Ethiopia, including the mottled, red, white and black varieties. The leading white bean varieties are the Awash 1, Awash melka and Mexican 142 varieties. The pure red and pure white colored beans are the most common commercial varieties [7]. Haricot bean is ranked as the second largest pulse crop in the country in terms of production with a share of 17 percent, next to

Faba beans [10]. CSA 2014/15 report also shows that the production share of haricot bean has consistently been 19 percent of all the pulses for the last two years.

Haricot beans are a grain crop mainly produced in Ethiopia for home consumption and export purpose. It grows in most of the agro-ecology zones of low and mid altitude areas of the country. A market demand for the haricot beans both in the export market has become the main instrument for the growing trends in volume of production [11]. Haricot beans are among the most important grain legumes produced by small-scale farmers for both subsistence and cash, mainly in the lowlands and in the rift valley areas of Ethiopia. They are high in starch, protein, and dietary fiber, and are an excellent source of minerals and vitamins.

According to [12] world market prices for agricultural goods have been increasing. The reason for the increasing trend of agricultural world market prices is that global demand growth exceeds the growth in global supply, and this trend will continue in the foreseeable future. The global demand for food will continue to grow mainly for two reasons. One is the continued growth in world population; the other is the sustained growth in per capital incomes in developing and newly industrialized countries, with corresponding increase of per capital food consumption. This fact in turn has a positive impact on the home consumption and export of high value agricultural commodities and creates international market opportunity. Shortage in one end of the world becomes an opportunity in the other end of the world, this leads to increase the production of agricultural commodities in the potential production areas. Consequently, this might accelerate economic growth. Therefore, the competitiveness of agricultural commodities in global market are imperative for exportable products.

As indicated above, now adays SoRPARI adapted releasing the common beans specially haricot bean. So, we believe that based on literature and how haricot beans are important in terms of macro, micro-nutrient and anti-nutrient content, its mandatory to investigate its quality before home consumption and export purpose. Different research centers under Somali region pastoral and Agro-pastoral research institute have been working on the haricot bean varieties. Therefore, the aim of the present study was to analyses the nutritional value, anti-nutritional value, mineral contents, functional and physical properties of haricot bean varieties adapted and released by SoRPARI.

2. MATERIALS AND METHOD

Six different haricot bean varieties produced/adapted under SoRPARI were collected and with one variety as a control was purchased from the local market. A total of 15 samples with six varieties produced or adapted under SoRPARI that were used for this study includes Awash 2, Awash mittin, Seri 119, Seri 125, Adi and on control sample whereas the control haricot bean is type might be the one with most likely used by local community and imported one. Haricot bean samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. The proximate composition of rice flours was determined using the standard AOAC methods (AOAC, 2000). Gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000). The mineral contents were determined by the procedure of AOAC (2000). All the analysis were performed in duplicate and presented as mean ± standard deviation. Statistical significance of the data obtained were analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using GenStat version 17.0. The level of significance was considered at $P < 0.05$.

3. RESULT

3.1. Macronutrient content of different haricot bean varieties

Table 1 shows proximate composition of different haricot bean varieties. The moisture content is the range of 7.915% (K-Ser 119) to 11.533% (F-Ada) variety. Overall, there is no significance difference in moisture content of different haricot bean varieties collected both from Dolo-Ado and Kelafo research center at $P<0.05$. When it comes to ash content, F-Awash 2 has the lowest (4.218%) and K-Seri 125 with highest (5.606%) ash content. Significant difference was observed between 15 different samples of haricot bean at $P<0.05$ while in between some samples there is no significant difference at $P<0.05$.

Table 1: Proximate composition of different haricot bean varieties

Haricot bean Varieties	Results in (%) (100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
DAwash2	8.095±0.5^{a}	5.500±0.2^{gh}	3.160±0.2^{f}	18.96±0.6^{i}	2.250±0.09^{k}	62.03±1.81^{b}	344.2±2.51^{fg}
D Awash –Mittin	8.141±0.3^{a}	5.473±0.2^{fgh}	3.230±0.2^{g}	22.18±0.8^{m}	1.620±0.07^{g}	59.36±1.22^{a}	340.7±3.01^{def}
D Control	8.395±0.6^{ab}	5.060±0.3^{def}	3.410±0.2^{hi}	17.25±0.5^{d}	1.740±0.07^{h}	64.15±2.11^{de}	341.2±3.12^{def}
D-Seri 119	8.782±0.7^{abc}	4.835±0.1^{bcd}	3.280±0.2^{g}	20.14±0.7^{k}	1.440±0.06^{f}	61.52±1.75^{b}	339.6±2.98^{de}
D-Seri125	8.584±0.5^{ab}	4.966±0.2^{cde}	3.350±0.3^{h}	18.77±0.6^{h}	0.540±0.02^{a}	63.79±2.08^{d}	335.1±2.87^{bc}
F-Adi	11.553±0.8^{e}	4.614±0.2^{abc}	2.760±0.1^{c}	19.63±0.7^{j}	1.400±0.06^{f}	60.04±1.32^{a}	331.3±2.68^{ab}
F-Awash 2	9.203±0.9^{bc}	4.218±0.1^{a}	4.480±0.3^{l}	18.02±0.6^{g}	0.790±0.03^{b}	63.29±1.90^{cd}	331.3±2.69^{ab}
F-Awash Mittin	10.954±0.8^{de}	4.516±0.2^{ab}	3.430±0.2^{i}	17.59±0.5^{e}	1.160±0.05^{d}	62.35±1.95^{bc}	330.2±2.56^{a}
F-Seri 119	10.613±0.7^{d}	4.296±0.1^{a}	3.620±0.2^{k}	16.75±0.4^{b}	1.070±0.04^{c}	63.65±2.06^{d}	331.2±2.68^{ab}
F-Seri 125	9.530±0.6^{c}	4.535±0.2^{ab}	2.230±0.1^{a}	20.29±0.8^{l}	1.310±0.05^{e}	62.10±1.98^{b}	341.4±3.03^{def}
K-Adi	8.689±0.5^{abc}	5.112±0.3^{defg}	2.400±0.1^{b}	17.88±0.5^{f}	1.740±0.07^{h}	64.18±2.32^{de}	343.9±3.56^{efg}
K-awash 2	8.678±0.6^{abc}	5.304±0.3^{efgh}	3.040±0.2^{e}	18.99±0.6^{i}	1.570±0.06^{g}	62.42±1.98^{bc}	339.8±3.04^{de}
K-awash Mittin	8.319±0.6^{ab}	5.284±0.3^{efgh}	3.230±0.2^{g}	17.59±0.5^{e}	1.910±0.08^{i}	63.67±2.21^{d}	342.2±3.23^{def}
K-Seri 119	7.915±0.3^{a}	5.160±0.2^{defg}	2.930±0.2^{d}	16.93±0.4^{c}	2.130±0.09^{j}	64.93±2.34^{e}	346.6±3.95^{g}
K-Seri 125	8.137±0.4^{a}	5.606±0.3^{h}	3.530±0.3^{j}	16.21±0.4^{a}	1.460±0.06^{f}	65.06±2.51^{e}	338.2±3.86^{cd}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
D: Dolo-Ado, F: Fafan, K: Kelafo Research center and Sub-centers. CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these haricot bean varieties

With respect to crude fiber content, sample with F-Seri 125 has lowest in crude fiber content while sample with F-Awash 2 has highest in crude fiber content as indicated in table above. When it comes to comparison among different samples collected from different research centers, those samples collected from Fafan research center have highest crude fiber followed by Dolo-Ado and Kelafo research center respectively. K-Seri 125 has lowest in crude protein content (16.21%) while D-Awash mittin has the highest in crude protein content (22.18%). There is no significant difference at $P<0.05$ between samples with code K-Awash mittin and F-Awash mittin. Except these two samples, the crude protein content is significantly different in between al samples at $P<0.05$. In general, the data shows, haricot bean is good source of crude protein.

D-Seri 125 has lowest in crude fat content (0.54%) while D-Awash-2 has the highest in crude fat content (2.25%). There is no significant difference in between (K-Seri 125 & F-Adi), (D-Awash mittin & K-Awash 2) and (D-Control & K-Adi) at $P<0.05$. Except these mentioned samples, the crude fat content is significantly different in between others haricot bean samples at $P<0.05$. When it comes to carbohydrate content, K-Seri 125 has the highest in carbohydrate content (65.06%) while D-Awash mittin has the lowest in carbohydrate content which is 59.36. Lastly the energy, sample code with F-Awash mittin has the lowest in energy obtained (330.2Kcal/100g) while K-Seri 119 has the highest in energy content which is 346.6Kcal/100g. Except few samples, the energy obtained is not significantly different at $P<0.05$.

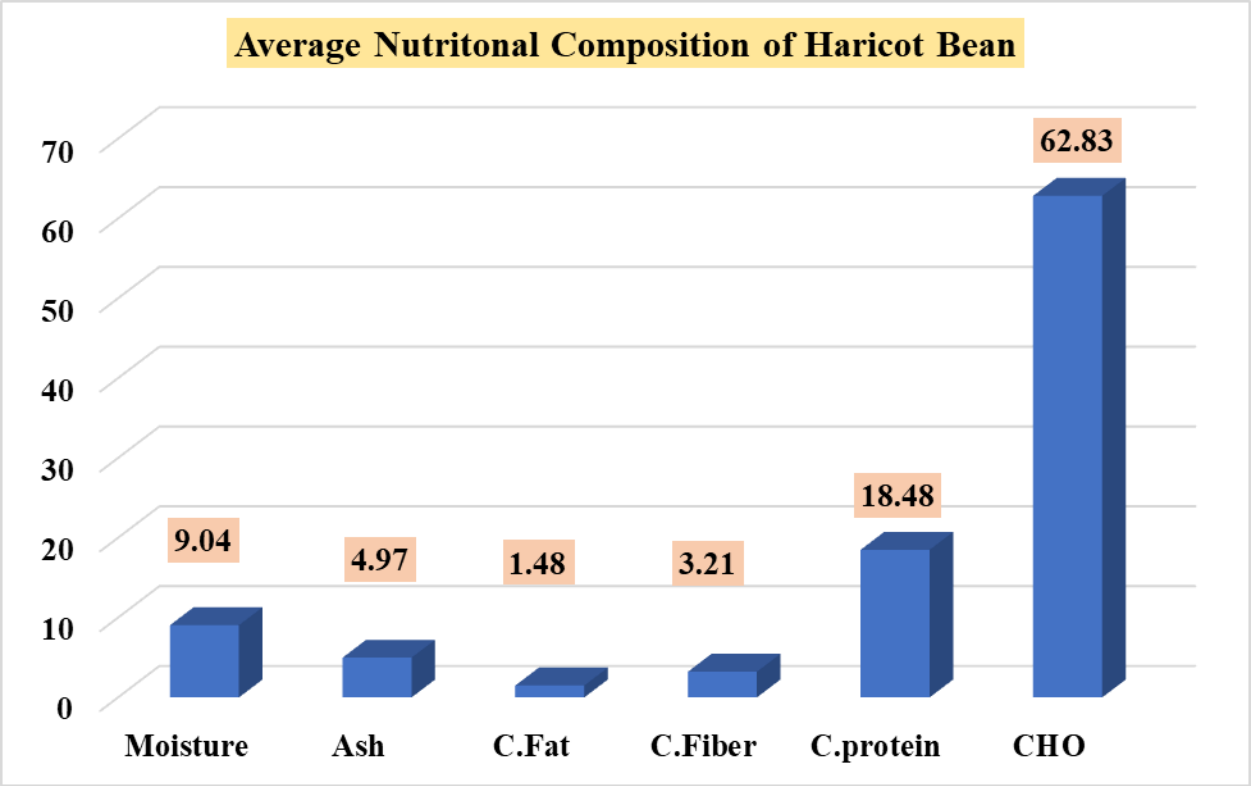


Figure 1: Average nutritional composition of haricot bean

Key: C-Crude, CHO-Carbohydrate

The general nutritional content indicated in figure 1 above. The figure indicates that, the average nutritional composition of 1.48%, 3.21%, 4.97%, 9.04%, 18.48% and 62.83% for crude fat, crude fiber, ash (Inorganic component), moisture, crude protein and carbohydrate in their order of increasing respectively.

3.2. The minerals content of different haricot bean varieties

The mineral content of different haricot bean varieties has indicated in table 2 below. The calcium content is in the range of 65.96mg/100g for sample code F-Adi while the highest amount of calcium is registered for sample with code D-Control which is 108.07g/100g. Except few samples, significant difference was observed for calcium in most of the sample in a one-to-one comparison at $P<0.05$. Sample with code K-Awash-2 has the lowest in zinc content (3.092mg/100g) while D-Awash 2 has the highest in zinc content which is (4.798mg/100g). Except few samples, there is no significant difference in zinc content if one-to-one and general comparison is considered at $P<0.05$.

Table 2. Minerals content of different haricot bean varieties

Haricot bean Varieties	Results in (mg/100g)			
	Calcium	Zinc	Iron (Fe)	Potassium (K)
DAwash2	83.04±1.50^{fg}	4.798±0.98^{f}	5.227±0.99^{ab}	150.3±1.89^{e}
D Awash -Mittin	79.96±1.35^{defg}	4.152±0.82^{cdef}	4.543±0.79^{a}	147.8±1.79^{de}
D Control	108.07±1.85^{i}	3.739±0.79^{abcd}	6.571±1.04^{b}	145.1±1.71^{cde}
D-Seri 119	68.19±1.25^{ab}	4.422±0.92^{def}	5.666±0.99^{ab}	126.0±1.21^{a}
D-Seri125	65.96±1.21^{a}	4.106±0.80^{cdef}	5.219±0.99^{ab}	138.1±1.34^{bc}
F-Adi	85.32±1.62^{g}	3.780±0.78^{abcd}	4.534±0.75^{a}	135.6±1.32^{b}
F-Awash 2	80.93±1.42^{efg}	4.025±0.78^{cde}	4.538±0.81^{a}	133.3±1.31^{ab}
F-Awash Mittin	92.49±1.48^{h}	3.541±0.65^{abc}	5.671±0.97^{ab}	133.3±1.31^{ab}
F-Seri 119	72.79±1.29^{bc}	3.706±0.69^{abcd}	4.995±0.91^{ab}	131.0±1.30^{ab}
F-Seri 125	78.32±1.35^{def}	3.457±0.59^{abc}	6.343±1.02^{b}	140.3±1.61^{bcd}
K-Adi	83.01±1.50^{fg}	3.860±0.72^{bcde}	4.988±0.94^{ab}	145.0±1.71^{cde}
K-awash 2	83.42±1.52^{fg}	3.092±0.52^{a}	5.433±0.93^{ab}	147.5±1.76^{de}
K-awash Mittin	77.09±1.29^{cde}	3.256±0.58^{ab}	5.665±1.01^{ab}	145.1±1.72^{cde}
K-Seri 119	75.14±1.19^{cd}	3.941±0.76^{bcde}	4.306±0.71^{a}	147.5±1.78^{de}
K-Seri 125	84.55±1.42^{g}	4.582±0.91^{ef}	5.663±1.02^{ab}	152.1±1.95^{e}

When it comes to iron content, sample with K-Seri 119 has lowest in iron content (4.306mg/100g) while sample with code D-control has the highest in iron content which is 6.571mg/100g. Almost all no significant difference was observed in between most of the haricot sample when it comes to iron content at $P<0.05$. Lastly, the potassium content of different haricot bean samples are in the range of 126.0mg/100g for sample with code D-Seri 119 and 152mg/100g for sample with code K-Seri 125. Except few samples, there is no significant difference in potassium content if one-to-one and general comparison is considered at $P<0.05$. Relatively minor difference was observed in potassium content for same sample but collected from different sources or area.

3.2.1. Anti-Nutritional factors of different haricot bean varieties

Table 3 Anti-Nutritional factors of different haricot bean varieties

Haricot bean Varieties	Results (mg/g)	
	Tannins	**Phytate**
DAwash2	0.66±0.08[a]	2.663±0.28[a]
D Awash –Mittin	0.86±0.94[a]	3.594±0.36[a]
D Control	13.65±1.26[b]	2.539±0.26[a]
D-Seri 119	34.95±1.93[e]	4.050±0.43[a]
D-Seri125	28.60±1.87[d]	2.319±0.23[a]
F-Adi	0.30±0.05[a]	2.657±0.28[a]
F-Awash 2	0.30±0.05[a]	2.317±0.24[a]
F-Awash Mittin	0.52±0.07[a]	2.658±0.28[a]
F-Seri 119	22.22±1.57[c]	2.315±0.22[a]
F-Seri 125	26.31±1.51[cd]	2.310±0.21[a]
K-Adi	0.44±0.06[a]	2.309±0.20[a]
K-awash 2	1.91±0.09[a]	3.009±0.31[a]
K-awash Mittin	0.77±0.09[a]	2.662±0.29[a]
K-Seri 119	28.85±1.68[d]	2.193±0.21[a]
K-Seri 125	30.61±1.86[d]	2.784±0.30[a]

Key: Same letter in the same column is not significantly different from each other at $p<0.05$

D: Dolo-Ado, F: Fafan, K: Kelafo Research center and Sub-centers.

The anti-nutritional content (Tannins and phytate) of different haricot bean varieties has been indicated in table 3. Regarding tannins content, Sample with code F-Adi and F-Awash-2 has the lowest in tannins content (0.30mg/g) while D-Seri 119 has the highest in tannins content which is 34.95mg/g. in addition to this, high level of tannin were obtained on sample code with K-Seri 125, K-Seri 119, D-Seri 125, F-Seri 125, F-Seri 119 and D-Control sample with values of 30.61mg/g, 28.85mg/g, 28.60mg/g, 26.31mg/g, 22.22mg/g and 13.65mg/g respectively. Except few samples, there is no significant difference in tannins content if one-to-one and general comparison is considered at $P<0.05$. When it comes to the phytate content, D-Seri 119 has the highest in phytate

content (4.050mg/g) while k-Seri 119 has the lowest in phytate content which is 2.193mg/g. There is no significant difference between all haricot sample collected form all centers at $p<0.05$.

4. DISCUSSION

4.1. Proximate Composition of Different Haricot Bean Varieties

Table 1 shows proximate composition of different haricot bean varieties. The moisture content is the range of 7.915% (K-Ser 119) to 11.533% (F-Adi) variety. When it comes those verities collected from Fafan research center, the moisture content F-Ada & F-Awash mittin are significantly different as compared to F-Awash 2, F-Ser 119 and F-Ser 125 at $P<0.05$. This might be due to difference in maturity during harvest, storage condition. According to the report of research done by Demirew Abera et.al., [13] and Shimelis and Rakshit [14], Moisture content concentration varied from 9.33 to 10.62 g/100g (DM) and 9.08 to 11.01g/100g (DM) respectively. Ash is a part of the proximate composition and is related to mineral residue. The level of ash content represents total inorganic matters that are located in food ingredients. F-Awash 2 has the lowest (4.218%) and K-Seri 125 with highest (5.606%) ash content. This value is much higher with one reported by Demirew Abera et.al.,[13]. The difference might be due the fact that, agro-ecological difference, farming system or management difference, nature of soil and some others.

The percentage of the crude fiber suggested that diet prepared with common beans could help to ensure good gut movement of food through the gut to provide energy and ensure break down of the food. Moreover crude fiber is known to influence production of high butyrate levels and butyrate has been linked to lower risks for cancer [15]. Except few haricot bean samples under study (D-Seri 125 and D-Control samples), the crude fiber content of most samples is significantly different at $P<0.05$. The crude fiber content is significantly different at $P<0.05$, in some of the same sample but collected from different research centers. The crude fiber content of those fifteen haricot bean varieties were relatively lower than the one reported by Derese [16], Shimelis [14] and Demirew Abera et.al [13] were ranged from 4.86g/100g to 7.01g/100(DM), 4.66 to 5.95 g/100g (DM) and 4.40% to 8.89% respectively. This might be due difference in other content of the bean, agro-ecological difference, farm management and this result indicates that proximate composition varied from variety to variety.

Protein is another part of proximate composition which is the second dominant in percentage after carbohydrate that help in physical and mental growth and development as earlier reported by [17, 18]. There is no significant difference at P>0.05 between samples with code K-Awash mittin and F-Awash mittin. Except these two samples, the crude protein content is significantly different in between all samples at P<0.05. Even there is significant different in between same sample but collected from different research centers at P<0.05. In general, the data shows, haricot bean is good source of crude protein. The total mean protein content of Fifteen samples were lower than the research done by Demirew Abera et.al [13] on improved and released common bean varieties that were in the range of 18.62% -25.98% But comparable with [14] which was in the range of 17.96g/100g to 22.07g/100g for the improved Ethiopian beans.

4.2. Mineral content of different haricot bean varieties

Except few samples, significant difference was observed for calcium in most of the sample in a one-to-one comparison at P<0.05. When it comes to the potassium content except few samples, there is no significant difference in potassium content if one-to-one and general comparison is considered at P>0.05. Relatively minor difference was observed in calcium and potassium content for same sample but collected from different sources or area. Range of calcium content was from 4.84-44.51mg/100g, 731.93 to 1629.77mg/kg (73.19-162.97mg/100g) according research report by Demirew Abera et.al [13], Shimelis and Rakshit [14] respectively and potassium content from 186.81-423.84mg/100g, according research report by Demirew Abera et.al [13].

Sample with code K-Awash-2 has the lowest in zinc content (3.092mg/100g) while D-Awash 2 has the highest in zinc content which is (4.798mg/100g) (table 4.2). Except few samples, there is no significant difference in zinc content if one-to-one and general comparison is considered at P>0.05. When it comes to iron content, sample with K-Seri 119 has lowest in iron content (4.306mg/100g) while sample with code D-control has the highest in iron content which is 6.571mg/100g (table 4.2). Range of Iron content was from ND-8.58mg/100g, 61.81 to 83.99mg/kg (6.181-8.399mg/100g) and zinc content from 0.05-1.4mg/100g, 15.36 to 28.22mg/kg (1.536-2.822mg/100g) according research report by Demirew Abera et.al [13], Shimelis and Rakshit [14]. Similarly the ranges of these results were also reported by Derese and shimelis [16] from

46.80 to 72.40mg/kg and from 14.30 (4.680mg/100g) to 22.90mg/kg (2.290mg/100g) for iron and Zinc content respectively.

4.3. Anti-Nutritional content of different haricot bean varieties

Regarding tannins, except few samples, there is no significant difference in tannins content if one-to-one and general comparison is considered at $P<0.05$. Relatively minor difference was observed in tannins content for same sample but collected from different sources or area except some samples. The tannins content of those Seri 119 and Seri 125 are significantly different as compared with other haricot bean varieties at $P<0.05$. The research done on different varieties of haricot bean indicate that, the tannins content is the range of 0.82 - 3.49mg/100g [19]. When it comes to the phytate content, there is no significant difference between all haricot sample collected form all centers at $p<0.05$. The phytate content was in contradict with that of Phytate from 124.63- 217.44mg/100g, specifically that of Seri 119 and Seri 125 were 124.63 and 146.26mg/100g respectively, according to the research report by Demirew Abera et.al [13]. On the other hand, the research done on different varieites of haricor bean indicate that, the phytate content is the range of 122.26- 143.21mg/100g [19] .

5. Conclusion

The research was done on six haricot bean varieties with fifteen total samples collected from three research centers under Somali Region Pastoral and Agro-Pastoral research institute (SoRPARI). From the data obtained we conclude that, the ash content of all sorghum varieties is high which an indication for their high mineral content. The moisture content of all varieties were below 12% which is an indication for their better shelf stability. The fiber, and carbohydrate is also up to the standard which indicates that, haricot bean is good sources these components. The protein content of all haricot bean varieties is very high which indicate haricot bean is the good source protein which in turn helps in fighting against protein energy malnutrition. But fat content of all haricot bean varieties is very low. When it comes to minerals content, all varieties of sorghum have high amount calcium, iron, zinc and potassium. Regarding the anti-nutritional content of haricot bean, especially sample with varieties name Seri 119 and Seri 125 is high both tannins and phytate content. Generally, haricot bean with variety name Awash mittin is good in almost all parameter such as protein, ash, fiber, mineral and anti-nutritional content. Significant different were observed in all varieties for both macronutrient, micronutrients and Anti nutritional content of different

haricot bean varieties where agro-ecology, varietal difference, soil nature, farming management are the main expected factors for their difference.

6. Recommendation

Based on the data obtained from this research we forward the following recommendation;

- The data shows that, all haricot bean varieties have high amount of protein, ash and fiber, therefore, we recommend possibility of using haricot bean by mixing with other staple cereals such maize, sorghum in the preparation meal so that the nutritional content can be enhanced.
- We specifically recommend, haricot bean with varieties name *Awash mittin* to be used in the preparation different food product such as complementary food, weaning food as it has high amount of protein, ash, minerals and less amount of anti-nutritional factors.
- Further research should be done by including more nutritional parameters such as more minerals, vitamins and also to see the impact of soil nature on haricot bean mineral and other nutritional content.
- Further research and then technologies should be introduced on mean to minimize anti-nutritional content especially when it comes to haricot bean with *Seri 119* and *Seri 125* varieties.

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CONFLICT OF INTEREST

- This is to confirm that, there is no conflict of interest between authors for this study

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3. PROXIMATE COMPOSITION, PHYSICOCHEMICAL, FUNCTIONAL, AND ANTI-NUTRITIONAL PROPERTIES OF SOYA BEAN

MAHAMMED DOL[1], ABDULKARIM MOHAMMED[2], HODO MOHAMED[2]
[1]Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition program
[2]Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition program

Abstract
Soybean is the major source of high-quality protein and oil legumes and which is important for human consumption which can be prevent malnutrition for the vulnerable groups general. The objective of this study was to investigate the proximate composition, physicochemical, functional and antinutritional properties of some new varieties of soya bean adapted by SoRPARI research center Kelafo and Dolo-ado).Five different varieties with two different location such as D-Gezale, D-Gizo, D-Pawa 1, D-Pawa 2, D-Pawa 3 from Dolo-ado center and K-Gezale, K-Gizo, K-Pawa 1, K-Pawa 2, K-Pawa 3 from Kelafo center, L-Gode from Gode and L-Jigjiga from Jigjiga were collected. The grains of 12 varieties of soya bean have been analyzed for moisture, 100 seed weight, bulk density, water absorption capacity, oil absorption capacity, ash, fat, protein and crude fiber and minerals. These soya bean varieties contained 4.78-7.34% moisture, 7.0-15.755%,100 seed weight, 0.68-0.78% bulk density, 1.51-2.67% water absorption capacity, 0.86-1.49% oil absorption capacity, 3.82-6.30% ash, 5.37-21.61% fat, 19.65-30.35% protein and 3.75-6.29% crude fiber and minerals. The total calcium, iron, magnesium and zinc content ranged between 48.9-157.2, 5.37-12.06, 658.50-2429.10, and 3.79-6.45 mg/100g, respectively. Results indicated that K-Pawa 1, K-Pawa 3, D-Pawa 3, and D-Gezale contains high protein, crude fat contents, and carbohydrates. The fiber content was low but still can be useful for helping our body for preventing or release constipation, and correcting some of the problems that many people are facing like diabetes and obesity. Also, the ash content was high in some of the soya bean varieties, and this indicated that they are important sources of minerals like magnesium, calcium, zinc, and iron.

Key words: *Soya bean, Proximate composition, Functional Properties, Physical properties.*

INTRODUCTION

The soya bean, botanically called Glycine max (L.) originated from Eastern Asia, probably in north and central China. Mature soya bean seed contains approximately 40% protein, 20% oil, and 10% water-soluble carbohydrates (Byth, 1968). Glycine max is an important legume increasingly consumed for both its nutritional and economic values (Bayero et al., 2019). High-quality protein and oil are of paramount importance to human beings. One primary source of high-quality protein and oil is the soya bean (Medic et al., 2014). The quality of soya beans is usually determined by seed protein, oil, fatty acid, and mineral contents, as such its quality is key to improving human and animal nutrition. This importance is probably related to the fact that soya bean products are

excellent sources of proteins, minerals, phosphorus, and vitamins all at a very low cost (Wang et al., 2003). On another hand, soya bean products are largely known to play an important role in health and healthy living. Soya bean intake is reported to prevent heart disease, obesity, hypercholesterolemia, cancer, diabetes, kidney disease, and osteoporosis, and it is also suitable for people with allergic reactions caused by animal milk (Friedman & Brandon, 2001). Glycine max has the highest protein content (40%) among cereals and other legumes. Other legumes have a protein content of between 20 to 30%, while cereals have a protein content in the range of 8-15% (Yohannes et al., 2020).

Soya beans' protein content (40%) is higher and more economical than that of beef (19%), chicken (20%), fish (18%), and groundnut (23%) (IITA 1990). Soya bean is also of particular interest as a vegetable protein source because of its cholesterol-lowering abilities in patients with type II hyperlipoproteinemia (Sridhar & Bhat, 2007). The soya bean also contains about 20% oil, the second highest content among all food legumes, with the highest oil content found in peanuts, which is about 48% on a dry matter basis, while the third-highest oil content is chickpea which is about 5% (Liu, 1997). Soya bean is also rich in minerals and vitamins such as iron, zinc, copper, thiamine, riboflavin, niacin, and pantothenic acid, as well as phospholipids (Bourre, 2006). Most of these vitamins and minerals are well-known hematinic and are essential in the formation of red blood cells (Joel & U, 2011). Soya bean is reported to contain flavonoids, especially isoflavones, and this is the reason why they are regarded as having a powerful ability to fight and prevent cancers in humans, as well as other diseases (Messina et al., 1994).

Different research centers under the Somali region pastoral and Agro-pastoral research institute have been working on the Soya bean varieties and possible this was released and proximate analysis must check its quality. Therefore, the aim of the present study will profile the nutritional value, antinutritional value, mineral contents, and functional and physical properties of soya bean varieties adapted and released by SoRPARI. Knowing the soya bean's nutritional diversity would have a direct impact on the improvement of soya beans for quality breeding and food product development to reduce the prevalence of food insecurity, malnutrition, and mineral deficiency, especially for those low-income communities. Therefore the objective of the study was aimed to Analysis of the proximate composition, physicochemical, functional, and anti-nutritional properties of soya bean.

MATERIAL AND METHODS

Mature soya bean seeds were obtained from Kelafo, Dolo-Ado Research center, and two local varieties were bought from the local market of Gode city and Jigjiga city in Somali Regional State, Ethiopia. Then seeds were cleaned from any foreign material and removed any damaged or insect infestation seeds and then washed with tape water after that it was sundried for 8 hours to remove any moisture absorption during washing and then milled into flour powder and then packed in airtight polyethylene plastic bags and stored in 4° for further analysis. The proximate compositions of the soya bean varieties were determined using standard analytical methods. All measurements were done in triplicates and values were presented in percentages. All the analyses were performed in duplicates (unless stated otherwise) and presented as mean ± standard deviation. The statistical significance of the data obtained by analyzing Gestat ver.15. The level of significance of study ($p<0.05$).

RESULTS

Proximate composition of soya bean varieties

The samples of the soya bean varieties were analyzed for different proximate compositions including ash content, moisture content, crude fat content, crude fiber content, crude protein content, carbohydrate content, and energy content using different standard techniques, and the results are presented in Table 1. K-Pawa 1 was the highest moisture content of all other varieties but it was not significantly different from K-Pawa 2 whereas the lowest moisture content was in L-Jigjiga but also it was significantly different from L-Gode. Variety D-Pawa 1 indicated the highest ash content compared to the varieties however, except K-Gezale and Local varieties there is no significant difference between the other varieties. Table 1 shows that the D-Gezale has the highest crude fat content compared to other varieties however, variety K-Pawa 3 indicated no significantly different from G-Gezale but local varieties indicated the lowest crude fat content. the result indicated that the local varieties have a higher amount of fiber compared to the varieties. As seen in the result, D-Pawa 3 contained a significantly higher amount of protein, and the lowest protein content had seen in local varieties. The carbohydrate content was higher in the local varieties and there was a significant difference among the local varieties whereas the K-Pawa 1 indicated the lowest carbohydrate content. About the energy content, D-Gezale shows the highest

significant amount compared to verities and there was no significant difference between variety D-Pawa 1, D-Pawa 2, K-Gizo, K-Pawa 1, K-Pawa 2, and K-Pawa 3.

Table 1. Proximate Composition of Different Soybean Varieties

Varieties	Parameters						
	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Protein (%)	Crude Fiber (%)	Carbohydrate (%)	Energy (%)
D-Gezale	5.09±0.04^{c}	5.62±0.07^{ab}	21.61±0.03^{a}	28.92±0.03^{c}	3.75± 0.13^{d}	35.01±0.18^{ef}	450.21±0.32^{a}
D-Gizo	5.51±0.02^{abc}	5.76±0.03^{ab}	13.04±0.02^{h}	28.68±0.03^{d}	5.04± 0.03^{b}	41.97±0.04^{c}	399.96±0.23^{e}
D-Pawa 1	5.53±0.03^{abc}	6.30±0.48^{a}	21.47±0.01^{b}	28.73±0.02^{d}	4.45± 0.09^{bc}	45.35±0.05^{efg}	489.5±0.39^{b}
D-Pawa 2	5.17±0.01^{bc}	5.75±0.19^{ab}	20.83±0.01^{e}	27.96±0.02^{f}	4.14± 0.05^{cd}	47.07±0.00^{d}	487.6±0.26^{b}
D-Pawa 3	5.81±0.11^{abc}	5.77±0.08^{ab}	20.02±0.00^{f}	30.35±0.02^{a}	4.57± 0.05^{bc}	45.06±0.52^{fg}	481.8±2.00^{c}
K-Gezale	6.25±0.02^{abc}	5.22±0.07^{b}	16.56±0.01^{g}	26.35±03^{g}	4.32± 0.24^{bcd}	52.77±0.22^{c}	465.6±0.88^{d}
K-Gizo	6.52±1.68^{abc}	5.34±0.09^{ab}	21.27±0.00^{c}	26.35±0.03^{g}	4.92± 0.30^{b}	35.60±0.32^{d}	439.23±1.26^{b}
K-Pawa 1	7.34±0.61^{a}	5.64±0.55^{ab}	21.13±0.05^{d}	29.52±0.02^{b}	4.62± 0.02^{bc}	44.73±0.06^{g}	487.2±0.17^{b}
K-Pawa 2	7.17±0.42^{a}	5.84±0.50^{ab}	21.12±0.00^{d}	28.49±0.01^{e}	4.36± 0.20^{bcd}	46.03±0.01^{e}	488.2±0.09^{b}
K-Pawa 3	7.12±0.02^{ab}	5.61±0.27^{ab}	21.60±0.00^{a}	27.94±0.02^{f}	4.63±0.03^{bc}	31.1±0.00^{e}	430.56±0.08^{b}
L-Gode	4.79±0.70^{c}	4.27±0.38^{c}	5.37±0.02^{j}	19.86±0.02^{h}	5.94±0.30^{a}	59.77±0.29^{a}	366.85±1.32^{f}
L-Jigjiga	4.78±0.08^{c}	3.82±0.12^{c}	6.34±0.02^{i}	19.65±0.04^{i}	6.29±0.08^{a}	59.12±0.02^{b}	372.14±0.43^{g}
G. Mean	**6.59**	**5.43**	**17.53**	**26.9**	**4.75**	**50.82**	**468.64**
CV (%)	**11.6**	**7.8**	**0.2**	**0.1**	**6.2**	**0.6**	**0.3**
LSD (%)	**1.66**	**0.658**	**0.071**	**0.076**	**0.644**	**0.664**	**2.63**

All values are the means expressed on a dry matter basis ± standard error.
Means with the same superscripts do not differ significantly (P<0.05) G=grand D=Dolo-Ado, K=Kelafo, L-local CV=Coefficient of Variation, LSD=Least Significance Difference.

Mineral contents and Anti-nutritional factors of different soybean varieties

The result of the analysis of some mineral elements, including calcium, Iron, magnesium, and zinc are presented in Table 2. The result showed that the mineral concentration of mg/100 g of the soya bean flour. Variety K-Pawa 3 had the highest calcium content followed by D-Pawa 3 and D-Gizo but there was no significant difference between D-Pawa 3 and D-Gizo. Also, variety K-Pawa 3 indicated the highest Iron content compared to others and most poor mineral content was in local varieties. The magnesium content was found the highest concentration in variety K-Pawa 2 and the next highest magnesium content was found in variety K-Pawa 3 and this indicated that K-Pawa 3 was significantly higher in all mineral content compared to other varieties. The lowest value of zinc content was on L-Jigjiga.

As seen in table 3 the result indicated that the anti-nutritional contents of soya bean varieties were presented in table 2. It was observed that the anti-nutritional content of tannin was significantly higher from the local varieties whereas adopted varieties were having less concentration on the

other hand adopted varieties of SoRPARI Center the results indicated that D-Pawa 2 had a higher amount of anti-nutritional compounds D-Gizo was the lowest concentration of the polyphenols but there was no significantly different from the K-Pawa 2, also local varies have significant differences among the phytate contents.

Table 2.total mineral contents and anti-nutritional factors of different soybean varieties

Varieties	Parameters (mg/100g)					
	Calcium %	Iron %	Magnesium %	Zinc %	Tannins (%)	Phytates (%)
D-Gezale	130.8± 0.19^{d}	9.570± 36.07^{bcd}	930.9±36.07^{e}	6.040±0.01^{abc}	0.148 ± 0.01^{d}	3.348 ± 0.13^{bc}
D-Gizo	143.0± 2.10^{b}	9.765± 111.75^{bcd}	1144.1±111.75^{cd}	6.030±0.09^{abc}	0.228 ± 0.04^{cd}	2.317 ± 0.0.23^{d}
D-Pawa 1	137.9± 1.47^{c}	8.105± 67.80^{de}	1073.5±67.80^{cde}	6.000±^{abc}	0.180 ± 0.04^{d}	3.236 ± 0.00b^{cd}
D-Pawa 2	135.4± 1.57^{c}	9.990± 2.87^{bc}	1231.8±2.86^{bc}	6.075±0.19^{abc}	0.121 ± 0.03^{d}	4.861 ± 0.22^{a}
D-Pawa 3	143.7± 1.32^{b}	10.815± 16.23^{ab}	1140.0±`6.23^{cd}	5.680±0.19^{cd}	0.169 ± 0.01^{d}	4.045 ± 0.13^{ab}
K-Gezale	137.9± 1.34^{c}	9.165± 11.90^{bcde}	978.1±11.90^{de}	6.450±0.00^{a}	0.260 ± 0.13^{cd}	2.659 ± 0.35^{cd}
K-Gizo	138.1± 1.21^{c}	9.355± 0.13^{bcde}	1117.3±0.13^{cde}	6.275±0.30^{ab}	0.285± 0.04^{cd}	3.463 ± 0.01^{bc}
K-Pawa 1	130.2± 0.81^{d}	8.715± 61.65^{cde}	1095.1±61.64^{cde}	6.385±0.03^{ab}	0.398 ± 0.09^{c}	3.353 ± 0.10^{bc}
K-Pawa 2	127.1± 1.74^{d}	8.110± 1.07^{de}	2429.1±1.07^{a}	6.120±0.07^{abc}	0.164 ± 0.03^{d}	2.777 ± 0.24^{cd}
K-Pawa 3	157.2± 0.74^{a}	12.060± 9.51^{a}	1378.2±9.51^{b}	5.960±0.08^{bc}	0.239 ± 0.04^{cd}	4.279 ± 0.82^{ab}
L-Gode	55.4± 1.10^{e}	7.705± 1.20^{e}	658.5±1.12^{f}	5.275±0.03^{d}	4.179 ± 0.11^{b}	3.468 ± 0.23^{bc}
L-Jigjiga	48.9± 1.38^{f}	5.375± 123.48^{f}	945.3±123.48^{e}	3.790±0.16^{e}	6.660 ± 0.02^{a}	3.931 ± 0.23^{ab}
G. Mean	**123.79**	**9.06**	**1177.0**	**5.840**	**1.086**	**3.478**
CV (%)	**1.5**	**7.6**	**6.8**	**3.3**	**8.1**	**12.3**
LSD (%)	**4.11**	**1.49**	**173.3**	**0.41**	**0.19**	**0.93**

All values are the means expressed on a dry matter basis ± standard error.
Means with the same superscripts do not differ significantly (P<0.05) G=grand D=Dolo-Ado, K=Kelafo, L-local CV=Coefficient of Variation, LSD=Least Significance Difference.

Functional and Physical Properties of Soya bean

Table 3 shows the various functional properties of soya bean varieties. The water absorption capacity (WAC) and oil absorption capacity (OAC) of soya bean flour with six varieties ranged between 2.532-1.507 and 1.495-o.870 respectively. About the WAC K-Gizo showed the highest water absorption capacity and K-Pawa 2 indicated the lowest water absorption capacity. Similarly, K-Gizo and K-Pawa 2 indicated the highest oil absorption capacity, however, there was no significant difference between all the varieties. As seen in table 3, the result indicated that one hundred seed weight and bulk density of soya bean varieties ranged from 16.50-7.00 and 0.766-0.683 percent and 0.766-0.682 ml respectively. D-Pawa 2 had a significantly higher seed weight compared to other seed varieties and L-Gode indicated the lowest seed weight. From the bulk

density, L-Gode indicated the highest volume of the soya bean varieties whereas the D-Pawa 1 shows the lowest volume compared to other varieties.

Table 3. Functional and physical Properties of Soya bean

Varieties	Parameters			
	WAC (%)	AOC (%)	Seed Weight %	Bulk density %
D-Gezale	1.670 ± 0.10^{cd}	1.038 ± 0.18^{a}	15.75 ± 0.24^{a}	0.7635 ± 0.00^{a}
D-Gizo	2.350 ± 0.19^{abc}	1.183 ± 0.00^{a}	10.75 ± 0.25^{bc}	0.7115 ± 0.00^{cd}
D-Pawa 1	2.077 ± 0.16^{abcd}	1.438 ± 0.06^{a}	14.50 ± 0.22^{a}	0.6825 ± 0.03^{f}
D-Pawa 2	1.700 ± 0.04^{cd}	1.093 ± 0.17^{a}	16.50 ± 0.23^{a}	0.7195 ± 0.01^{bcd}
D-Pawa 3	1.638 ± 0.06^{cd}	1.008 ± 0.02^{a}	11.50 ± 0.25^{b}	0.7170 ± 0.20^{bcd}
K-Gezale	2.077 ± 0.00^{abcd}	1.060 ± 0.08^{a}	10.50 ± 0.05^{bc}	0.7255 ± 0.01^{bc}
K-Gizo	2.532 ± 0.05^{ab}	1.495 ± 0.03^{a}	11.50 ± 0.21^{b}	0.7020 ± 0.10^{de}
K-Pawa 1	1.998 ± 0.06^{abcd}	1.245 ± 0.31^{a}	11.00 ± 0.20^{b}	0.7345 ± 0.00^{b}
K-Pawa 2	1.507 ± 0.42^{d}	0.863 ± 0.26^{a}	11.75 ± 0.02^{b}	0.7145 ± 0.01^{cd}
K-Pawa 3	2.675 ± 0.23^{a}	1.085 ± 0.26^{a}	8.28 ± 0.01^{cd}	0.7170 ± 0.01^{bcd}
L-Gode	1.585 ± 0.13^{d}	0.870 ± 0.08^{a}	$7.00 \pm 0.03d$	0.763 ± 0.01^{a}
L-Jigjiga	1.890 ± 0.50^{bcd}	1.390 ± 0.31^{a}	$7.50 \pm 0.03d$	0.7660 ± 0.00^{a}
G. Mean	1.975	1.147	11.38	0.719
CV (%)	15.7	22.5	5.1	0.6
LSD (%)	0.68	0.26	1.25	0.01

All values are the means expressed on a dry matter basis ± standard error. Means with the same superscripts do not differ significantly (P<0.05) G=grand D=Dolo-Ado, K=Kelafo, L-local CV=Coefficient of Variation, LSD=Least Significance Difference.

DISCUSSION

Proximate Composition of Soya Bean

The result of the study indicated that soya bean has low moisture content ranging from 4.78-7.34%. This result implies that it can be stored for a very long time since moisture is an important medium for the multiplication of microorganisms. Also this study is in line with a study that was conducted in Nigeria the results shows that soya bean has a lower amount of moisture content can be stored for a long time and micro-organisms can't grow easily (6.12%) (NWOSU et al., 2019). On the other hand, the ash content of the soya bean is significantly higher and ranged between 3.82-6.30% which implies that higher ash content the higher important in mineral sources also, the study is an inline study that was conducted in Nigeria the result indicated that the ash content of 4.29% is indicative that the flour sample could be important sources of minerals (Etiosa et al., 2017).

The soya bean protein content is ranged from 19.65-30.35% which indicates a higher concentration of protein compounds and these results can be used for solving many malnutrition problems, especially protein-energy malnutrition cases such as marasmus and kwashiorkor. Compared to other literature the crude fat content ranged from 5.37-21.61% which is lower content but still some of the varieties like D-Gezale and K-Pawa 1 indicated promising results of 21.61% and 21.60% respectively also the results of this study were in agreement with (Etiosa et al., 2017). the fiber content of this study was found between 3.75% and 6.29% of D-Gezale and L-Jigjiga respectively. Fiber has many benefits for humans and can prevent constipation as well as can cut the risk of colon cancer also this finding agreed with the reported results by (Bayero et al., 2019) and the authors revealed 6.84% of fiber content.

Results of the study indicated significantly higher carbohydrate content of range between 44.75-68.82 percent. These can be promising results that can be used for managing protein energy malnutrition because of higher carbohydrate content the body can manage protein, fat, and mineral substance to use for bodybuilding, repairing damaged tissues rather than using them as a source of energy. This study is in line with the reported results by (Eshun, 2012) and he showed that high carbohydrate content ranges between 34.97-39.86 percent. The energy content (kcal/100g) ranged from 403.1-450.21 percent and this study is in line with research that was conducted in Ghana and the result revealed that energy content ranged (from 458.58-473.62% (Eshun, 2012).

Mineral Concentrations of Soya Bean

The finding of the study indicated that the calcium contents ranged from 48.9-157.21% and these results can be developed for many products like complementary foods for infants because calcium helps to build the bones and teeth of infants since calcium is one of the main components of teeth and bones. This study is in line with the research result of (Eshun, 2012) which indicated that calcium is responsible for teeth and bone formation.

The Iron content of soya beans in this study was significantly higher and Iron contents ranged between 5.37-12.06 % K-Pawa 3 indicating a superior result this can be used for better management of Iron deficiency in vulnerable groups like lactating mothers, young children, and adolescent girls also this agreed with (Mehas, 2001) which indicates that iron plays a vital role for red blood cells that carry on and release oxygen.

Magnesium indicated significantly higher content and magnesium helps our body for enabling protein formation and plays a role in holding calcium content to the teeth as well as helping to release energy. The results of the study indicated that zinc content ranges from 3.79-6.45 percent according to the different literature zinc has many health benefits and this research is in line with research that indicated magnesium helps protein-making and energy releasing and zinc helps the immune system fight off invading bacteria and viruses (Eshun, 2012).

CONCLUSION

The results of this study indicated that soya bean varieties that were grown in Kelafo and Dolo-Ado center are promising results. From the key finding of study K-Pawa 1, K-Pawa 3, D-Pawa 3, and D-Gezale contains high protein, crude fat contents, and carbohydrates. It's also an inexpressive source of macronutrients which is good sources for developing many food products and intervention programs that can alleviate the protein energy malnutrition. The fiber content was low but still can be useful for helping our body for preventing or release constipation, and correcting some of the problems that many people are facing like diabetes and obesity. Also, the ash content was high in some of the soya bean varieties, and this indicated that they are important sources of minerals like magnesium, calcium, zinc, and iron.

RECOMMENDATIONS

According to the results of the study, the authors is suggesting some recommendations about the benefits of the soya bean

- K-Pawa 1, K-Pawa 3, D-Pawa 3, and D-Gezale are highly promotable for developing many food products like weaning foods for infants and solving PEM
- It's very important for preparing one extra meal for lactating mothers
- Product development with enriching cereals with low protein, fat, and minerals contents

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CONFLICT OF INTEREST

- This is to confirm that, there is no conflict of interest between authors for this study

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4. PHYSICOCHEMICALPROPERTIES, PROXIMATE, ANTI-NUTRITIONAL AND FUNCTIONAL PROPERTIES OF DIFFERENT WHEAT VARIETIES PRODUCED/ADAPTED UNDER SoRPARI AND MARKETED/LOCALS IN SOMALI REGIONAL STATE

Hoodo Mohamed Jama[1], Abdulkarim Mohammed Ali[2], Mohammed Dol Ateye[2].

1. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***hoodoqali042@gmail.com***
2. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. ***adnanbdu302@gmail.com*** ***Ateye069@gmail.com***

Abstract

Wheat is one of staple crop that widely consumed in Somali community. The study was conducted in Somali Regional state with objective to analyze the proximate, functional and physical characteristics of different wheat varieties adapted in Somali regional state. Nine different types of samples such as *fantail, jay, nasired, Qunfo, shid, xiryane, Local* and control as control sample were collected from Kelafo research sub-center and other areas like Tuuli, and Lafcise. The collected wheat samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Zinc, Magnesium, and Potassium were determined by AOAC. The anti-nutritional content such as phytate & tannins and functional & physical properties were also determined by different standard procedure. Based on the result obtained the moisture, ash, crude fiber, protein and fat are in the range of 11.21 (bardheer) -7.71% (fantail), 2.64% (fantail) - 0.67% (jay), 2.51%(xiryane) 1.46% (jay), 13.23% (Qunfo) 6.36% (fantail) and 1.10% (local) 1.75% (control) respectively and most of them are statistically different at $P<0.05$. The minerals content is also in the range of 55.77 (fantail) – 35 mg/100g (bardheer), 7.47% (fantail) 3.24 mg/100g (local), 406.8 (fantail) – 204.3mg/100g (Qunfo) and 6.950 (fantail)-2.53mg/100g (local) for calcium, potassium, zinc and iron respectively and more or less they were statistically different at $P<0.05$. Regarding the anti-nutritional content, the tannins and phytate content is in the range of 6.381% fantail and xiryane) 3.481% (control) 0.077% and (xiryane) 0.035% (control) - (xiryane) for tannins and phytate respectively and statistically different for tannins content at $P<0.05$. The functional and physical properties of different wheat varieties under study were more or less statistically different at $p<0.05$. Overall, from the finding we conclude that, adapted wheat varieties have better in nutritional content especially, ash and fiber and protein content especially varieties with Qunfo. Varietal difference, agro-ecology, nature of soil, farming management and some other reason might be the factor for their different in their nutritional content. Wheat is reached in protein, minerals and other important nutrient and therefore, we recommend that, it can be used either alone or mix with those staple legumes as part of fighting against malnutrition and in the preparation of different recipe.

Key words: *Wheat, Varieties, Proximate analysis, Anti-nutritional factors, functional properties.*

1. INTRODUCTION

Wheat (Triticumaestivum) is one of the world's most important cereal crops produced and consumed around the world (1) Wheat is the grass widely cultivated for its seed a cereal grain which is worldwide staple food the many species of wheat together make up the genus wheat is grown on more land area than any other food crops largest producer of wheat contributing 3.17 percent of the total world wheat production (2)

It contributes 13.8 percent to the value addition in agriculture grain hardness being the most important. Wheat quality is dependent upon soil composition and environmental factors including temperature, rainfall, Humidity etc. (3). Variation in quality parameters like physic-chemical, rheological and functional characteristics of wheat varieties suitable for chapatti making is due to the differences in soil, environmental conditions and agronomic practices (4). Fluence quality of wheat (5) and 30 percent to the total GDP of Pakistan.

Africa produces more than 25 million tons of wheat on10mha while sub-Sahara Africa (SSA) produce at total of 7.5MT on a total area of 2.9mha accounting for 40 and 1.4 percent of the wheat production in Africa and global level respectively (7). The wheat which on the account for 95 percent of the wheat production at the global level is also dominant types produce in SSA from 1970 to 2014. The most important wheat producing countries in SSA are; Ethiopia, South Africa, South Sudan, Kenya, Tanzania, Nigeria, Zimbabwe, and Zambia.Ethiopia account for the largest production area (1.7mh) followed by South Africa. Wheat consumption in Africa has been rising faster than in any other region around the world. The population of the Sab-Sahara Africa was 50 percent greater than it had been 14 years prior and the last year Sub-Sahara Africans were consumed one-third more wheat (8).

Wheat (Triticum aestivum L.) is a major crop grown in many countries. It is predominantly used for the production of products, such as bread, pasta, cereals and cakes, which are consumed on a regular basis Thus; wheat has the potential to contribute to the reduction of malnutrition and deficiency-related ailments by contributing to food security and the daily required intake of essential macro- and micro-nutrients in individual. Nutritional quality is a collective term that refers to the bioavailability or concentration of desirable nutritional components for human health such as iron (Fe), zinc (Zn), vitamins and selected phenolic acids found in the wheat grain.

These key nutritional components are found in different wheat grain compartments at varying concentrations [9]. The wheat germ and bran region contain the highest levels of these nutritional components [10]

Micronutrient deficiencies, especially those arising from Fe, Zn and vitamins pose a serious threat to human health as they affect more than 2 billion people worldwide especially women and children under the age of 5 years [11]. Cardiovascular diseases, diabetes, cancer and malnutrition are among the most dreadful diseases. These diseases could be prevented through regular consumption of selected nutritionally important components, such as wholegrain products and antioxidants, which are acquired as phenolic acids from various foods including the wheat grain [12].

Human health through ensuring that the required dietary intake of essential nutrients can reach poor individuals in a more sustainable and cost-effective manner. Bio fortification is a process of enhancing the dietary bioavailability or concentration of desirable nutritional components in plants genetically [13]. This process has been used to successfully improve the bioavailability or levels of β-carotene in rice, Zn and Fe in wheat grain as well as levels of other nutrients in other crops [11].

As a result, a number of strategies have been deployed to improve nutritional quality in wheat, such as conventional, technological and transgenic approaches that were undertaken in efforts to improve the levels and bioavailability of micronutrients and phenolic acids, mainly through the bio fortification route [9]. This includes several efforts that managed to successfully increase the total grain nutrient content and bioavailability of some micronutrients through genetic bio fortification, agronomic bio fortification, the use of bioavailable.

Wheat is a strategic food security commodity in Ethiopia, and its production has effected significant change in the livelihoods of farmers and has well for a large number of people across different areas of the country. In the Somali region, the production of wheat plays an important role in abating the problem of food insecurity in the farming community. Enriching Livelihoods and increasing the quality and nutritional analysis of wheat production in the Somali region is mandatory. Therefore, this is research is aimed at helping by evidence or data on all efforts made on mass production of this strategic crop through analysis nutritional content of different wheat

varieties. researchers as baseline information to conduct their research. Based on the recommendation come out from this study, policymakers, government, non-Government organizations and other interested institutions working on the area was expected to get up-to-date information from.

METHOD AND MATERIAL

Materials and Equipment Used

Nine sample adapted under s Somali Region were collected. Two wheat varieties produced or adapted under Somali Region it was collected from **Qalaf**o center and **Tulli** a & **Lafcise** and another three wheat samples were purchased from each respective centers/area market as a control for comparison purpose. Only wheat without any physical damage or insect infestation was selected for analysis. All equipment used in sample preparation was expected to be obtained from laboratories and missed equipment was used from local institutes further, after bringing to the laboratory, wheat samples was individually ground to a find powder (30 mesh size), packed in air tight polyethylene plastic bags and was stored at 4°C until further analysis

Proximate Composition

Moisture content

The moisture content of the samples was determined by drying 10g of sample in an air oven at 105oC to constant weight (16 -18 h)

Protein content of the flour

Protein content was determined according to AOAC (2000) using the official method 979.09, which comprised three major steps: digestions, distillation and titration, and quantification.

Digestion

Fresh samples (in duplicate) of each 0.5g was added into Tecator tubes and 6ml of acid mixture (5parts of concentrated ortho-phosphoric acid and 95 parts of concentrated sulfuric acid) was added into each tubes and mixed, and 3.5ml of 30% hydrogen peroxide was added step by step, resulting in violent reaction. Following the cessation of violet reaction, the tubes should be shaken and placed back to the rack. Catalyst mixture (ground 0.5g of selenium metal with 100g of potassium sulfate) of 3g was added into each tube and was allowed to stand for about 10

minutes before digestion. Following the attainment of digester temperature at 370^{o}C, the tubes was low ill bed into the digester. The digestion was continued until a clear solution was obtained (~ after 4 hours). The tubes in the rack should be cooled in a fumehood. 25 ml of de-ionized water was added and the mixture should be shaken to avoid precipitation of sulfate in the solution.

Distillation and titration

The digested and diluted sample solution was distilled using boric acid and the distillate was subjected to titration using 0.1N hydrochloric acid until reddish color appeared.

Quantification of crude protein concentration

$$\text{Nitrogen } \% = \frac{\text{VHCl} * [\text{HCl}]}{\text{Wo}} * 14 * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\text{Protein } \% = 6.25 * \% \text{ Nitrogen} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where; V is the volume of HCl consumed in liter, N is the normality of HCl (0.1N), W_O is the sample weight on dry mass basis and 14 is the molecular weight of nitrogen.

Experimental analysis of fat

The fat content of the complementary food samples (flours) was determined using a semi-continuous solvent extraction method (Sox let method) following the procedures of AOAC 960.39 (2000). In this method, the solvent builds up in the extraction chamber for 5-10 minutes and completely surrounds the sample and then siphons back to the boiling flask.

The crude fat content (percent weight by weight) was calculated as follows:

$$F = \left(\frac{W2 - W1}{W}\right) * 100\% \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where;

F= Crude fat content in percent weight by weight

W_1 = Weight of the extraction flask in gram (g)

W_2 = Weight of the extraction flask and the dried crude fat in gram (g)

W = Weight of sample in gram (g)

Experimental analysis of ash content

The ash content was determined based on AOAC (2000) using the official method 923.03. Briefly, porcelain crucible that is was behed using distilled water was ed in a muffle furnace at 550^{o}C for 30 minutes. Then, the crucibles will be cooled by placing it in desiccators for 30 minutes at room temperature. Following this step, they was weighed to the nearest milligram (M_1) using the dried, cooled and weighed crucible, 2.5g of fresh sample together (M_2). Then the sample was thoroughly char in fume-hood by placing it on a hot plate, and increasing the temperature slowly until smoking ceases. After the completion of charring, the sample was placed into the muffle furnace at 550^{o}C for 5 hours. The ignition was continuing by cooling for 1hour and weighing until a clean and white ash was obtained, which was then measured to the nearest milligram (M_3).

$$\text{Total ash(in \% weight by weight)} = \left(\frac{M3 - M1}{\text{M2} - \text{M1}}\right) * 100 \ldots\ldots\ldots\ldots\ldots (5)$$

(M_2-M_1) is the weight of sample in gram (g) on dry basis
(M_3-) $M_1$is the weight of ash in gram (g)

Experimental analysis of carbohydrates

The total available carbohydrate concentration was determined by difference according to AOAC official method, (922.02, 925. 05).

% Carbohydrate = 100% - (%moisture + %protein + %fat + %ash + % crude fiber)….

Experimental analysis of the crude fiber content

The crude fiber content of the complementary foods (flour) was determined by using the official method of AOAC (2000). The method involved the digestion of a fresh sample, filtration, will being, drying and combustion. Following these steps, the crude fiber was calculated using the following formula:

$$\text{Crude fiber in } \left(\frac{g}{100g}\right) = \frac{[(W2 - W3) * 100]}{W1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where;

W_1 = weight of the fresh sample

W_2 = weight of crucible with the sample after

W3 = weight of the crucible with the sample after ashing

Gross energy (total calorie)

Gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories.

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Mineral analysis

The mineral contents were determined by the procedure of AOAC (1984). Calcium, iron, and zinc will be determined according to AOAC 2000 official methods of 985.35 using an Atomic Absorption Spectrophotometer while phosphorous was determined by official method of 986.24 using calorimetric method using ammonium molybdate. After removal of organic material by dry ashing, the residue was dissolved in dilute acid. The solution was sprayed into the flame of Atomic Absorption Spectrophotometer (Varian SpectraAA-20Plus, Varian Australia Pty., Ltd., and Australia) and the absorption of the metal to be analyzed was measured at a specific wavelength.

The stock standard solutions of minerals (iron, zinc and calcium) was diluted with 0.3 N HCl to concentrations that fall within the working range (0, 0.6, 1.0, 1.4, 1.8, μg/ml for zinc analysis; 1.0, 1.5, 2.5, and 3.0 μg/ml for calcium analysis and 0, 2.0, 6.0, 10.0 12.0 μg/ml for iron analysis). The Atomic Absorption Spectrophotometer (AAS) used for mineral determination will be calibrated using standard solutions and the reagent blank solution will be run with the sample.

Ashes was obtained from dry ashing. The ash was wetted completely with 5ml of 6N HCl, and dried on a low temperature hot plate. A 7ml of 3N HCl was added to the dried ash and heated on the hot plate until the solution just boils. The ash solution was cooled to room temperature at open air in a hood and filtered through a filter paper (What man 42, 125mm) into a 50ml graduated flask. A 5ml of 3N HCl was added into each crucible dishes and heated until the solution just boil, cooled, and filtered into the flask. The crucible dishes were again was bath three times with de-ionized water; was filtered into the flask. A 2.5mL of 10% Lanthanum

chloride solution was added into each graduated flask. Then the solution was cooled and diluted to the mark (50ml) with deionizer

Water. A blank was prepared by taking the same procedure as the sample.

Calculation:

Mineral content (mg/100g) = [(a-b) x V]/10W

Mineral content (mg/Kg) = [(a-b) x V]/W

Where, W = weight in grams of samples

V = Volume in ml of extract

A = concentration in micro gm/ml of sample solution

B = concentration in micro gm/ml of blank solution.

Anti-nutritional factors determination

Determination of tannin content

Quantitative estimation of tannin was carried out using the modified vanillin – HCl method according to Price. The vanillin HCl reagend was prepared by mixing equal volumes of 8% concentrated HCl in methanol and 1% vanillin in methanol. The two solvents of the reagent were mixed just prior to use; it was discarded if a trace of color appeared. Catechin will be used to prepare the standard curve; this will be done by adding 100mg of catching to 50 ml of 1% HCl in methanol. From this solution a series of dilutions was prepared. Five milliliters of vanillin/HCl reagent was added to 1 ml of each dilution. The absorption was read using spectrophotometer at 500nm after 20 min from addition of the reagent at 300C. The absorbance was plotted against catching concentration. A 0.2g of the sample was placed in a test tube, and then 10ml of 1% HCl/ methanol are added. The test tube will be capped and continuously shaken for 20 min. and then centrifuged at 5000 rpm for 5 min. one milliliter of the supernatant was pipetted into the tube and then proceeding as was described in the standard curve above. For zero setting before absorbance will be read, 1 ml of blank solution (1% HCl in methanol) was mixed with 5ml 4% concentrated HCl and 5ml of vanillin – HCl reagent in a test tube and incubated for 20min at 300C. Absorbance was read at 500nm and the concentration of condensed tannin was determined from the standard curve. Tannin concentration was expressed as % as follows:

$$CE\ (\%) = \frac{C \times 10 \times 100}{200}$$

Where:

CE = Concentration corresponding to the optical density

C = Concentration

10 = Volume of extract (ml)

200 Sample weight (mg)

Determination of Phytic acid:

Phytic acid content was determined by the method described by Wheeler and Ferrel Two grams of milled dried sample were weighed in 125ml conical flask with 50ml of 3% trichloroacetic acid (TCA) for 3 hrs with mechanical shaking. The suspension was centrifuged for 5 min. Ten milliliters aliquot of the supernatant was transferred to 50ml boiling tube; 4ml of FeCl3 solution (made to contain 2 mg ferric ion per ml in 3% TCA) was added to the aliquot. The tube was heated in a boiling water bath for 45min. One or two drops of 3% sodium sulphate in 3% TCA) were added. Then the tube was cooled and centrifuged for 10-15 min at 2500 r. p .m. The clear supernatant was carefully decanted. The precipitate will be washed twice by dispersing well in 25 ml 3% TCA, heated for 10 -15 min in a boiling water bath, then centrifuged again. Washing was repeated once more with water. The washed precipitate was dispersed in a few ml of water and 3 ml of 1.5N NaOH was added and the volume completed to 30 ml with water. The tube was heated in a boiling water bath for 30 min and hot filtered using Whatman No. 1; the precipitate was washed with 60ml hot water; the washings was decanted. The precipitate was dissolved from the filter paper with 40 ml 3.2N HNO3 (hot) into 100ml volumetric flask. The paper was washed with hot water. The washing was collected in the same flask then completed to the volume. Then 0.5 ml aliquot will be taken from the above solution and trans.

ferred into 10 ml volumetric flask, then 2 ml of 1.5N potassium thiocyanate (KSCN) was added and the volume was completed to 10 ml with distilled water. The density of colour was read immediately at 480 nm using spectrophotometer (Jenway 6305 uv/vis). A standard curve of different $Fe(NO_3)_2$ concentrations was plotted to calculate the ferric ion concentration assuming 4:6 iron: potassium molar ratio.

$$\text{Phytate (mg/100g)} = \frac{6/4[A \times C \times 20 \times 10 \times 50]\ \text{mg/100g sample}}{1000 \times 2}$$

Where:

A = optical density

C = concentration corresponding to optical density

10 = volume of extract taken from supernatant

1000 = to convert from g to mg

4:6 = iron to phosphorus molar

20 = dilution factor

50 = volume of T.C.A

Statistical analysis

All the analysis was performed in duplicates (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed and modeled using genets ® version 6.0.2, Minneapolis, USA. The level of significance was accepted at probability ($p<0.05$).

RESULT AND DISCUSSION

RESULT

Macronutrient contents of different Wheat varieties

The proximate composition/macro-nutrient contents of different wheat varieties are indicated in table 1 below. The moisture content of K-Fantale was found the lowest 7.71% while the T-Bardheer has the highest moisture content was found 11.21%. The moisture were statistically different among T-bardheer (11.211), T-Qunfo (7.968), T-jay (9.609) at $p<0.05$. The moisture content is also significantly different in between T-Jay (9.609) and k-fantail &t-xiryane respectively at $P<0.05$. On the other hand, there is no significant difference in moisture content among T-shid (8.370), T-local (8.315) control (8.841), L-Nasired (8.886) Qunfo (7.968)) at P <.0.05.

Ash content of nine varieties under study were in the of range of 0.673 to 2.643. The T- jay" has the lowest while the fantail has highest. The ash content is significant different among the Bardheer (0.948), T- Fantail(k) (2.643), T-jay (0.673) at $p<0.05$. The Ash is also significantly different in between T-Jay (0.673) and k-fantail & Nasired respectively at $P<0.05$. On the other hand, the Ash content is not significantly different among Bardheer (0.948) T-local (1.049), control (1.072), Qunfo (1.073) Xiryane (1 2.509)) at $P<0.05$.

The crude fat content T-Jay has the lowest (1.46 %) while Xiryane varieties has highest (2.51%). The crude fat for all wheat varieties were significantly different at $p<0.05$. When it comes to protein content, it ranges from 6.36% to 13.23%. Fantail has the lowest in protein while Qunfo has the highest protein and all sample were significantly different at $p<0.05$. T- local has the lowest (1.10%) the crude fiber content while the control has highest (1.75) and there are no significant different in between most of the varieties. With carbohydrate content K-fantail has the highest in carbohydrate (79.41) while Xiryane has the lowest 73.76. The carbohydrate for all varieties are not significantly different except two varieties which are T-local (76.50) Fantail (k) (79.41), at $p<0.05$. Finally, when it comes to energy obtained from 100g of wheat varieties it is in the range of 350.47(Xiryane) to 368.8 kcal (Qunfo). There is no significant different in energy in between most of the samples. But the energy is significantly different in between Bardheer (352.58) and Qunfo (368.8) & Jay (352.51) respectively at $P<0.05$.

Table 1: Macronutrient contents of different wheat varieties.

Varieties	Parameters						
	Moisture %	**Ash %**	**C .fat %**	**C. protein %**	**C. Fiber %**	**CHO %**	**Energy %**
Bardheer	11.21 ±0.0^{d}	0.95±0.10 ^{ab}	1.62±0.01^{bc}	10.55±0.20^{b}	1.72±0.005^{c}	73.95±0.10^{a}	352.58 ±0.5 ^{a}
Fantail(k)	7.71±0.35 ^{a}	2.64±0.30^{c}	2.26±0.02^{f}	6.36±0.14 ^{a}	1.62±0.01 ^{c}	79.41±0.48^{c}	362.34 ±2.7 ^{bc}
Jay (t)	9.61±0.1^{cd}	0.67±0.12 ^{a}	1.46±0.02 ^{a}	12.34±0.5^{e}	1.64±0.005^{c}	74.28±0.18^{a}	352.51±0.08 ^{b}
Nasired	8.89±0.52^{abc}	1.32±0.02 ^{b}	1.80±0.04^{d}	12.41±0.28^{e}	1.38±0.17^{b}	74.20 ± 0.5^{a}	362.64±1.47^{bc}
Qunfo	7.97± 0.55^{b}	1.07±0.03 ^{ab}	1.88±0.03^{e}	13.23±0.1 ^{f}	1.11±0.003^{a}	74.74 ± 0.7^{a}	368.8±2.3^{c}
Shiidit(t)	8.37±1.01^{abc}	1.25±0.100^{b}	2.32±0.03^{g}	11.67±0.257^{d}	1.64±0.018^{c}	74.75±0.83^{a}	365.75±4.3^{bc}
Xiryane	9.79±0.37 ^{cd}	1.27±0.05^{b}	2.51±0.02 ^{h}	11.00±0.07^{bc}	1.67±0.007^{c}	73.76±0.32^{a}	350.47±1.57^{bc}
Local(t)	8.31±0.02^{abc}	1.05±0.05^{ab}	1.67 ±0.04 ^{c}	11.37±0.16^{cd}	1.10±0.028^{a}	76.50 ± 0.8^{b}	360.93±0.25^{bc}
Control	8.84±0.547^{abc}	1.07±0.02 ^{ab}	1.61 ±0.03 ^{b}	11.42±0.175^{cd}	1.75±0.019^{c}	75.31±0.36^{ab}	361.41±2.29^{bc}
CV %	7.7	13.5	1.2	2.3	5.6	0.9	0.8
LSD %	1.567	0.3845	0.05017	0.5879	0.1915	1.588	0.7806

Mineral contents content of different Wheat varieties

The mineral content of the wheat varieties is indicated in table 2 below. Regarding the calcium content, bardheer has the lowest 35.71mg/100g while fantail varieties has highest 55.77mg/100g in calcium content. Except the bardheer and fantail varieties which is significantly different as compared to the other varieties under study, there is no significantly different in calcium content among the other seven varieties at $p<0.05$. When it comes to Iron content, it ranges 3.245mg/100g up for 7.474mg/100g. J-local has the lowest iron while fantail has the highest in iron content and the iron content is statistical different among fantail (7.474), nasired (4.489) and T- local (3.245) at $p<0.05$ On the other hand, the Iron is not significantly different among Bardheer (3.494) control (3.996), Jay (3.491), shid (3.989) Xiryane (3.991) at $P<0.05$. With respect to potassium**,** the "fantail" varieties has the highest (406mg/100g) while the "Qunfo" sample has the lowest which is 204mg/100g. There is significant difference in potassium content among Fantail, Qunfo, and control varieties at $P<0.05$. But there is no significant difference in potassium content in between "Nasired", "Bardheer" and "Jay" varieties at $P<0.05$.

When it comes to Zinc content, the Jay variety has the highest (6.95mg/100g) while the T-local variety has the lowest (2.53mg/100g). There is significant difference in Zinc content among" Jay", "Qunfo", and "local" at $P<0.05$. On the other hand no significant difference in Zinc content among "Bardheer," "Fantail", "Nasired,"" Xiryane" and control varieties at $P<0.05$. Lastly, regarding magnesium content, fantail has highest (193mg/100g) while the jay has lowest (62.18mg/100g). There is significant difference in magnesium content among "Fantail", "Bardheer," "Nasired," "Qunfo" and" control" at $P<0.05$. But other is no significant in magnesium among Xiryane, local, and Shiidit at $P<0.05$.

Table 2: The mineral content of different wheat varieties

Varieties	Parameters minerals in mg/100 gm				
	Calcium	Iron (Fe)	Potassium	Magnesium	Zinc
Bardheer	35.71±0.322[a]	3.494±0.006 [ab]	236.5±14.46[ab]	63.98±0.55 [a]	2.979± 0.03 [bc]
Fantail(k)	55.77±0.63[c]	7.474 ± 0.0074[d]	406.8±41.65[c]	193.16±2.83 [e]	2.933±2.05[abc]
Jay (t)	45.74 ±0.03 [b]	3.491 ± 0.003[ab]	221.5±0.22[ab]	62.18± 2.79[a]	6.958±0.033[d]
Nasired	45.74 ± 2.30[b]	4.489±0.044 [c]	241.3±0.103[ab]	104.36±8.57 [d]	2.775±0.04[abc]
Qunfo	45.74±1.29 [b]	4.492±0.0056 [c]	204.3±12.14 [a]	79.24±2.22 [b]	3.059±0.16 [c]
Shiidit(t)	45.74 0.79 [b]	3.989 ±1.414 [bc]	256.1±9.71 [ab]	87.62±2.020[bc]	3.096±0.203 [c]
Xiryane	45.74 ± 1.70[b]	3.991±0.0027[bc]	268.6±2.68 [b]	82.06±1.56[bc]	2.615±0.00 [ab]
Local(T)	45.74 ± 0.17[b]	3.245 ± 0.248 [a]	276.3±5.096[b]	84.02 ±1.56[bc]	2.536± 0.04 [a]
Control	45.74 ±0.55[b]	3.996 ±2.826 [bc]	276.3±2.59 [b]	92.20±4.44 [c]	2.981± 0.001[bc]
CV %	1.5	6.1	8.5	5.5	5.2
LSD %	3.045	0.5969	50.31	11.84	0.3886

The Anti-Nutritional Content of different Wheat varieties

The anti-nutritional contentof the wheat varieties is indicated in table 3. below the Phytate of Bardheer and Xiryane was the same and found the lowest 3.481mg/g while the K-Fantail has the highest Phytate content was found 6.381mg/g. There is no significant different among varieties like bardheer, xiryane at $p<0.05$. On the other hand, the Phytate is significantly different among K-Fantail (6.381 %) Nasired (4.40%), Bardheer (3.481%), T- Jay (3.597), Qunfo (3.713) at $P<0.05$. When it comes to Tannin content range 0.0355% up for 0.0775% Xiryane has the lowest Tannin while L- Local has the highest and no significant different among all varieties at $p<0.05$.

Table 3: Anti nutritional of different wheat varieties

Varieties	Parameters	
	Phytate %	**Tannin %**
Bardheer	3.481± 0.002[a]	0.03903 ± 0.01 [a]
Fantail(k)	6.381 ±0.116[c]	0.04754 ± 0.004[a]
Jay (t)	3.597 ±0.116[a]	0.04902 ± 0.01[a]
Nasired	4.409 ±0.464[b]	0.07454 ± 0.01[a]
Qunfo	3.713 ±0.003[a]	0.06704 ± 0.003[a]
Shiidit(t)	3.945 ±0.002[ab]	0.05904 ± 0.01[a]
Xiryane	3.481 ± 0.003 [a]	0.03552 ± 0.023[a]
Local(J)	3.597 ± 0.116[a]	0.04854 ± 0.03[a]
Control	3.713 ± 0.002 [a]	0.07752 ± 0.006[a]
Grand Mean	4.035	0.055
CV %	5.9	30.5
LSD %	0.5393	0.0382

The physical properties of different Wheat varieties

The physical properties of different wheat varieties are indicated in table 4 below. Regarding 100 seed weight, T-jay (2.65g) has the lowest while T-Bardheer has the highest (3.900g). The 100 seed weight were statistically different among T-bardheer (3.900g), T-xiryane (3.350+0.150g), T-jay (2.65+0.150g) at $p<0.05$. The 100 seed weight is also significantly different in between T-Jay (2.650g) and T-Xiryane & J-control respectively at $P<0.05$. On the other hand, the 100 seed weight is not significantly different among T-shid (3.100g), T-Xiryane (3.350g), L-Qunfo (3.250g), L-Nasired (3.450g), L-local (3.400g) and J-control.

Regarding bulk density weight, k-fantail (0.635g/ml) has the lowest while T-jay has the highest (0.7294ml). the bulk density statistical different among T-jay (0.7294g/ml), L-local (0.7275g/ml), k-fantail(0.6351g/ml) at $p<0.05$ the bulk density is also significance different between k-fantail and L-local respectively at $P<0.05$. On the other hand, bulk density is not significant among (Qunfo 0.7020g/ml, J-control 0.6674g/ml, bardheer 0.7020g/ml, xiryane 0.6782g/ml, and T-shid 0.6674g/ml k- fantail.

DISCUSSION

The Macronutrient content of different wheat varieties

Table 1 indicates the macro nutrient content of different wheat varieties. Regarding the moisture contents, Bardheer variety which is significantly different as compared to the other varieties under study and there is no significant difference in moisture content among the other varieties $P<0.05$. It is highest level of moisture is present in L-Bardheer T- Xiryane and T-Jay with values of (11.21%), - (9.79%) and (9.61%) respectively. Our value is higher than moisture contents of wheat varieties determined 9.67%. (14) that was conducted in Pakistan. The results show that wheat has a lower amount of moisture content can be stored for a long time and micro-organisms can't grow easily (9.67%). (14).

On the other hand, the ash content of the wheat is significantly higher and ranged between 0.673 - 2.643 which implies that higher ash content the higher important in mineral sources also, the study is an inline study that was conducted in Pakistan. The result indicated that the ash content of 2.16% is indicative that the flour sample could be important sources of minerals.

The fat content is in the range of 1.46 -2.51% as indicated in table 1. The fat content is significantly different among all wheat varieties under study at $P<0.05$. The difference may be due to the fact that being different in variety types, origin of the seed, farm management and some other reasons. The result obtained for fat content is in line with the research done by [15] for the wheat grown in Pakistan. The wheat protein content is ranged from 13.23% - 6.36% % which indicates a higher concentration of protein compounds and these results can be used for solving many malnutrition problems, especially protein-energy malnutrition cases such as marasmus and kwashiorkor.

The fiber content of this study was found between 1.10% and 1.75% of T- Jay and T- Shid respectively. Fiber has many benefits for humans and can prevent constipation as well as can cut the risk of chronic disease such as cancer also this finding agreed with the reported results by (14) and the authors revealed 1.85% of fiber content.

Results of the study indicated significantly higher carbohydrate content of range between 79.41-73.76 percent. These can be promising results that can be used for managing protein energy

malnutrition because of higher carbohydrate content the body can manage protein, fat, and mineral substance to use for bodybuilding, repairing damaged tissues rather than using them as a source of energy. This study is in line with the reported results by (16) and he showed that high carbohydrate content ranges between 73.74-71.61percent.

Energy is calculated with standard factors designed for carbohydrate, fat and protein. The energy was calculated in calorie unit and is in the range of 368.8 - to 350. 47. Significance difference was observed in energy content among some of the wheat varieties in this research at $P<0.05$. This difference come as result of being different in macro component (Protein, fat and CHO) which in turn due to being different in variety and some other reasons.

Mineral Content of wheat

The mineral contents of different wheat indicated in table 2. The calcium content in Fantail and Nasired wheat were 55.77and 45.74 mg/100 g, respectively. The results are greater than 36.2mg/100 g and 35.8 mg/100 g of the wheat reported by [15]. These results can be developed for many products like complementary foods for infants and pregnant women because calcium helps to build strong bones and teeth of infants and pregnant women since calcium is one of the main components of teeth and bones. This study is in line with the research result of (15) which indicated that calcium is responsible for teeth and bone formation.

The results indicated the highest iron content (7.47%) and the lowest indicates (3.24%) from Fantail and J- Local respectively. According to the finding of this indicates a promising results compared to study that was conducted by (17) and results shows that the highest (4.45%) and lowest (3.82) from RSP-561 and PBW-396 respectively. K- Fantail indicating a superior result this can be used for better management of Iron deficiency in vulnerable groups like lactating mothers, young children, and adolescent girls also this agreed with (17) which indicates that iron plays a vital role for red blood cells that carry on and release oxygen.

When it comes to potassium, the result indicated the highest potassium content (406.8%) and the lowest (204.3%) from Fantail and Qunfo respectively. According to the finding of this indicates a promising results compared to study that was conducted by (15) and results shows that the

highest (503.4%) and lowest (395%) from Ogolcho and kingbird respectively. K- Fantail indicating a superior result this can be used for better management potassium content helps to maintain body weight and regulate water and electrolyte balance in the blood.

Magnesium indicated significantly higher content and magnesium helps our body for enabling protein formation and plays a role in holding calcium content to the teeth as well as helping to release energy. The results of study indicated that zin content the range from (6.95%- 2.53%) from jay and J- Local respectively. according to the different literature zinc has many health benefits and this research is in line with research that indicated magnesium helps protein-making and energy releasing and zinc helps the immune system fight off invading bacteria and viruses (15).

CONCLUSION

The study was conducted with aim of analyzing the macro and micronutrient content of the different wheat varieties grown in Somali Region especially Fafan zone. The protein, fat, fiber, moisture carbohydrate content were analyzed in this study. The moisture content is in the range of 7.71-11.21% and this indicated for shelf stability of the wheat while the ash and the fiber of content of wheat under study were too low which is an indicated for its lower minerals content. The protein content of the wheat are in the range of 6.36-13.23% which make more or less better in protein content for same kind of varieties the energy in caloric unit is up the standard as most part of cereals. Generally, wheat with variety name K-fantail and Qunfo is good in almost all parameter such as fat protein carbohydrate ash moisture minerals

RECOMMENDATION

Based on the result of the study on the finding and identified gaps, the following points are recommended;

- Further research should be done by expanding the area coverage and adding more samples from different areas of the region including the control samples.
- Fantail, Qunfo, are highly promotable for developing many food products like bread, flour, past, for people and solved food and nutrition insecurity
- Further study is also required to see the agro-ecology effect on nutritional composition of wheat.

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CONFLICT OF INTEREST

- This is to confirm that, there is no conflict of interest between authors for this study

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5. PROXIMATE AND FUNCTIONAL PROPERTIES OF DIFFERENT SORGHUM VARIETIES PRODUCED IN SOMALI REGIONAL STATE ETHIOPIA

ABDULKARIM MOHAMMED ALI[1], HOODO MOHAMED JAMA[2]

adnanbdu302@gmail.com, hoodoqali042@gmail.com

Somali Region Pastoral and Agro-Pastoral Research Institute, Food Science and Nutrition Research Directorate. Jigjiga, Ethiopia.

Abstract

Sorghum is one the staple food or crop that widely consumed in Somali community. The study was conducted in Somali Regional state with objective to analyze proximate, functional and physical of different sorghum varieties produced in Somali reginal state. Six different types of samples such as Dekeka, AdoKaye, ESH-1, Melkam, ASSO-1 and JLM control as control sample were collected. The collected sorghum samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Magnesium and Total phosphorous were determined by AOAC. The functional and physical properties of the sorghum were determined different standard procedures. Based on the result all locally adapted those sorghum varieties adapted by the Somali region research institute were better in both macro and micro nutrients especially when it comes fiber, total ash, moisture content as compared to the control sample with brand name JLM control which imported from abroad. All sample's protein content is very low which in the range 5.23 to 6.50%. There is significant different in different components of sorghum between different varieties at $p<0.05$. Significance difference were also observed at $p<0.05$ in minerals content such as Calcium, zinc, iron and Total Phosphorous. The functional and physical properties of different sorghum varieties under study are almost not significantly different at $p<0.05$. Overall, from the finding we conclude that, almost all locally adapted sorghum varieties have better in nutritional content especially moisture, ash and fiber and very poor in protein content. Therefore, all actors on sorghum should apply fortification especially bio-fortification to enhance the nutrient content in particular the protein content as sorghum is one of the staple crops in Somali region.

Key words: *Sorghum, Proximate composition, Functional Properties, Physical properties.*

Introduction

Judging from the 2017 available data from FAOSTAT, Africa is the largest contributor to world sorghum production, with a production quantity of approximately 29.7 million tones [1]. Sorghum grains are a widely adaptable species and mostly cultivated in tropical, subtropical and temperate regions [2]. It is said to have originated from the Northeast quadrant of Africa [3]. Millet, barley, teff and wheat are also members of the Poaceae family [4] and are likewise known

for their ecological dominance in many ecosystems, as well as their capacity to grow in low rainfall and harsh environmental extremes conditions [5]. As indicated by Ratnavathi and Komala [6], over 20 sorghum species are known.

In developing countries, especially in Africa, over 78% of the sorghum produced is used for food, with about 14% for animal feeding and 7% for other uses [7]. Proximate composition of sorghum from earlier studies has indicated that its protein content ranges from 6.2% to 14.9%, carbohydrates (54.6%-85.2%), fat (1.3%-10.5%), ash (0.9%-4.2%) and fiber (1.4%-26.1%). The variations in these values might possibly be related to the genotypes of the grains and growth conditions, as well as other cultivar specific differences. Sorghum contains fairly high levels of potassium (K) (900-6957.67 mg/kg), and phosphorus (P) (1498-3787.25 mg/kg), minerals known to assist with muscle movement, keeping the nervous system healthy and building strong bones and teeth [8,9].

Sorghum (*Sorghum bicolor* L) Mönch is the world's fourth major cereal in terms of production with annual production volume of about 60million MT from land cover of over 40million hectares. Sorghum is a staple food for over 500 million people in Africa, Asia and Latin America [10]. Ethiopia is one of the major producers of sorghum, ranking 7^{th} in the world and third in Africa contributing 12% and 5% of African and world annual production respectively. Sorghum in Ethiopia accounts for about 18% of annual production and 16% of land cover allocated for the entire grain crops including cereals, pulses and oilseeds [11].

In Ethiopia, sorghum is the third (3^{rd}) most important staple cereal crop after teff and maize [12]. Sorghum crop is grown in almost all regions of Ethiopia and used as a staple food crop on which the lives of millions of poor Ethiopians depend on it. Sorghum is used in various ways in our country; the grain is used for human foods such as injera, bread, porridge, Nifro, infant food, syrup, and also, the leaf and stalk are used for animal feed, and further, the stalks are used for the construction of houses and fences and as fuelwood. Different research centers under Somali region pastoral and Agro-pastoral research institute (SoRPARI) have been working on the sorghum over the last many years; during this period, varieties of sorghum have been released. The released varieties had different specific qualities such as disease resistance, malt quality, and earliness. However, none of the varieties had no comprehensive nutritional profile data let it be

macro-nutrient, micronutrient and other content, since the quality of sorghum produced worldwide is affected by biotic and abiotic constraints [13]. Therefore, the aim of the present study was to profile the nutritional value, antinutritional value, mineral contents, functional and physical properties of sorghum varieties adapted and released by SoRPARI and grown in different parts of Somali region of Ethiopia.

Materials and Methods

Materials and Equipment Used

Five different sorghum varieties produced/adapted under SoRPARI were collected from Dolo-Ado research center and one popular widely marketed variety as a control was purchased from the local market in Jigjiga. The five varieties produced or adapted under SoRPARI that were going to use for this study includes *Dekeka, AdoKaye, ESH-1, Melkam, ASSO-1*, whereas the control sorghum type might be the one with most likely used by local community named *JLM-Control* for this particular study. Only whole sorghum grains without any physical damage or insect infestation were selected for analysis. All equipment used in sample preparation were expected to be obtained from SoRPARI laboratories and missed equipment can be used from local institutes Further, after bringing to the laboratory, sorghum samples were individually ground to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4 °C until further analysis.

Proximate Composition

The proximate composition of sorghum flours was determined using the standard AOAC methods [13]. Moisture content was done by the gravimetric method in a hot air oven at 105 ºC until constant weight, and the quantity of ash was analyzed using a muffle furnace at 550 ºC. Crude protein content was measured by a standard Kjeldahl method using 5.95 as the conversion factor. Flour lipids were analyzed by the solvent extraction procedure. The content of total carbohydrates was determined by difference from the analysis of moisture, ash, protein and lipids. Whereas, gross energy was determined by calculation from fat, carbohydrate and protein contents using at water's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000).

Mineral analysis

The mineral contents were determined by the procedure of AOAC [14]. Calcium, iron, and zinc were determined according to AOAC 2000 official methods of 985.35 using an Atomic Absorption Spectrophotometer while phosphorous was determined by official method of 986.24 using calorimetric method using ammonium molybdate.

Hundred (100) kernel weight and bulk density

One hundred sorghum kernels were randomly selected and weighed separately. For bulk density, 50 g of sorghum grains was weighed and will be dropped into a graduated glass measuring cylinder from a constant height (approximately 30 cm). The volume occupied by sorghum samples were recorded and bulk density were calculated as g/ml ratio [15, 16].

Oil and Water Absorption Capacity Determination

For this 2 g of the samples was mixed with 10 ml of distilled water for five minutes respectively on a magnetic stirrer. The mixture was centrifuged at 3500 rpm for 30minutes and the volume of the supernatant was measured by using 10 ml measuring cylinder on each of the sample. The water density was taken to be 1g/ml.

$$\text{WAC}=volume of water absorbed/\text{Weight of the sample used}\times 100$$

Statistical analysis

All the analysis was performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using GenStat version 18.0. The level of significance was considered at $P < 0.05$.

Results

Table 1: Proximate composition of different Sorghum Varieties

Key: Same letter in the same column is not significantly different from each other at $p<0.05$

Varieties	Results in (%) (100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
JLM Control	11.61 ± 0.24^{cd}	2.330 ± 0.01^{a}	2.720 ± 0.11^{b}	6.320 ± 0.24^{bc}	6.570 ± 0.14^{c}	70.45 ± 0.31^{ab}	366.2 ± 0.55^{b}
AdoKaye	12.51 ± 0.11^{d}	2.910 ± 0.02^{b}	2.840 ± 0.02^{bc}	6.210 ± 0.23^{b}	5.500 ± 0.23^{b}	70.03 ± 0.46^{a}	354.5 ± 0.98^{a}
Dekeka	9.63 ± 0.22^{ab}	3.110 ± 0.11^{bc}	2.410 ± 0.03^{a}	6.490 ± 0.11^{c}	5.165 ± 0.31^{a}	73.19 ± 0.34^{c}	365.2 ± 0.87^{b}
ESH-1	10.65 ± 0.12^{bc}	3.260 ± 0.21^{cd}	2.410 ± 0.12^{a}	6.240 ± 0.12^{bc}	8.270 ± 0.25^{f}	69.17 ± 0.12^{a}	376.1 ± 0.94^{c}
Asso-1	10.07 ± 0.31^{ab}	3.410 ± 0.08^{d}	2.910 ± 0.03^{bc}	6.500 ± 0.21^{c}	7.270 ± 0.34^{e}	69.84 ± 0.48^{a}	370.8 ± 0.84^{bc}
Melkam	9.36 ± 0.23^{a}	3.830 ± 0.10^{e}	3.000 ± 0.14^{c}	5.230 ± 0.14^{a}	6.940 ± 0.26^{d}	71.64 ± 0.51^{b}	369.9 ± 0.96^{bc}

JLM: The control sorghum sample
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these sorghum varieties

The proximate composition of different sorghum varieties has been depicted in table 1 above. Melkam variety has the lowest in moisture content while Adokaye is the highest. No significance difference was observed between Melkam, Asso-1, Dekeka varieties of sorghum under study at P<0.05. JLM control has the lowest in ash content while Melkam has the highest. When it comes crude fiber content, Melkam has the highest while (Ash-1 and Dekeka) has the lowest. The crude fiber content was significantly different between Melkam and (Ash-1 and Dekeka) and JLM control sample at P<0.05. With respect to crude protein content, Melkam has the lowest while Asso-1 variety has the highest in crude protein content. There is no significance difference in between JLM control, Adokaye and Esh-1 samples at P<0.05. Dekeka has the lowest while Esh-1 has the highest in crude fat content. The crude fat content was significantly different among all varieties of sorghum under study at P<0.05.

When it comes carbohydrate content, all sorghum varieties have high amount of carbohydrate as shown in table 1. Dekeka variety has the highest while Esh-1 has the lowest in carbohydrate content. There is no significant difference in carbohydrate among Asso-1, Esh-1, Adokaye and JLM control samples at P<0.05. There is also no significance difference in between Melkam and JLM control samples. The energy in calory unit were also calculated and depicted as shown in table 1 above. Adokaye variety has the lowest while Esh-1 has the highest in energy obtained from consuming 100g of each sample. The energy obtained is significantly different in between Esh-1 and Adokaye at P<0.05. Significant difference was also in between (Esh-1 & Adokaye) varieties and the rest of others sorghum varieties under study at P<0.05.

Table 2. Minerals content of different Sorghum varieties

Varieties	Results in (mg/kg)			
	Calcium	**Zinc**	**Iron (Fe)**	**Total Phosphorous**
JLM Control	900±2.50^{a}	32.39±0.98^{a}	67.9±0.92^{a}	2600±8.85^{a}
AdoKaye	1200±3.65^{b}	34.83±0.96^{b}	100.4±0.98^{b}	3300±8.95^{b}
Dekeka	900±4.24^{a}	34.16±0.86^{b}	127.4±1.24^{c}	3600±7.95^{c}
ESH-1	1401±6.55^{d}	37.50±0.94^{c}	160.7±1.55^{d}	4100±9.96^{e}
Asso-1	1300±6.75^{c}	33.45±0.92^{ab}	175.8±2.08^{e}	3800±9.02^{d}
Melkam	1400±7.01^{d}	40.42±0.97^{d}	180.1±2.21^{f}	4200±9.13^{f}

Same letter in the same column is not significantly different from each other at p<0.05

JLM: The control sorghum sample

Minerals are important in fighting against hidden hunger or micronutrient deficiency. The calcium content in the range of 900 mg/Kg to 1401 mg/kg for sorghum sample JLM control and Eshi-1 respectively. The calcium content is significantly different between Asso-1 and the rest of others sorghum varieties under study at P<0.05. When it comes zinc content different sorghum varieties, it is in the range of 32.39 mg/Kg to 40.42 mg/Kg for JLM control and Melkam sample respectively. No significant difference in zinc content were observed in between Adokaye, Dekeka and Asso-1 varieties at P<0.05. The iron content of different sorghum varieties is also indicated in table above. The iron content in the range of 67.9 mg/Kg to 180.1 mg/Kg for JLM control sample and Melkam sorghum sample respectively. Significant difference was observed in iron content in all sorghum varieties under study at P<0.05. The total phosphorous content is also indicated in table 2 above. In a similar fashion JLM control has the lowest (2600 mg/Kg) while Melkam sorghum sample has the highest in total phosphorous sample which is 4200mg/kg. Significant difference was observed in total phosphorous content of all sorghum varieties under study at P<0.05.

Table 3: Functional Properties of different Sorghum varieties

Varieties	Results	
	Water Absorbing Capacity	**Oil Absorbing Capacity**
JLM Control	1.640 ± 0.02^{b}	0.9150 ± 0.03^{a}
AdoKaye	0.875 ± 0.04^{a}	0.6050 ± 0.05^{a}
Dekeka	1.080 ± 0.03^{a}	0.6900 ± 0.04^{a}
ESH-1	1.075 ± 0.03^{a}	0.6250 ± 0.06^{a}
Asso-1	0.850 ± 0.02^{a}	1.0500 ± 0.09^{a}
Melkam	0.930 ± 0.04^{a}	1.1900 ± 1.01^{a}

Key: Same letter in the same column is not significantly different from each other at p<0.05
JLM: The control sorghum sample
WAC= Water Absorbing Capacity OAC= Oil Absorbing Capacity

The functional properties of different crops or food types are important in determining the integration of food with oil, water and other ingredients. Water absorbing capacity in the range of 1.075 to 1.640 for Esh-1 and JLM control samples respectively. No significant difference was observed in water absorbing capacity among all sorghum samples except JLM control samples which is significantly different at P<0.05 as indicated above. When it comes to oil absorbing capacity, it is in the range from 0.6050 to 1.1900 for Adokaye and Melkam sorghum samples

respectively. The oil absorbing capacity is not significantly different among all sorghum samples as indicated above at P<0.05.

Table 4. Physical properties of different sorghum varieties

Varieties	Results in	
	100 seed weight	**Bulk density (g/ml)**
JLM Control	3.645±0.23[b]	0.760±0.01[b]
AdoKaye	3.045±0.31[a]	0.695±0.02[a]
Dekeka	2.800±0.24[a]	0.750±0.02[b]
ESH-1	2.975±0.26[a]	0.770±0.03[bc]
Asso-1	2.855±0.30[a]	0.685±0.01[a]
Melkam	3.005±0.34[a]	0.785±0.03[c]

Same letter in the same column is not significantly different from each other at p<0.05 JLM: The control sorghum sample

The different physical properties are also important as quality indicators for different crop types. The 100 seed weight is in the range of 2.800 g to 3.645 g for Dekeka and JLM control sorghum samples respectively. When it comes to bulk density, it is in the range of 0.685 g/ml to 0.785 g/ml for Asso-1 and Melkam sorghum samples respectively. The bulk density of Melkam sample is significantly different as compared to other sorghum samples under study except Esh-1 sample at P<0.05.

Discussion

Proximate composition/Macronutrient/ of different sorghum varieties

The proximate composition different sorghum varieties indicated in table 1. The moisture content is significantly different among some sorghum samples. The difference in moisture content is might be due difference in variety, farm management, agro-ecology, soil fertility and some other reasons. The result obtained is in line with the research done by Mesresha *et.al*. [20] for the sorghum grown in Ethiopia. The result is in contradict with the research done in Sudan by Nefisa [18], and Mexico by Miria *et.al* [19]. The findings confirm that varieties of sorghum tested were not exposed to deterioration due to mold growth or any damage related to wetness. This could be attributed to a moisture level of less than 15% [17]. The ash content of different sorghum varieties in the range of 2.33 to 3.83%. Significant difference was observed among some sorghum varieties as indicated in table 1. The difference is due to the fact that being difference in variety, farm management, soil fertility and some other reasons. The result is in

contradict with the research done in Sudan by Nefisa (18), in Mexico by Miria *et.al* in (19) and with the research done by Mesresha *et.al* [20]. for the sorghum grown in Ethiopia. This might be virginity and fertility of Somali region soil which expected to contributed to higher ash content of sorghum samples.

Significant difference in fiber content was observed among different sorghum varieties. The difference might be being different in varieties type and farm management during farming. The fiber content of the six varieties under this research were lower as compared to the other research done in Sudan by Nefisa [18], in Mexico by Miria *et.al* [19] and with the research done by Mesresha *et.al*. [20] for the sorghum grown in Ethiopia. This may be due to the high in ash, moisture and carbohydrate content of these varieties. The protein content in the range of 5.23 to 6.50% is significantly different among different sorghum sample in this research as indicated in table 4.1 above. The difference in protein content might be due being different in varieties, farm management and some other cases. The protein contents of these six varieties in this research is relatively lower as compared to the other research done in Sudan by Nefisa [18], in Mexico by Miria *et.al* [19] and with the research done by Mesresha *et.al*. [20] for the sorghum grown in Ethiopia. This indicates, these sorghum and the other sorghum varieties need some kind of interventions like bio-fortification.

The fat content in the range of 5.165 to 8.270% as indicated in table 1. The fat content is significantly different among all sorghum varieties under study at $P<0.05$. The difference is due to the fact that being different in variety types, origin of the seed, farm management and some other reasons. The result obtained for fat content is in line with the research done by Mesresha *et.al*. [20] for the sorghum grown in Ethiopia. The result is in contradict with the research done in Sudan by Nefisa [18] and Mexico by Miria *et.al* [19]. The carbohydrate content of different sorghum depicted in table 1 above. There is significant difference in carbohydrate content among some sorghum varieties under study. This is mainly contributed due to being difference in variety type and especially the difference in other macro components such as protein, fat, moisture, fiber and ash of sorghum under study. The result of carbohydrate is in line with or comparable with the research done by Mesresha *et.al*. [20] for the sorghum grown in Ethiopia

and with the research done in Sudan by Nefisa [18] while it is in contradict with the research done in Mexico by Miria *et.al* [19].

Energy is calculated with standard factors designed for carbohydrate, fat and protein. The energy was calculated in calory unit and is in the range of 354.5 Kca; to 376.1 Kcal. Significance difference was observed in energy content among some of the sorghum varieties in this research at $P<0.05$. This difference come as result of being different in macro component (Protein, fat and CHO) which in turn due to being different in variety and some other reasons.

Mineral's content of different sorghum varieties

The calcium content is the range of 900 mg/Kg to 1401 mg/Kg. There is significant difference in calcium content among some sorghum varieties under this research at $P<0.05$. This might be due to being different in variety, soil fertility, farm management. The result obtained is comparable to the with the research done in Sudan by Nefisa [18]. The Zinc content of different sorghum varieties are in the range of 32.38 mg/kg to 40.42 mg/Kg as indicated in table 2. The zinc content is significantly different among some sorghum varieties at $P<0.05$. This might be due to being different in variety, soil fertility, farm management.

The iron content in the range of 67.9 mg/Kg to 180.1 mg/kg and it is significantly different among all sorghum varieties in this research. This might be due to being different in variety, soil fertility, farm management. The phosphorous content also indicated in table 2. It is in the range of 2600 mg/Kg to 4200mg/kg. The phosphorous content significantly different among all sorghum varieties in this research. This might be due to being different in variety, soil fertility, farm management. The result obtained is in contradict with the research done in Sudan by Nefisa [18]. This might be the fact that, the difference in ash content, agro-ecology difference, soil fertility and some other reasons.

Functional Properties

The water and oil absorbing capacity of the sorghum varieties shows no differences in their association with oil and water except the control sample. Water absorption capacity (WAC) is the capacity of the flour to absorb water and swell for enhanced consistency in food (21). The

observed mini variation in water absorption capacities between different sorghum varieties maybe attributed to different protein concentrations, their degree of interaction with water and their conformational characteristics (22). Oil absorption capacity is an indication of the rates at which proteins bind to fat in food formulations (21). Oil absorption capacity is an important functional property that enhances the mouth feel while retaining the flavors of food products which intron important in food formulation (22). The oil absorption capacities of the flours were different among the different sorghum varieties as shown in table 3 above. From statistical analysis, there was no significant difference ($p< 0.05$) in the oil absorption capacity of the flour samples.

Physical properties

The physical properties among different sorghum varieties are depicted in table 4. There is more or less some significance difference between different sorghum varieties with respect bulk density. The difference in bulk density may be due to the intrinsic characteristics of each variety. Density values are useful in design of silos and storage bins. Hundred seed weight showed significant difference and varied from 2.855 to 3.645 g. Low hundred seed weight may due to the low moisture content which increases the probability of more damaged grains during milling.

Conclusion and recommends

The research was done on six sorghum varieties of which one is a control sample. From the data obtained we conclude that, the moisture content of all varieties below 15% which is an indication for their better shelf stability. The ash content of all sorghum varieties is high which an indication for their high mineral content. The fiber, carbohydrate and fat content of all sorghum varieties are also high enough. But the protein content of all sorghum varieties is very low. When it comes to minerals content, all varieties of sorghum have high amount calcium, iron, zinc and total phosphorous. Significant different were observed in all varieties for both macro and micro nutrients. Therefore, we recommend, further research and biofortification or any other ways of fortification to all sorghum varieties.

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CONFLICT OF INTEREST

- This is to confirm that, there is no conflict of interest between authors for this study

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6. MACRO AND MICRO-NUTRIENT ANALYSIS OF DIFFERENT SESAME VARIETIES PRODUCED/ADAPTED UNDER SoRPARI IN SOMALI REGIONAL STATE

ABDULKARIM MOHAMMED ALI[1], HOODO MOHAMED JAMA[2],

3. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. adnanbdu302@gmail.com
4. Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research directorate. hoodoqali042@gmail.com

Abstract

The study was conducted in Somali Regional state with objective to analyze the macronutrient and micronutrient (minerals) content of different sesame varieties produced in Somali reginal state. Five different types of samples such as *Idaan, Adi*, *Barsan Local* and JLM control as control sample were collected. The collected sesame samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Zinc and Total phosphorous were determined by AOAC. Based on the result all locally adapted those sesame varieties adapted by the Somali region research institute were better in both macro and micro nutrients especially when it comes fiber, protein, total ash, moisture content as compared to the control sample with brand name *JLM control* which is purchased from Jigjiga local market. Fat content is exceptional which means the control sample has high amount fat as compared to samples. There is significant different in different components of sesame between different varieties at $p<0.05$. Significance difference were also observed at $p<0.05$ in minerals content such as Calcium, zinc, iron and Total Phosphorous. Overall, from the finding we conclude that, almost all locally adapted and the control sesame varieties have better in nutritional content especially moisture, ash, protein fat, and fiber and very poor in carbohydrate content. Therefore, all actors should engage in mass production of sesame with improved varieties so as to get more income and currency from abroad.

Key words: Sesame, macronutrient composition, micronutrient composition, oil content.

1. INTRODUCTION

Sesame is one of the world's important and oldest oilseed crops [1, 2] and has been used extensively for thousands of years as a seed of worldwide significance for edible oil, paste, cake, confectionary purposes and flour due to its highly stable oil contents, nutritious protein (rich in methionine, tryptophan and valine) and savory nutty roasted flavor [2, 3]. The oil contains, in addition to phytosterol and tocopherol, two compounds which are not found in any other oil, namely sesamolin; this, upon hydrolysis, yielded sesamol, which is responsible for the antioxidant behavior of sesame seed crop oil [4].

Some of the variations in the seed are hundred seed weight that can range 0.11 - 0.46 g [5], protein 19% - 30% [6, 7], oil 34.4% - 59.8% [6], carbohydrates 6.4% - 21.0% [8]. In Ethiopia, improved sesame seed varieties were developed through researches that have good disease resistance, improved yields, different oil composition, size and color [9-11]. Sesame contains important minerals and vitamins such as Ca, P, and Fe, niacin and thiamin [8] [12, 13].

Sesame (Sesamum indicum L.) is an oilseed herbaceous crop of the Pedaliaceae fam is produced by only a few developing countries in the world due to its high demand for labor farming and harvesting [44]. About 96% of the world sesame production is contributed from Asia and African countries. Considering a 10-year average report (from 2008 to 2018), the top ten sesame producers are Myanmar, India, Tanzania, Sudan, China, Nigeria, Sudan (Former), Ethiopia South Sudan, and Burkina Faso, in the same order (http://www.fao.org/faostat/en/#data/QC/ visualize, accessed on 12th August 2021).

Study reports indicate that Ethiopia is among the six producers of sesame seed, linseed and niger seed in the world [7]. In Ethiopia, the production of sesame is both by small- and large-scale farmers; and it is an important crop and export commodity [14]. The major sesame seed producing regions are situated in the North West and South West Ethiopian in Humera, North Gondar and Wollega [8-10]. The major sesame producing areas are situated in the low land of Tigray, Gambella, Benshangul Gumuz, Somalia, Amhara, Southern and Oromia regions of Ethiopia [7]. Sesame production is increasing in the country due to increase in demand and price. Thus, sesame cultivation is expanding to new potential growing areas [45]. Sesame is an important annual oilseed crop being cultivated as an ingredient for human food oil, meal, and animal feeds [41, 42].

These days, there are several varieties and genotypes of sesame adapted to different geographical conditions. However, the cultivation of modern varieties is limited due to insufficient genetic information [43]. According to some studies the seed is believed to exist in 16 genera and 60 species, most of which exist in Africa [43]. Due to the high market demand and adaptability to several environmental factors, sesame production is increasing year to year in different countries [44]. In Ethiopia, sesame seed production and export alone are twice larger than all other oil seeds together. In Ethiopia, both black and white sesame seed varieties are cultivated but the oil

yield, the dominant fatty acid constitutes of the oils and phenolic compounds of these sesame seed varieties cultivated in these districts have not been reported so far, though the country is one of the major sesame seed producers and exporters from Africa.

As sesame seed is nutritionally important in some parts of the world, few reports were documented about color, size, oil and other nutritional content of Ethiopian sesame seeds in the literature [17-19] and oil characteristics [28]. So, limited scientific research has been done on the physico-chemical composition of sesame varieties. The scientific information generated from this research could serve as an important input for production, marketing, food industry, human nutrition and maximum utilization, particularly for the benefits of sesame growing areas. Therefore, the objective of this study was to investigate some, proximate, mineral compositions of different sesame varieties grown under SoRPARI potential areas and Somali Region in Ethiopia.

2. MATERIALS AND METHOD

Four different sesame varieties produced/adapted under SoRPARI were collected from Kelafo research sub center and one popular widely marketed variety as a control was purchased from the local market. The five varieties produced or adapted under SoRPARI that were used for this study includes Adi, Local, Barsan sesame, Iidan sesame whereas the control sesame sample was purchased from Jigjiga City local market. Only whole sesame grains without any physical damage or insect infestation were selected for analysis. All equipment used in sample preparation was expected to be obtained from SoRPARI laboratories and missed equipment can be used from local institutes Further, after bringing to the laboratory, sesame samples were individually ground to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis.

2.1. Proximate Composition

2.1.1. Moisture content

Moisture content (%) of the sesame seeds was determined according to the procedure described in the Association of Official Analytical Chemists, No. 930.15. Five gram of each sample was accurately weighed into a moisture dish and transferred into a hot air-oven at 103°C and then

dried until a constant weight was attained. The final weight of each sample was taken after cooling it in desiccator (AOAC)[15]. The analysis was carried out in triplicate and the average value was recorded as moisture content.

$$\text{Moisture (\%)} = \frac{\text{(Initial moisture of the sample-Weight of Oven Dried sample) *100}}{\text{Initial weight of the samples}}$$

2.1.2. Protein content

The crude protein content of sesame seed was determined from the nitrogen content by Kjeldahl method (AOAC)[15]. The percentage of crude protein was calculated from the % nitrogen as:

$$\text{Nitrogen (\%)} = \frac{\text{((Vs-Vb)*mMHCl*0.014008)) * 100}}{\text{Weight of the sample}}$$

Where Vs = Volume (mL) of HCl required to titrate sample; Vb = Volume (mL) of acid required to titrate the blank; mM HCl = Molarity of acid; W = Weight of sample (g). Crude protein (%) = % nitrogen *F, where F (conversion factor), equivalent to 6.25 (AOAC)[15]. A blank was run through along with the sample and triplicate analysis was conducted for samples.

2.1.3. Determination of crude fiber

The crude fiber in the sample was determined by following the method described in the Association of Official Analytical Chemists, No. 962.09 (AOAC,)[15]. The percentage of fiber was calculated as:

$$\text{Crude fiber (\%)} = \frac{\text{(Weight of dried sample – Weight of Ash) * 100}}{\text{Initial weight of samples}}$$

2.1.4. Determination of crude fat

The crude fat in the powdered samples was determined by Soxhlet extraction method described in the Association of the Official Analytical Chemists, No. 2003.06 (AOAC)[15]. The % fat in the sample was calculated as:

$$\text{Fat (\%)} = \frac{\text{(Wt. of flask containing the crude fat in the filter paper – Wt of flask plus paper) *100}}{\text{Weight of sample}}$$

2.1.5. Determination of total ash content

The total ash content was determined by using direct method described in the Association of the Official Analytical Chemists, No. 923.03 (AOAC)[15]. The weight of ash was determined by subtracting the weight of dried empty crucible from the weight of crucible containing ash.

$$\text{Ash (\%)} = \frac{\text{Weight of Ash}}{\text{Weight of initial Sample}}$$

2.1.6. Determination of total carbohydrate and gross energy values

The carbohydrate content of the sample was obtained by subtracting the sum of percentages moisture, fat, fiber, protein and ash from 100 % following a standard procedure reported [16].

Carbohydrate (%) = 100 – (% moisture + % fat + % protein + % fiber + % ash).

Gross energy values (kcal/100 g) of the samples were determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9 (AOAC):

Energy value (kcal/100 g) = (crude protein *4) + (Total carbohydrate *4) + (Crude fat * 9).

2.1.7. Mineral analysis

Mineral contents (Fe, Zn and Ca) of sesame seed were determined by Atomic Absorption Spectrophotometer (AOAC)[15] The powdered sesame seed sample (1.0 g) was taken in a glass tube. Twelve milliliters of HNO3 were added to the powdered sample and the mixture was kept for overnight at room temperature. Then, 4 ml HClO4 was added into the mixture and put in the fumes block for digestion. The temperature was gradually increased starting from 50°C until completion of digestion as indicated by the appearance of white fumes. The mixture was cooled down and the contents of the tubes were transferred into 100 ml volumetric flask and the volume was made to 100 ml with distilled water. The wet digested solution was transferred to the plastic bottle and the digest was used for mineral determination. Phosphorus is determined by AOAC method No. 964.06, which was demonstrated as adequate recovery, reproducibility and has no bias. It is an alkalimetric ammonium molybdophosphate method appropriate for all concentrations of phosphate (AOAC)[17].

2.2. Statistical analysis

All the analysis were performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way

analysis of variance (ANOVA) followed by Duncan test by using Genstat version 18.0. The level of significance was considered at $P < 0.05$.

3. RESULT AND DISCUSION

3.1. RESULT

Table 1: Proximate composition of different Sesame Varieties

Varieties	Results in (%)/(100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
JLM control	2.94± 0.2^{a}	4.15±0.4^{a}	7.78±0.3^{a}	21.70±1.2^{a}	55.60±2.6^{c}	7.83±0.3^{b}	618.5±2.9^{d}
Idaan	3.98±0.32^{b}	6.93±0.5^{d}	8.94±0.4^{c}	25.65±1.4^{e}	52.98±2.5^{b}	1.52±0.01^{a}	585.5±2.2^{c}
Adi	4.00±0.1^{b}	5.95±0.6^{b}	12.18±0.3^{e}	22.68±1.3^{b}	47.87±2.4^{a}	7.32±0.2^{b}	550.8±2.1^{a}
Barsan	4.00±0.2^{b}	6.43±0.4^{c}	9.40±0.4^{d}	24.92±1.5^{d}	47.78±2.3^{a}	7.47±0.2^{b}	559.6±2.2^{ab}
Local	4.02±0.4^{b}	6.82±0.3^{cd}	8.44±0.4^{b}	24.55±1.3^{c}	48.50±2.2^{a}	7.67±0.3^{b}	565.4±2.3^{b}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these sesame varieties

Table 1 above indicates the macronutrient contents of different sesame varieties under study. The JLM control variety has the lowest moisture content 2.94% while the "local" variety has the highest in moisture content 4.02%. Except the "JLM control" varieties which is significantly different as compared to the others four varieties under study, there is no significant difference in moisture content among the other four varieties at $P<0.05$. The ash content of the five sesame varieties under study is in the range of 4.15 up to 6.93%. The "JLM control" has the lowest while the "Idaan" has the highest in ash content. The ash content is significantly different among the five sesame varieties under study at $P<0.05$. But there is no significant difference in between "Idaan" and "Local" vartieties and the same is true for "Barsan" and "Local" varieties at $P<0.05$.

The "JLM control" sample is lowest in Crude fiber content (7.78%) while the "Adi" variety has the highest (12.18%). The crude fiber content for all sesame varieties is significantly different at $P<0.05$. When it comes to crude protein content, it in the range of 21.70% (For "JLM Control"

sample) and 25.65% (for "Idaan" sample) as shown in table 4.1. above. The crude protein content is significantly different among all sesame varieties at P<0.05.

The fat content of "JLM control" sample is the highest (55.60%) while that of "Barsan" sample is the lowest which is 47.78% as shown in table above. There is no significant different in fat content among "Adi", "Barsan" and "Local" varieties of sesame under study at P<0.05. But there is significant difference in fat content between "JLM control" variety and that of "Idaan" variety at P<0.05.

With respect to carbohydrate content, "Idaan" variety has the lowest (1.52%) and while "JLM control" has the highest which is 7.87%. Except the "Idaan" sesame variety which has the lowest in carbohydrate content, there is no significant different in carbohydrate content among the others sesame varieties at P<0.05. Finally, when it comes to energy obtained from 100g of sesame varieties, it is in the range of 550.8Kcal (for "Adi" sesame variety) to 618.5Kcal (for "JLM Control" sample) as indicated in table above. There is no significant difference in energy for "Local" & "Barsan" varieties and as well in between "Barsan & "Adi" at P<0.05. But there is significant difference in between "Adi" & "Local" and "JLM control" & "Idaan" sesame varieties and vice versa at P<0.05. as shown in table1. above.

Table 2. Mineral's content of different sesame varieties

Sesame varieties	Result in (mg/100g)			
	Calcium (Ca)	**Zink (Zn)**	**Iron (Fe)**	**Total phosphorous (TP)**
JLM control	55 ± 2.5^{a}	4.087 ± 1.8^{d}	10.25 ± 1.5^{a}	620.0 ± 6.4^{ab}
Idaan	133 ± 4.5^{b}	3.992 ± 1.6^{c}	20.62 ± 2.4^{d}	600.0 ± 6.2^{ab}
Adi	104 ± 3.5^{b}	3.559 ± 1.5^{a}	17.66 ± 1.6^{c}	540.0 ± 5.6^{a}
Barsan	140 ± 4.9^{b}	5.208 ± 1.9^{e}	22.86 ± 2.5^{e}	590.0 ± 5.7^{ab}
Local	135 ± 5.7^{b}	3.690 ± 1.7^{b}	17.54 ± 1.8^{b}	640.0 ± 6.8^{b}

Key: Same letter in the same column is not significantly different from each other at p<0.05

The mineral contents of different sesame varieties are indicated in table 2. above. The "JLM control" sample is the lowest in calcium content (550mg/Kg) while "Local" sesame variety has the highest which is 1350mg/Kg. The "JLM Control" sample is significantly different in calcium

content from other four varieties of sesame at P<0.05. But there is no significant difference in calcium content among “Idaan”, “Adi”, “Local” and “Barsan” sesame varieties at P<0.05. With respect to zinc content, the “Adi” variety has the lowest (35.59mg/Kg) while the “Barsan” variety has the highest which is 52.08mg/Kg. There is significant difference in Zinc content among all sesame varieties at P<0.05.

When it comes to Iron content, the “Barsan” sesame verity has the highest (228.6mg/Kg) while the “JLM control” sample has the lowest which is 102.5mg/Kg. There is significant difference among all sesame varieties in iron content at P<0.05. Lastly, The total phosphorous content in the range of 5400mg/Kg (For “Adi” sesame variety) to 6400mg/Kg for “Local” sesame Varieties. There is significant difference in total phosphorous content among “Local” and “Adi” sesame varieties at P<0.05. But there is no significant difference in total phosphorous content in between “JLM control”, “Idaan” and “Barsan” sesame varieties and the vice versa at P<0.05.

3.2. DISCUSSION

3.2.1. The Macronutrients content of Different Sesame Varieties

Table 1 above indicates the macronutrient contents of different sesame varieties under study. Except the “JLM control” varieties which is significantly different as compared to the others four varieties under study, there is no significant difference in moisture content among the other four varieties at P<0.05. The difference in moisture content might be due to agro-ecology, farm management difference. The moisture content of the studied sesame seeds was low, which corresponds to the moisture content of different sesame varieties ranging from 4.16% to 7.80% [18, 19]. [4]reported the moisture content of sesame varieties from Werer Agricultural Research Center ranged from 4.4% to 4.8%. The relatively low moisture content of sesame seeds is helpful for the storage of sesame seeds. At low moisture, deterioration would occur relatively slowly [20].

The ash content of the five sesame varieties under study is in the range of 4.15 up to 6.93%. The ash content was significantly different among the five sesame varieties under study at P<0.05. The difference may as a result of being different varieties, soil condition in which they grown. Ash content was observed significantly ($p \leq 0.05$) different between sesame varieties. T-85 had the highest (6.19 g/100g) ash content and least was for bawnji (4.46 g/100g)[21]. [22] reported

ash values to be between 1.4 and 6.6 g/100g for Saudi Arabia and foreign varieties (Lebanese, Indian and World collection), which is similar with the results of this study. High level of ash makes the oilseed a good source of mineral nutrition to the consumer [23][49].

The "JLM control" sample is lowest in Crude fiber content (7.78%) while the "Adi" variety has the highest (12.18%). The crude fiber content for all sesame varieties is significantly different at $P<0.05$. The difference may be as a result of being different in varieties, farm management and some other reasons. Fiber contents were higher than the fiber contents of previously reported values fiver contents (5.24 to 7.70%) from Ethiopia sesame varieties [24], indicating the studied sesame varieties from Somali region could be useful source of fiber.

When it comes to crude protein content, it in the range of 21.70% (For "JLM Control" sample) and 25.65% (for "Idaan" sample). The crude protein content is significantly different among all sesame varieties at $P<0.05$. The difference might be due to varietal difference among sesame, farm condition and other components difference. The crude protein content in the studied sesame seeds was high, which was in agreement with that of sesame protein contents reported by [19] and by [18]Ogbonna and Ukaan (2008) (17.02%-21.00%), and [24]Amare et al. (2017) who reported the mean crude protein content (23.12%) of ten sesame seeds in Ethiopia. This result is consistent with range (18% - 25%) reported by [8] but are lower than those reported by [42] for Sudan varieties and USA genotypes (32.5% - 40.0%) and by [43] for 13 sesame accessions of Nigeria (27.50% - 45.68%). [25] found protein content (19.81% to 24.45%) in Turkey's sesame genotype. The difference might be due to varietal difference among sesame, farm condition, agro-ecology difference, fertilizer management.

The fat content of "JLM control" sample is the highest (55.60%) while that of "Barsan" sample is the lowest which is 47.78%. There is no significant different in fat content among "Adi", "Barsan" and "Local" varieties of sesame under study at $P<0.05$. But there is significant difference in fat content between "JLM control" variety and that of "Idaan" variety at $P<0.05$. The crude fat contents of the studied sesame varieties were comparable to the mean crude fat content (47.33%) reported by [4]. Higher crude fat content (46.6% to 52.4%) in sesame seeds has also been reported in India [26]. [27]reported the oil content can range from 43.4% to 58.8% for 42 strains of sesame with the highest oil content found in white-seeded strain. [28, 29]reported

oil content in Saudi and Indian sesame seeds ranging from 43.2% to 54.0%. Both the above results are consistent with the result of current study. Variation in the oil yield of sesame may be due to variation in variety, soil type, climatic, maturity of plant, the harvesting time of the seeds and the extraction method used [28, 29].

With respect to carbohydrate content, the "Idaan" sesame variety which has the lowest in carbohydrate content, there is no significant different in carbohydrate content among the others sesame varieties at $P<0.05$. Finally, when it comes to energy obtained from 100g of sesame varieties, it is in the range of 550.8Kcal (for "Adi" sesame variety) to 618.5Kcal (for "JLM Control" sample) as indicated in table above. There is no significant difference in energy for "Local" & "Barsan" varieties and as well in between "Barsan & "Adi" at $P<0.05$. But there is significant difference in between "Adi" & "Local" and "JLM control" & "Idaan" sesame varieties and vice versa at $P<0.05$. Carbohydrate content had ranged (7.32% - 7.83%) between varieties studied which is inconsistent with range (8.31% - 11.69%) reported by [21] but are higher than the range 1.05% - 2.88% reported by [30] for Sudan varieties and USA genotypes. The highest carbohydrate values (27.90% - 45.15%) were reported in 13 sesame accession of Nigeria by [18]. Compositional differences can exist among the different varieties of sesame seeds, and among the sesame variety grown in different countries. Further studies by [31][59] on some legume crops reported that there might be differences between varieties of the same species. The mean energy value of the studied sesame varieties was lower than energy value of sesame seeds reported by [4].

3.2.2. The mineral contents of different Sesame varieties

The mineral contents of different sesame varieties are indicated in table 2. The "JLM control" sample is the lowest in the calcium content in the range of (55-140mg/100g. The "JLM Control" sample is significantly different in calcium content from other four varieties of sesame at $P<0.05$. But there is no significant difference in calcium content among "Idaan", "Adi", "Local" and "Barsan" sesame varieties at $P<0.05$. This might be the fact that, being different varieties, different agro-ecolology, soil type, fertilizer and other farm management. The calcium content of this study is lower than 1450 mg/100g reported by [32] and [33] in some Indian sesame varieties. However, some Lebanese sesame varieties exhibited the lowest (228.3 mg/100 g) calcium

content [34]. The current study results which are in the range 55 - 140 mg/100g is also lower than the research done on different sesame varieties which are in the range of 600 - 2000 mg/100g.

With respect to zinc content, the “Adi” variety has the lowest (3.559mg/100g) while the “Barsan” variety has the highest which is 5.208mg/100g. There is significant difference in Zinc content among all sesame varieties at $P<0.05$. This zinc content found is higher than the range (0 - 3.8 mg/100g) reported by [22] for Saudi Arabia and varieties (Lebanese, Indian, Nigerian and World collection). This might be the due to difference in variety, soil condition, farm management and agro-ecology.

When it comes to Iron content, the “Barsan” sesame verity has the highest (22.86mg/100g) while the “JLM control” sample has the lowest which is 10.25mg/100g. There is significant difference among all sesame varieties in iron content at $P<0.05$. The values were comparable with the Fe content of sesame varieties reported from Saudi Arabia (10.4 mg/100g Fe) [35]. This indicated that the studied sesame varieties could be considered to have normal amount of iron that can help consumers identify products with higher iron content [36]. Iron is an essential element for human being by contributing to a wide variety of metabolic processes including oxygen transport, DNA synthesis and electron transport, transportation of oxygen around in the body [37]

Lastly, The total phosphorous content in the range of 540mg/100g (For “Adi” sesame variety) to 640mg/100g for “Local” sesame Varieties. There is significant difference in total phosphorous content among “Local” and “Adi” sesame varieties at $P<0.05$ as shown in table 4.2 above. But there is no significant difference in total phosphorous content in between “JLM control”, “Idaan” and “Barsan” sesame varieties and the vice versa at $P<0.05$. The P content was comparable with that reported elsewhere (501.99 - 762.79 mg/100 g) [38].

CONCLUSION

The study was conducted with aim of analyzing the macro and micronutrient content of the different sesame varieties. The protein, fat, fiber and moisture content are up to the standard while the carbohydrate content is very low. The lower moisture content is the indication for shelf stability of the different sesame varieties. The higher fat content is the indication for the studied sesame varieties are good for oil production. In addition to this, with being higher in protein

content, all sesame varieties are nutrient rich which is indicated in their calory content that are higher than 550kcal/100g of sesame. The higher ash content of all sesame varieties indicates, all varieties have good source of minerals. Except the calcium content, all sesame varieties have high amount of zinc, iron and total phosphorous.

RECOMMENDATION

Based on the finding and identified gaps, the following points are recommended;

- Further research should be done by expanding the area coverages and adding more samples from different areas of the region including the control samples.
- More parameters should be added in the future research that going to be done on different sesame varieties.
- Sesame is one of the nutrient dense crops. Community should use it by mixing with the different stables crop they use as regular food.
- Especial research should be done on the oil characterization of the different sesame varieties.
- More to be done on the different products that can be produce from sesame and as well the different use of sesame such as culinary, medicinal, industrial

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CONFLICT OF INTEREST

- This is to confirm that, there is no conflict of interest between authors for this study

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7. PROXIMATE COMPOSITION ANALYSIS OF DIFFERENT MAIZE VARIETIES ADAPTED UNDER SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI) ETHIOPIA.

ABDULKARIM MOHAMMED[1], MOHAMMED DOL[2], HOODO MOHAMMED[2], HOODO MOHAMED MOHAMUD[2]

1) Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research Directorate.
2) Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research Directorate.

Abstract

The study was conducted in Somali Regional state with objective to analyze macronutrient and mineral content of different maize varieties adapted under Somali Region pastoral and Agro-pastoral research institute (SoRPARI). Four different types of samples such as Melkasa-6Q, MH-138, BH661 and BH-549 sample were collected. The collected maize samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, different minerals like Calcium, Iron, zinc and total phosphorous were determined by AOAC. Based on the result obtained, the ash content of the four maize varieties is in the range 4.06(Bh-549)-5.88% (Melksa-6Q), while the protein content from 12.82 (BH-549)-15.24% (Melkasa-6Q). The fat content is in the range 11.89 (BH661)-31.61%(Melkasa-6Q) while the carbohydrate content is in the range of 34% (Melkasa-6Q)-59.07% (BH-549). Significant difference was observed in most of these macronutrient content at $p<0.05$. Significant difference was also observed at $p<0.05$ in minerals content such as Calcium, Zinc, iron and Total Phosphorous where Melkasa-6Q had highest in almost all minerals content. Overall, from the finding we conclude that, all adapted maize varieties have good in both macronutrient and minerals especially Melkasa-6Q. Therefore, all actors of maize should contribute to the promotion of nutrient dense varieties of maize to the local community which in turn important for the fight against malnutrition.

Key words: *Maize, maize varieties, macronutrient, mineral content*.

1. Introduction

Maize belongs to Family Poaceae and Genus *Zea*. By origin, it is a tropical crop and has adapted magnificently to temperate environments with much higher productivity. It is grown from latitude 580 N to 400 S, from sea level to higher than 3000 m altitude and in areas receiving yearly rainfall of 250 to 5000 mm (Dowswell *et al.,* 1996; Premlatha and Kalamani, 2010). Major maize producers are the USA (30%), China (15%), European Union (14%), Brazil (4%) and India (3%). These five countries have around 60% of the world's corn harvested area (Annonymous, 2007; Tao Ye *et al.,* 2015).

In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population and it remains the most important agricultural crop for over 70 million farm families worldwide. Of the

22 countries in the world where maize forms the highest percentage of energy in the national diet, 16 are in Africa (Nuss and Tanumihardjo, 2011). Ethiopia is among the major maize producers in Africa and ranked third next to South Africa and Nigeria (FAO,2012). Maize production takes significant share of cereals and grain in any production year. Among cereals, maize ranked second to tef in area coverage (21.7% for maize and 27.4% for tef), and first in total production (28.5% for maize and 19.9% for tef) and productivity (Mosisa et,al, 2011).

Maize is used as a basic food ingredient, either in its original or modified form. Maize grains are a rich source of starch (72%), ash (17%), protein (10.4%), fiber (2.5%), oil (4.8%), vitamins and minerals (Farhad *et al.*, 2009; Zhiqiang *et al.*, 2018). The oil and protein contents have commercial value and are used in food products manufacturing (Paliwal, 2000). Maize is used primarily as a food for humans in most areas of the world, in contrast to the United States where about 85 percent of the crop is used as cattle feed. Byproducts of processing are gluten feed, gluten meal, oil cake meal, germ meal, distiller's and brewer's grains.

Maize is used as human food in the form of tortillas, porridge, popcorn and barbecues and as forage and silage for animals. It is also a good source of industrial products such as starch (Zhang *et al*., 2012), vitamin (Warman and Havard, 1998), fiber, oil, weaning porridges (Mburu et al., 2012) and ethanol (Lamsal et al., 2011). Yellow maize, in addition to being dietary source of energy, lipids, protein, minerals and vitamins, it is a source of carotenoids (Adam & Liu. 2012, Menkir et.al, 2008). Food composition data is important in nutritional planning and provides data for epidemiological studies (Ali et.al, 2008). However, there is no or limited study about the nutritional content of the different maize varieties growing in Ethiopia particularly in Somali region. This study is designed to provide information on macronutrient and mineral composition of different maize varieties adapted under Somali region pastoral and agro-pastoral research institute (SoRPARI) Somali Region in Ethiopia.

2. Materials and Method

2.1. Materials and Equipment Used

Four different maize varieties produced/adapted under SoRPARI were collected from Kelafo agricultural research sub center. The four varieties collected were BH661, BH-549, Melkasa 6 Q

and MH 138. Maize samples were individually ground to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis.

2.2. Proximate Composition

The proximate composition of maize flours was determined using the standard AOAC methods (AOAC, 2000). Moisture content was done by the gravimetric method in a hot air oven at 105 ºC until constant weight, and the quantity of ash was analyzed using a muffle furnace at 550 ºC. Crude protein content was measured by a standard Kjeldahl method using 5.95 as the conversion factor. Flour lipids were analyzed by the solvent extraction procedure. The content of total carbohydrates was determined by difference from the analysis of moisture, ash, protein and lipids.

Whereas, gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories (AOAC, 2000).

2.3. Mineral analysis

The mineral contents were determined by the procedure of AOAC (1984). Calcium, iron, and zinc were determined according to AOAC 2000 official methods of 985.35 using an Atomic Absorption Spectrophotometer while phosphorous was determined by official method of 986.24 using calorimetric method using ammonium molybdate.

2.4. Statistical analysis

All the analysis was performed in duplicate (unless stated otherwise) and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using Genstat version 18.0. The level of significance was considered at $P < 0.05$.

3. Result and Discussion

3.1. Macronutrient content

Table 1: Proximate composition of different Maize Varieties

Varieties	Results in (%)/(100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
BH661	10.68±0.00^{c}	4.07±0.00^{a}	3.11±0.11^{c}	13.49±0.80^{a}	11.89±0.38^{a}	56.77±1.26^{b}	400.5±1.96^{a}
BH-549	10.00±0.02^{a}	4.06±0.02^{a}	1.85±0.04^{b}	12.82±0.23^{ab}	12.20±0.29^{a}	59.07±0.01^{b}	404.7±1.51^{a}
MH-138	10.36±0.015^{b}	4.74±0.22^{a}	1.77±0.11^{b}	14.57±0.23^{ab}	11.96± 0.11^{a}	56.60±0.21^{b}	399.5±1.45^{a}
Melkasa-6Q	10.94±0.035^{d}	5.88±0.37^{b}	1.44±0.015^{a}	15.24±0.21^{b}	31.61±1.04^{b}	34.89±2.20^{a}	490.8±3.86^{b}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these maize varieties

The macronutrient content of different maize varieties has been indicated in table 1. As indicated, the moisture content significantly different among different maize varieties at $p<0.05$. The variation of moisture contents in maize flours may be attributed by different factors such as agronomic, environmental factors and the maize variety. The result in moisture content is in agreement with research done on seven different maize varieties by Kidist (2018) with is in between 9.42-11.45%. It is inconsistent with research done by (Kumar U. and Kweera B., 2014) which is in between 4.3 to 6.7%. On the other hand, the result of moisture content indicates all maize are in very good range for their shelf stability.

As shown in table 1, all maize varieties have high amount ash. The ash content beyond normal values of most common maize varieties of anywhere. This indicates all maize varieties have good source of different minerals. The ash content is a little bit different in amount among the four varieties and some are significantly different at $P<0.05$. This might be the fact that, there are different in variety, there response against different harsh condition might be different, the way they are managed during their farming time and some other reasons. Ash content of BH661, BH-549 and MH-138 maize flour was also in relatively good agreement with the literature 1.4–3.3% (Shaista Qamar et al.2016), whereas it is higher in melkasa -6Q maize. All maize ash content is inconsistent with result obtained by Kidist (2018) which is in between 1.37 to 1.74%.

The difference might be due being in different agro ecology, different farming system and environmental factors.

Fiber has beneficial effects on diabetes, atherosclerosis, cancer, and appendicitis and prevention of duodenal ulcer formation and varicose veins (Yeung D. L. and Laquatra I. 2003). The fiber of different maize varieties under this study shows some significantly different at $P<0.05$ as shown in table 4.1. This might be due being different in variety, the resistance against different environmental factors. The result crude fiber content is in agreement with the research done by Kidist (2018) which are in the range of 1.62 to 3.46%.

Protein is the building block of all cells. All maize varieties have highest in protein content especially Melkasa-6Q which 15.24% as shown in table 1. But there is Significant difference among maize varieties under study at $P<0.05$. This might be the fact that, because of being different in their variety, their difference in their resistance and utility of naturally occurring nutrient, soil difference. The result of protein content is in agreement with the research done by Kidist (2018) on seven different varieties which are in the range of 9.69 to 15.30%. In a similar fashion, the present study range of crude protein contents were within the range reported by (Fageer et.al., 2004) for twelve genotype 11.3 to 16.9% and (Ullah I., Ali M. and Farooqi A. (2010)) for 10 varieties 7.7 to 14.6%. Fat is one the macronutrient which provide more than twice of energy than carbohydrate and protein. Exceptionally, melkasa-6Q has the highest crude fat content than any other maize varieties under study as shown in table 4.1. This might be the fact that, melkasa-6Q is one the new varieties released for its high in protein and some other useful nutrient content in fighting malnutrition. The result obtained is inconsistent with the research done on seven different maize varieties by Kidist (2018) which are in the range of 5.13 to 7.22%.

Carbohydrate is one the macronutrient which provide energy. The carbohydrate content of three maize varieties (BH661, BH-549, MH-138) are under normal range. But there is Significant difference at $p<0.05$ in carbohydrate content when it comes to Melkasa-6Q as shown in table 1. This difference mainly come as result of melkasa -6Q has high amount fat content. And it is also the fact that being different variety, their response against different environmental factors. The

result obtained is inconsistent with the research done on seven different maize varieties by Kidist (2018) which is in the range of 67.10 to 69.99%.

Energy is obtained from the main macronutrients such as carbohydrate, protein and fat. There is no significant difference at P<0.05 in energy between all maize varieties except melkasa-6Q as shown in table 1 above. But there is a little difference in energy content among the three maize varieties under study except Melkasa-6Q. This is because of their difference in protein, carbohydrate and fat content. The result obtained is a little bit different from the research done by (Ullah I., Ali M. and Farooqi A. (2010)) on ten different maize varieties which are in the range of 365.95 to 385.83Kcal/100g.

3.2: Mineral content of maize

Table 2. Mineral's content of different Maize varieties

Maize varieties	Result in (mg/Kg)			
	Calcium (Ca)	**Zink (Zn)**	**Iron (Fe)**	**Total phosphorous (TP)**
BH661	670.7±41.54^{a}	59.62±1.59^{a}	135.1±7.85^{a}	669.9±21.38^{a}
BH-549	852.6±53.32^{b}	61.84±1.22^{a}	129.4±6.6^{a}	759.7±11.98^{a}
MH-138	1068.3±2.31^{c}	66.84±3.43^{a}	150.6±6.49^{ab}	976.5±19.82^{b}
Melkasa-6Q	1001.0±31.84^{c}	85.42±0.31^{b}	186.9±12.7^{b}	901.4±26.59^{b}

Key: Same letter in the same column is not significantly different from each other at p<0.05

Minerals are essential for body functions. The calcium content is in the range of 670.7 to 1068.3mg/Kg as shown in table 2 above. Except MH-138 and Melkasa-6Q there is significant difference in calcium content at P<0.05 among the maize varieties under study at p<0.05. This might be due to difference in variety, environmental factors, their utilities toward minerals in the soil. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 219.8 to 481.0mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 1290.27 to 1327.56mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons.

When it comes to Zinc, the values are in the range of 59.62 to 85.42mg/Kg. There is no significant difference in zinc content except Melkasa-6Q at $P<0.05$ as shown in table 2. This little difference comes as result of being difference in variety, their response against different harsh condition, soil types. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 23.1 to 29.3mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 6.1 to 33.89mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons.

The iron (Fe) content of different maize varieties under study is in the range of 129.4-186.9mg/Kg. There is some significance difference among maize varieties under study as shown in table 2 above. This is because of being different in their variety type, utility of minerals with in a soil, difference in soil minerals continent. The result obtained is in contradict with the research done in Ethiopia by Kidist (2018) on seven maize varieties which are in the range of 23.4 to 37.3mg/Kg and it also inconsistent with result of (Shaista Qamar et al.2016) done in Pakistan which are in the range of 80.73 to 115.13mg/Kg. This difference may be due to being in different agro-ecology, different farm management system, virginity of soil and some other reasons. Finally, the total phosphorous content of the four maize under study is in the range of 669.9 to 976.5mg/Kg. There is some significant difference among maize varieties under study as shown in table 4.2 above. These differences come as a result of being different in variety, soil mineral content, their utility toward this mineral.

4. Conclusion and Recommendation

From the result we conclude that, all maize verities have high macronutrients and minerals content especially melkassa-6Q. The high in protein and ash content is most important in fighting malnutrition especially the hidden hunger if these maize varieties are mixed with nutrient dense legumes and nuts or fortified with different supplements. The high in minerals content is an indication that our region soil is rich of minerals and virgin. Therefore, we recommend all stakeholders to work in collaboration to provide stress resistant, nutrient dense maize varieties to the community in ensuring food security.

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CONFLICT OF INTEREST

This is to confirm that, there is no conflict of interest between authors for this study.

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8. PHYSICOCHEMICAL PROPERTIES, PROXIMATE AND FUNCTIONAL PROPERTIES OF DIFFERENT RICE VARIETIES PRODUCED/ADAPTED UNDER SOMALI REGION AND IMPORTED RICE

ABDULKARIM MOHAMMED[1], MOHAMMED DOL[2], HOODO MOHAMMED[2], HOODO MOHAMED MOHAMUD[2]

1) Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research Directorate.
2) Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition research Directorate.

Abstract

Rice is one the staple food or crop that widely consumed in Somali community. The study was conducted in Somali Regional state with objective to analyze proximate, functional, physical and cooking qualities of different rice varieties produced in Somali reginal state. Six different types of samples such as Nerica 14, Nerica4, Nerica 2, Gode 1, Shabele 1 and Sukeyna as control sample were collected. Only whole rice grains without any physical damage or insect infestation were selected for analysis. The collected rice samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis. Proximate composition such as crude Protein, crude Fat, crude fiber, moisture content, carbohydrate, total energy, different minerals like Calcium, Iron, Magnesium and Total phosphorous were determined by AOAC. The functional and physical as well as cooking quality of the rice were determined different standard procedures. Based on the result all locally adapted rice varieties were better in both macro and micro nutrients especially Nerica 14, Nerica 2, and Gode 1 as compared to the control sample with brand name SUKEYNA which imported from abroad. The protein content ranges from 10.41% to 14.54%, while the ash content ranges from 0.51% to 1.25%. The same is true with other parameters such carbohydrate, crude fat, total energy too. There is significant different in different components of rice between different varieties at $p<0.05$. Significance difference were also observed at $p<0.05$ in minerals content such as Calcium, Magnesium, iron and Total Phosphorous where Nerica 14 had highest in almost all minerals content. The functional and physical properties of different rice varieties under study also significantly different at $p<0.05$. Overall, from the finding we conclude that, all locally adapted rice varieties have better in nutritional content both macro and micro -nutrient and also better in functional as well as physical properties. Therefore, all actors of rice should contribute the promotion as well large-scale production of these adapted rice varieties in order to substitute the imported rice from abroad.

Key words: Rice, Proximate composition, Functional Properties, Physical properties, Cooking time.

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal grain grown in the world. It is the staple food of nearly half of the world population. It is a regular Asian diet, usually taken as a whole grain after cooking, contributing about 40–80% of total calorie intake (Sarowar Hossain, Kumar Singh, & uz-Zaman, 2009). It is mostly consumed at household level as boiled or fried rice. The preference for taste, color, and stickiness of rice varieties varies among different cultures. The

two most important cultivated species of rice are *Oryza sativa* and *Oryza glaberriumn*. *Oryza sativa* is grown in most parts of the Asian and American continents, whereas *Oryza glaberriumn* is grown only in Africa. Rice consists mainly of carbohydrates in the form of starch, 72–75% of which contributes to the total grain composition. About 7% of protein mainly glutelin is present in rice. The glutelin present in rice is also called as oryzenin Sarowar (Hossain, Kumar Singh, & uz-Zaman, 2009).

Africa's rice production has not been able to match the growth in demand. With a high dependence on imports, Africa, as a whole, is highly exposed to international market shocks. This may have grave consequences for its food security and political stability. In many countries, African rice fails to compete with imports because large-scale commercial rice processing is poorly developed or limited, and urban consumers have become used to the look and feel of imported rice. The potential for growth in the overall African rice sector is enormous, but a rapid increase in the area under rice, irrigated as well as rainfed, is necessary (Alleoni, A.C.C., 2006).

In East Africa, a strong upward trend in production grew at a rate of 7.21% during the 2001-2005 period. Between 2001 and 2005, East Africa became nearly self-sufficient in rice, with rice imports representing only 7% of the total quantity consumed. However, with increasing rice demand in almost every country, reliance on the world market to supply rice to African consumers, even in relatively small amounts, is becoming a *very risky, expensive, and unsustainable strategy* and may lead to severe food insecurity and civil unrest. In terms of statistics, the total area brought under rice cultivation in East Africa increased at an annual rate of 0.45%. East Africa recorded a remarkably high rate of increase in yield between 2001 and 2005, at 6.73% per year (Childs N., 2015).

Rice is considered as the "Millennium Crop" to ensure food security in Ethiopia. In Ethiopia with about 17 million hectares of land suitable for rice production. Ethiopia has tremendous potential to increase the area under rice and is looking for partnerships to make use of this land. Constraints for sustainable increased production and productivity abound, however: poor access to improved rice varieties, especially for irrigated rice, and limited participation of seed growers in the production and marketing of rice seed; poor access and use of modern postharvest

techniques and equipment; grassy weeds and insect pests; limited access to credit; shortage of labor, specifically during periods of intensive weeding; poor knowledge of producers and other market actors about rice product quality; excessive numbers of intermediaries, and price seasonality; and finally, inadequate storage (MoA, 2010).

Rice is a strategic food security commodity in Ethiopia, and its production has effected significant change in the livelihoods of farmers and has created job opportunities for a large number of people across different areas of the country (Minilik T. et.al., 2013). In the Somali region, the production of rice will play an important role in abating the problem of food insecurity in the farming community. Enriching Livelihoods and increasing the quality control of rice production in the Somali region is mandatory, therefore it is important to implant with Rice Research in the Somali region. To the best of our knowledge, there is no literature available regarding the characterization of rice varieties grown in Somali region and despite the good progress with its possible challenges and other source indicate there is no research done on these rice varieties produced under SoRPARI and other part of the region so far. Therefore, this study is aimed to analyze proximate, functional, physical and cooking qualities of different rice varieties produced in Somali regional state.

METHODOLOGIES

Materials

Six different rice varieties produced/adapted under SoRPARI were collected and one popular widely marketed/imported variety as a control was purchased from the local market Supermarket. The six varieties produced or adapted under SoRPARI that were used for this study includes Shabele 1, Godey 1, Narica 14, Narica 2, Narica 4, and Sukeyna (as control sample) whereas the control rice type might be the one with most likely used by local community but imported one. Only whole rice grains without any physical damage or insect infestation were selected for analysis. Some equipment used in sample preparation were obtained from SoRPARI laboratories and missed equipment can be used from local institutes such as JJU. Further, after bringing to the laboratory, rice samples were individually grounded to a fine powder (30 mesh size), packed in air tight polyethylene plastic bags and were stored at 4°C until further analysis.

Physical properties

A. Thousand (1000) kernel weight, length–breadth ratio (L/B) and bulk density

One thousand rice kernels were randomly selected and weighed separately. For analyzing length-breadth ratio, the cumulative measurements of rice were measured in mm (n=10) and the value of L/B were recorded by dividing length by breadth. For bulk density, 50 g of rice grains was weighed and was dropped into a graduated glass measuring cylinder from a constant height (approximately 30 cm). The volume occupied by rice samples were recorded and bulk density were calculated as g/ml ratio (Seena and Sridhar, 2005; Singh *et al*., 2005).

Cooking properties

A. Minimum cooking time

Rice samples (2 g) was individually taken and cooked around 90°C in distilled water (20 ml) in a boiling water bath. The minimum time required for cooking were estimated by pressing the cooked rice samples between two glass slides (till no white core will left) by removing a few cooked kernels at regular time intervals.

Proximate Composition

Moisture content

The moisture content of the samples was determined by drying 10g of sample in an air oven at 105^{o}C to constant weight (16 -18 h).

Protein content of the flours

Protein content was determined according to AOAC (2000) using the official method 979.09, which comprised three major steps: digestions, distillation and titration, and quantification.

Experimental analysis of fat

The fat content of the complementary food samples (flours) was determined using a semi-continuous solvent extraction method (Soxhlet method) following the procedures of AOAC 960.39 (2000).

Experimental analysis of ash content

The ash content was determined based on AOAC (2000) using the official method 923.03.

Experimental analysis of the crude fiber content

The crude fiber content of the complementary foods (flour) was determined by using the official method of AOAC (2000).

Experimental analysis of carbohydrates

The total available carbohydrate concentration was determined by difference according to AOAC official method, (922.02, 925. 05).

% Carbohydrate = 100% - (%moisture + %protein + %fat + %ash + % crude fiber)…. (6)

Gross energy (total calorie)

Gross energy was determined by calculation from fat, carbohydrate and protein contents using the Atwater's conversion factors: 16.7 KJ/g (4 kcal/g) for protein, 37.4 KJ/g (9 kcal/g) for fat and 16.7 KJ/g (4 kcal/g) for carbohydrates and expressed in calories.

Mineral analysis

Mineral composition of the samples was determined according to methods recommended by Association of Official Analytical Chemists (AOAC, 2000). The mineral contents were determined by the procedure of AOAC (1984). Calcium, iron, and zinc were determined according to AOAC 2000 official methods of 985.35 using an Atomic Absorption Spectrophotometer while phosphorous was determined by official method of 986.24 using calorimetric method using ammonium molybdate.

Phosphorous determination

Phosphorous was determined by the colorimetric method using ammonium molybdate (AOAC, 2000).

Determination of functional properties

Oil and Water Absorption Capacity Determination

2g of the samples was mixed with 10ml of distilled water for 5 minutes respectively on a magnetic stirrer. The mixture was centrifuged at 3500rpm for 30minutes and the volume of the supernatant was measured by using 10ml measuring cylinder on each of the sample. The water density was taken to be 1g/ml.

WAC=$volume\ of\ water\ absorbed$/Weight of the sample used× 100

OAC=$volume\ of$ oil $absorbed$/Weight of the sample used× 100

Swelling index

4.0g of the Sample was filled up to 10 ml mark in a 100 ml graduated cylinder and added with water to adjust the total volume to 50 ml mark. The top of the cylinder (graduated) was firmly covered and mixed by the inverting of the cylinder. The suspension was then inverted again after 2 minutes and stood for additional 10 min. The volume occupied by sample was taken after 15 minutes.

Emulsion capacity (EC)

The flour/blend (2g) was dispersed in distilled water (10mL) and height of solution in the cylinder was measured. The solution was homogenized with refined canola oil (5mL) and the resulting emulsion was centrifuged at 1100 × g for 5 minutes. The height of the emulsified layer was measured and the emulsifying activity was calculated as the percent increase in the height of the solution by following equation:

$$\textbf{EC (\%)} = \boldsymbol{H2/H1 \times 100}$$

Where H1 is the initial height of solution before emulsification, H_2 is height of the emulsified layer.

Statistical analysis

All the analysis were performed in duplicate and presented as mean ± standard deviation. Statistical significance of the data obtained will be analyzed by One-way analysis of variance (ANOVA) followed by Duncan test by using GenStat version 17.0. The level of significance was considered at $P < 0.05$.

RESULT AND DISCUSSION

Result

Table 4.1: Proximate composition of different Rice Varieties

Varieties	Results in (%) (100g)						
	Moisture	**Ash**	**C.Fiber**	**C.Protein**	**C.Fat**	**CHO**	**Energy**
Shabele 1	9.235±0.04^{c}	0.86±0.02^{b}	0.70±0.01^{bc}	11.14±0.12^{b}	1.745±0.015^{a}	76.32±0.02^{d}	365.5±0.27^{b}
Gode 1	9.415±0.015^{d}	0.94±0.02^{c}	1.05±0.05^{cd}	12.21±0.08^{d}	2.115±0.095^{a}	74.27±0.22^{bc}	365.0±0.30^{b}
Nerica 2	8.915±0.015^{b}	1.24±0.00^{e}	0.65±0.15^{b}	11.56±0.115^{c}	2.485± 0.475^{a}	75.14±0.46^{c}	369.2±2.92^{bc}
Nerica 4	9.265±0.035^{c}	1.25±0.00^{e}	1.00±0.00^{bcd}	12.04±0.075^{d}	2.200±0.330^{a}	74.25±0.29^{bc}	364.9±1.51^{b}
Nerica 14	8.320± 0.05^{a}	1.18±0.02^{d}	0.25±0.05^{a}	14.54±0.105^{e}	2.650± 0.180^{a}	73.06±0.27^{a}	374.2±0.98^{c}
Sukayna	11.565±0.04^{e}	0.51±0.02^{a}	1.25±0.15^{d}	10.41±0.12^{a}	2.355± 0.287^{a}	73.91±0.31^{ab}	358.5±1.81^{a}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
Sukeyna: The control rice sample
CHO: Carbohydrate,
Energy: Energy in Calory unit obtained from consuming 100g of these rice varieties

Table 4.1: Show the proximate composition of different rice varieties produced under SoRPARI potential area and the control sample one with brand name SUKEYNA. In terms of moisture content, Nerica 14 has lowest while Sukeyna has highest moisture content. There is significant difference in moisture content between varieties but no significant difference between Shabele 1 and Nerica 4 varieties at $p<0.05$. When it comes to ash content, Nerica 4, Nerica 2 and Nerica 14 have high ash content than any other varieties. Sukeyna the control sample has least in ash content. Except Nerica 2 and Nerica 4 for which there is no significant difference in ash content all the other four varieties have significant difference in ash content at $p<0.05$.

From the two types of malnutrition, Protein energy malnutrition (PEM) is the one. In terms of protein content, Sukeyna the control sample has lowest protein content while Nerica 14 has the highest in protein content as compared to the other five samples. There is no significance difference in protein content between Gode1 and Nerica 4 varieties at $p<0.05$. but there is significant difference in protein content in between Shabele 1, Nerica 2, Nerica 14 and Sukeyna the control sample at $p<0.05$. According to table 4.1, there is no significance different in crude fat content between all samples at $P<0.05$.

Shabele 1 has the highest carbohydrate content while Nerica 14 has the lowest carbohydrate content. There is no significance difference between Nerica 14 and Sukeyna the control sample and also no significance difference between Gode 1 and Nerica 4 as well at P<0.05. There is no significance difference between Sukeyna the control sample, Nerica 4 and Gode 1 and also no significance difference Nerica 4, Nerica 2 and Gode1 in carbohydrate at P<0.05. Shabelle 1 has significantly highest carbohydrate than any other varieties at p<0.05. there is also significant difference in carbohydrate content between Nerica 14 and other varieties such as Nerica 4, Gode 1, Nerica2 and Shabele 1 at p<0.05.

Energy in calory unit was calculated based on the macronutrient content obtained. Based on this, Sukeyna the control has the lowest while Nerica 14 has the highest in energy content. There is no significance difference in energy obtained from consuming Shabele 1, Gode1, Nerica 2, and Nerica 4 at p<0.05. There is significant difference in energy obtained from consuming Nerica 14, Sukeyna the control sample at p<0.05. In general, Nerica 14 and others four varieties under SoRPARI adoption have high protein and energy and also Ash content which is the indicator for having highest minerals content as compared to SUKEYNA the control sample.

Table 4.2. Minerals content of different rice varieties

Varieties	Results in mg (%)			
	Ca	**Mg**	**Fe**	**TP**
Shabele 1	385.5 ± 0.00^{b}	749.3 ± 0.00^{bc}	29.11 ± 1.85^{d}	1685 ± 1.15^{c}
Gode 1	320.1 ± 11.04^{b}	563.2 ± 93.88^{ab}	19.46 ± 0.03^{b}	1383 ± 0.92^{b}
Nerica 2	411.6 ± 27.45^{b}	933.6 ± 0.00^{cd}	27.86 ± 0.355^{cd}	2280 ± 0.23^{e}
Nerica 4	462.7 ± 0.00^{b}	682.7 ± 120.48^{abc}	19.59 ± 0.02^{b}	1756 ± 0.46^{d}
Nerica 14	746.7 ± 92.66^{c}	1059.6 ± 132.45^{d}	25.16 ± 0.135^{c}	2434 ± 0.00^{f}
Sukayna	158.2 ± 0.00^{a}	432.6 ± 0.00^{a}	1.15 ± 0.00^{a}	1250 ± 0.00^{a}

Same letter in the same column is not significantly different from each other at p<0.05
Sukeyna: The control rice sample
Ca: Calcium, **Mg**: Magnesium **Fe**: Iron **TP**: Total Phosphorous

The minerals content of the different rice varieties under study also depicted in table 4.2. Calcium, magnesium, iron and total phosphorous were the minerals under study. Regarding the calcium content, Sukeyna the control sample has the lowest while Nerica 14 has the highest in calcium content. There is no significance difference in calcium content Shabele1, Gode1, Nerica2 and Nerica4 at P<0.05. There is significance difference in calcium content between

Nerica 14 and Sukeyna the control sample as well Nerica 14 with the others four varieties such as Shabele1, Gode1, Nerica 2, and Nerica 4 at $P<0.05$. With respect to magnesium content, Nerica 14 is again highest while Sukeyna the control sample has lowest in magnesium content. There is no significance difference in magnesium content between Sukeyna the control sample, Nerica 4, and Gode 1 at $P<0.05$. There is also no significance difference between Shabele1, Gode1 and Nerica 4 in magnesium content at $P<0.05$. In similar fashion, no significance difference was observed in magnesium content at $P<0.05$ between Nerica 2, Nerica 4 and Shabele 1. Significance difference were observed at $P<0.05$ between Nerica 14 and Sukeyna the control sample and between Nerica 14 and other four varieties such as Nerica2, Nerica 4, Shabele 1 and Gode 1.

When it comes to Iron content, Sukeyna the control sample has the lowest of all in Iron content while Shabele 1 has the highest. There is no significance between (Gode 1 and Nerica 4), (Nerica 14 and Nerica 2), (Shabele 1 and Nerica 2) in iron content at $P<0.05$. Significance difference were observed Shabele 1 and Sukeyna the control sample as well between Shabele 1 and Gode1, Nerica 4 and Nerica 14 at $P<0.05$. Last but not list, in total phosphorous content, Sukeyna the control sample has lowest while Nerica 14 has highest in total phosphorous content. There is 100% significance difference between every single varieties of the rice under this study at $P<0.05$. In general, Sukeyna the control sample has lowest content in the four minerals that were included under this study while Nerica 14, has highest content in 3 out 4 minerals under study except iron (Fe). It is Shabele 1 which is highest in Iron content as compared to other varieties. All in all, the five varieties under SoRPARI potential production have higher in Protein, Ash, energy obtained and all minerals than the control sample Sukeyna which is imported from abroad.

Table 4.3. Functional Properties of different rice varieties

Varieties	Results			
	WAC	**OAC**	**Swelling Index**	**Emulsion Capacity**
Shabele 1	7.950 ± 0.15^{c}	7.6 ± 0.20^{c}	50.00 ± 0.00^{c}	106.3 ± 0.20^{b}
Gode 1	6.900 ± 0.50^{b}	6.65 ± 0.25^{b}	48.75 ± 0.25^{ab}	109.7 ± 0.10^{c}
Nerica 2	7.550 ± 0.15^{bc}	7.15 ± 0.05^{bc}	49.00 ± 0.50^{bc}	107.6 ± 0.30^{b}
Nerica 4	6.750 ± 0.05^{a}	6.4 ± 0.20^{ab}	49.25 ± 0.25^{bc}	110.0 ± 0.50^{c}
Nerica 14	5.700 ± 0.3^{b}	5.7 ± 0.30^{a}	47.75 ± 0.25^{a}	115.0 ± 0.45^{d}
Sukayna	6.950 ± 0.15^{b}	7.5 ± 0.30^{c}	48.75 ± 0.25^{b}	104.8 ± 0.50^{a}

Key: Same letter in the same column is not significantly different from each other at $p<0.05$
Sukeyna: The control rice sample
WAC= Water Absorbing Capacity OAC= Oil Absorbing Capacity

Table 4.3 shows the functional properties of different rice varieties under study. According to the table 4.3, different result has observed when it comes water absorbing capacity (WAC). Nerica 4 has shown lowest while Shabele 1 has the highest WAC. There is no significance difference between Nerica 14, Nerica 2, Sukeyna the control sample and also no significance difference in between Nerica 2 and Shabele 1 at $p<0.05$. The WAC were significantly different in between some varieties such as Shabele 1 & Gode 1, Nerica 4, Nerica 14, and Sukeyna the control sample at $p<0.05$. Significance difference were also observed in between Nerica 4 and Nerica 14 & Sukeyna the control sample at <0.05.

When it comes to oil absorbing capacity (OAC), different result was observed. Nerica 14 has the lowest while Shabele 1 has the highest in OAC. There is no significance difference in OAC between Shabele 1 & Sukeyna the control sample, Nerica 14 & Nerica 4, Nerica 4 & Nerica 2, Nerica 2 & Gode1 at $p<0.05$. OAC were significantly different between Shabele & Sukeyna the control sample and Nerica 14, Nerica 4 & Gode 1 at $p<0.05$. Significant difference was also observed between Nerica 14 and Nerica 2 at $p<0.05$.

Swelling index of the different rice varieties are shown in table 4.3. Nerica 14 has the lowest while Shabele 1 is the highest in swelling index. Except some no that much significant difference were observed between varieties in swelling index as shown in table 4.3. Swelling index was significantly different in between Shabele 1 and Sukeyna the control sample and also in between Nerica 14 & Nerica 2 at $p<0.05$. Swelling index is also significantly different in between Shabele 1 and Nerica 2, Nerica 4, Nerica 14 and Sukeyna the control sample at $p<0.05$.

The final variable under this table about emulsion capacity as shown in table 4.3 above. Sukeyna the control sample has the lowest emulsion capacity while Nerica 14 has the highest. There is no significancy difference in emulsion capacity between Gode 1 & Nerica 4 and between Shabele 1 & Nerica 2 at $p<0.05$. Except those mentioned who have no significance difference between them, there is significance difference between others when it comes the emulsion capacity as shown in table 4.3 above.

Table 4.4. Physical properties and Minimum cooking time

Varieties	Results in			
	1000 Kernel weight	**Bulk density (g/ml)**	**Length-breadth ratio (L/B)**	**Minimum cooking time in min**
Shabele 1	19.55 ± 0.25^{a}	0.570 ± 0.01^{b}	3.5 ± 0.1^{c}	22.6 ± 0.2^{b}
Gode 1	25.5 ± 0.20^{b}	0.570 ± 0.01^{b}	3.2 ± 0.1^{c}	23.4 ± 0.6^{b}
Nerica 2	24.75 ± 0.55^{b}	0.515 ± 0.015^{a}	2.7 ± 0.2^{b}	26.3 ± 0.4^{c}
Nerica 4	23.90 ± 1.20^{b}	0.515 ± 0.005^{a}	2.4 ± 0.3^{ab}	28.5 ± 0.0^{d}
Nerica 14	30.30 ± 1.10^{c}	0.515 ± 0.005^{a}	2.14 ± 0.2^{a}	31.5 ± 0.1^{e}
Sukayna	23.75 ± 0.75^{b}	0.495 ± 0.005^{a}	3.6 ± 0.3^{c}	14 ± 0.4^{a}

Same letter in the same column is not significantly different from each other at $p<0.05$
Sukeyna: The control rice sample

The physical properties and minimum cooking time of the difference rice varieties have shown in table 4.4 above. Shabele 1 has the lowest the kernel weight while Nerica 14 has the highest. No significance difference was observed in 1000 kernel weight evaluation between Gode1, Nerica 2, Nerica 4 and Sukeyna the control sample at $p<0.05$. 1000 kernel weight is significantly different in between Shabele 1 & Nerica 14 and also significantly different between Shabele 1 and Gode1, Nerica 2, Nerica 4 and Sukeyna the control sample at $p<0.05$.

The bulk density of different rice varieties under study were also indicated in table 4.4 above. Sukeyna the control sample has the lowest while Shabele 1 and Gode 1 have the highest bulk density. Bulk density is not significantly different in between Shabele 1 and Gode 1 at $p<0.05$. In a similar fashion, there is no significant difference in the bulk density between Nerica 2, Nerica 4, Nerica 14 and Sukeyna the control, sample at $p<0.05$. But significance difference was observed in between the two group which means between Shabele 1 & Gode 1 and the other four varieties Nerica 2, Nerica 4, Nerica 14 and Sukeyna the control, sample at $p<0.05$.

The length-breadth ratio (L/B) of the different rice varieties also indicated in table 4.4 above. Nerica 14 has shown the lowest L/B while Sukeyna the control sample has the highest L/B. The L/B ratio is not significantly different in between Shabele 1, Gode1 and Sukeyna the control sample as shown in table above at $p<0.05$. Similarly, no significance difference in between Nerica 14 & Nerica 4 and also between Nerica 4 & Nerica 2 in L/B ratio at $p<0.05$. But there is significance difference in between Sukeyna the control sample, Shabele1 & Gode 1 and with others varieties like Nerica 2, Nerica 4 & Nerica 14 at $p<0.05$ in L/B ratio. Significance difference is also observed in between Nerica 2 and Nerica 14 at $p<0.05$ in L/B ratio.

Finally, the minimum cooking time of the different rice varieties is depicted in table 4.4 above. Sukeyna the control sample has the lowest minimum cooking time while the Nerica 14 has the highest minimum cooking time as shown in table above. Except Shabele 1 and Gode 1 for which no significant different was observed in the minimum cooking time, there are significant difference between others rice varieties under study at $p<0.05$. Nerica 14 which has the highest minimum cooking time is significantly different from all other varieties which followed by Nerica 4, Nerica 2, Gode1 and Shabele 1 at $p<0.05$.

DISCUSSION

Proximate composition (Macro-nutrient)

The macro-nutrient composition of the different rice varieties has been depicted in table 4.1; the five rice varieties adapted under SoRPARI potentials areas have lower moisture content than the control sample with SUKEYNA brand name. The lower in moisture content indicate advantage longer shelf life as compared to others varieties with higher moisture content. Basically, the lower moisture content is associated with dry condition storage environment during study time which means lower relative humidity. The difference in moisture content between varieties as compared to the control sample is come from agro-ecology and processing methods difference. Comparable result has been obtained from similar research on rice that has been done in Malaysia (Rachel T, et, al, 2013).

Table 4.1 also indicates the ash content of different rice varieties under study. Significant difference was obtained in ash content between the different rice varieties. In similar way, the

ash content of those rice varieties adapted under SoRPARI potential areas were by far higher than the control sample called Sukeyna. There is also difference in ash content between each variety of SoRPARI rice. This might be the agro-ecology difference especially soil and water, genetic difference, and processing methods difference. The high in ash content linked with advantage of having high minerals content for rice and any other food product. The result is in line with the research done in Nigeria Eboniyi State and Malaysia (Oko A, et, al, 2010 and Rachel T, et, al, 2013).

When it comes to protein content, those rice varieties under SoRPARI potential area which Gode in this case have higher than the control sample called Sukeyna as shown in table 4.1 above. Specially Nerica 14, Nerica 4 and Gode 1 have highest protein content as compared to others varieties. The highest in protein content might be at the cost of others lower component especially the moisture content. The highest in moisture content is highly advantageous in fighting against malnutrition the so-called protein energy malnutrition (PEM) for the community like Somali who use rice as their staple food. The difference in protein content might be associated with agro-ecology difference, processing method difference and genetic difference between rice varieties. Similar difference in protein content among difference rice varieties were obtained in the research done in India, Manipur province and in Nigeria Eboniyi State and Malaysia (Chagam K., et, al., 2020., Oko A, et, al, 2010 and Rachel T, et, al, 2013).

There also difference in other main composition such as fat, crude fiber, carbohydrate. This difference came as result of difference in processing methods, genetic difference among rice and some other reasons. The cumulative impact of difference in macro nutrient composition come with the difference in energy obtained from consuming these rice varieties as shown in table 4.1. The result is in line with other research done on difference rice varieties mentioned above.

Proximate composition (Micro-nutrient/Minerals)

Minerals have an abundant nutritional importance in human health and are required to maintain a balanced diet, which is important for conserving all regular metabolic functions. All pigmented rice varieties are a rich source of minerals, such as iron, calcium, phosphorus and magnesium.

The minerals content of different rice varieties is also depicted in table 4.2 above. The mineral content is more or less linked to the ash content of the rice as other food type. Overall, the

control sample called Sukeyna has lowest in almost all minerals content than any others varieties in study area. This indicates, the local varieties are still preferable than the control sample when it come minerals content. With respect to calcium, magnesium and total phosphorous content, Nerica 14 has highest, followed by Nerica 4 and by other varieties as shown in table 4.2. The variances in the mineral content of selected rice varieties may happen due to various factors such as rice genotypes, agronomic, cultivation conditions and the different processing methods followed. Similar difference in minerals among difference rice varieties were obtained in the research done in India, Manipur province and in Nigeria Eboniyi State and Malaysia (Chagam K., et, al., 2020., and Oko A, et, al, 2010).

Functional Properties

The functional properties of different rice varieties indicated in table 4.3 above. The water and oil absorbing capacity of the rice varieties shows differences in their association with oil and water. Water absorption capacity (WAC) is the capacity of the flour to absorb water and swell for enhanced consistency in food (Hannington. T. et.al. 2020). The WAC of a food product measures the water holding ability by the starch after the swelling in excess water, which corresponds to weight of the gel formed, and therefore is an index of degree of starch gelatinization. It depends on the availability of the hydrophilic groups which bind the water molecules and also on the gel-forming capacity of the macromolecules (Hannington. T. et.al. 2020).

Water absorption capacity is an important functional property required in food formulations especially those involving dough handling (Lorenz & Collins, 1980). The observed variation in water absorption capacities between different rice varieties maybe attributed to different protein concentrations, their degree of interaction with water and their conformational characteristics (McWatters, Ouedraogo, Resurreccion, Hung, & Phillips, 2003). This effect could be as a result of the loose association of amylose and amylopectin in the starch granules and weaker associative forces maintaining the granular structure. Water absorption capacity is important in bulking and consistency of products as well as in baking applications (Lorenz & Collins, 1980). Thus, the sample with the highest water absorption capacity is best accepted in baking applications.

Oil absorption capacity (OAC), also called oil absorption, is the binding of fat by the proteins' non-polar side chain. Oil absorption capacity (OAC) is mainly attributed to the entrapment of oils physically. It is an indication of the rates at which proteins bind to fat in food formulations (Hannington. T. et.al. 2020). Oil absorption capacity is an important functional property that enhances the mouth feel while retaining the flavors of food products which intron important in food formulation (Adebowale & Lawal, 2004). The oil absorption capacities of the flours were different among the different rice varieties as shown in table 4.3 above. From statistical analysis, there was a significant difference ($p < 0.05$) in the oil absorption capacity of the flour samples. Absorption of oil by food products improves mouth feel Physical properties and minimum cooking time.

The emulsion capacity values were ranged from 104.8 to 115.0 for the different rice varieties as shown in table 4.3. Emulsion capacity differs significantly among some of the rice varieties. The higher emulsion capacity could be as a result of higher protein content as different research result shows. The emulsion capacity (EC) of foods is associated with the amount of oil, water, residues of non-polar amino acids on the surface of protein, and other constituents in the food (Hannington. T. et.al. 2020). The swelling indices of different rice varieties also indicated in table 4.3 and the result ranged from 47.75 to 50.0. The swelling indices of the flour samples differed significantly ($p < 0.05$). This result may be due to the variety of the sample, difference in agronomy of rice, the processing method adopted. Swelling capacity is regarded as a quality criterion in some good formulations as bakery products. It is an evidence of non-covalent bonding between molecules within starch granules and also a factor of the ratio of α-amylose and amylopectin ratios (Rašper, 1969).

Physical properties and Minimum cooking time

The physical properties and the minimum cooking time among different rice varieties are depicted in table 4.4. There is more or less some significance difference between different rice varieties with respect bulk density. The bulk density ranged from 0.495 to 0.570 as shown in table 4.4. the difference in bulk density may be due to the intrinsic characteristics of each variety. Density values are useful in design of silos and storage bins. The same difference in bulk density

among different rice varieties also obtained in research done in Kashmir valley, India (Tanveer A. et, al., 2016).

Thousand grain weight showed significant difference and varied from 19.55 to 30.30 g. Nerica 14 had the highest thousand grain weight and Shabele 1 had the lowest. Low thousand grain weight may due to the low moisture content which increases the probability of more damaged grains during milling. The result obtained is in contrast to the research done in Kashmir valley, India (Tanveer A. et, al., 2016).

There was significant difference in the l/b ratio between different rice varieties studied as shown in table 4.4 above. The values of l/b ratio could be used to determination the shape of individual rice grain. An l/b ratio of above 3 is generally considered as slender and below 3 is generally considered as bold (IRRI International Rice Research Institute, 1980). L/b value of some of the varieties studied was below 3.0; while some other were above 3 hence, they can be considered as bold and slender respectively. According to McKenzie and Rutger (1983) cooking and eating qualities of rice are strongly influenced by shape and width of grains, hence determining the shape and width of grain is essential.

The cooking properties of rice are important as it is consumed almost immediately after cooking. Rice being a major staple food in most of the developing countries, reduced cooking time can be beneficial, especially when fuel consumption is of concern. Cooking time of a rice grain is usually ascertained when 90% starch of grain no longer shows an opaque center (Dipti, Bari, & Kabir, 2003). The minimum cooking time of all rice varieties are shown in Table 4.4. The varietal difference showed significant effect on cooking time. Cooking time varied between 18.0 and 31.5 min.

Variation in cooking time can be attributed may be due to difference in genetics, processing methods and different structure of the rice itself. Higher cooking time is required for rice varieties having fibrous bran layer attached (Juliano & Bechtel, 1985). In terms of fuel and energy consumption during cooking, lower cooking time is better. The variation in the cooking time could also be attributed to its gelatinization temperature, since gelatinization temperature positively determines the cooking time of rice. It has been asserted that the higher the value of gelatinization temperature, the longer time it takes to cook rice. According to Bhattacharya and

Sowbhagya (1971), cooking time is primarily related to the surface area of the milled rice and unrelated to other grain properties.

CONCLUSION

The study shows that, there is significance difference between different rice varieties in terms of proximate composition both macro and micro nutrient content, difference in functional properties and physical & cooking quality difference. Significance difference were observed in moisture, crude protein, ash, energy in calory unit and other contents among different rice varieties under study. The difference in macro nutrient more prominent when comparison made between the control sample with brand name SUKEYNA and others locally adapted varieties by Somali Pastoral and Agro-Pastoral Research Institute (SoRPARI) specifically with those NERICA varieties. Significance difference also observed when it comes to different minerals analyzed for these rice varieties such as calcium, magnesium, iron and total phosphorous. In this regard too, locally adapted varieties are by far better in minerals content than the control sample called SUKEYNA. With respect to functional and physical properties, all varieties had shown almost better association with different ingredient such as water, oil and other which very important to develop different food product from rice with other food products.

In general, the locally adapted rice varieties have better in terms of nutritional composition especially Nerica 14, Gode1 and Nerica 4 as compared to the widely used rice available in local market with brand SUKEYNA and others.

RECOMMENDATION

There are a huge gaps and problems seen as we gone through study on different rice varieties locally adapted by Somali Region Pastoral and Agro-Pastoral Research Institute and the imported rice with brand name SUKEYNA and other market dominated rice. Based on the gaps and problem identified the research team recommend the following points;

- Rice is one of the staple foods especially for Somali community. Government and other concerned bodies should come up with clear plan of policy and strategy that give more emphasis to rice production at national or if possible regional level just as it currently underway for wheat production to substitute imported rice.

- Rice needs mechanized agriculture as compared to other crop production. Government and other concerned bodies should adapt and come with different technologies of agricultural mechanization that are compatible with rice production especially post-harvest technology.
- Federal and Regional level government specially Investment commission should encourage investors to the provision of different technologies related rice industry or project and also facilitate & encourage them to engage in large scale rice production.

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CONFLICT OF INTEREST

- This is to confirm that, there is no conflict of interest between authors for this study

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9. DEVELOPMENT OF COMPLEMENTARY FOOD FROM SORGHUM BLENDED WITH PEANUT

Mohammed Dol[1], Abdulkarim Mohammed[2],Hodo Mohamed[2]

[1]Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition program
[2]Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition program

Abstract

Improving the nutritional status of the infants requires the optimum use of available food. The objective of this study was to develop a Product and Evaluate its Proximate Composition and Sensory Properties of Sorghum Blended with Peanut (SBP) For Nutritional Improvement of Sorghum Foods. To do this, the raw materails were cleaned, and de-hulled before being milled. seven formulations of composites flours composed of 100% of sorghum flour and 0% of peanut flour, 92.5% of sorghum flour and 7.5% of peanut flour, 85% of sorghum flour and 15% of peanut flour, 77.5% of sorghum flour and 22.5% of peanut flour, and 70% of sorghum flour and 30% of peanut flour were produced. The technological properties and the nutritional characteristics of the composite flours were determined using AOAC methods. From the results, the water absorption capacity(WAC) of the present study, the composite flour was varied between 128.15-133.96%. The results shows that the mixture proportions of the sorghum and peanut have a strong linear significance (P≤ 0.01)effect on the water absorption capacity. The moisture content of the SBP sample flour were ranged between 5.34 to 6.35%. also the mixture proportion of 70 grams of sorghum and 30 gram of peanut had the highest moisture contents compared to the other ratios of the mixture and these results indicated that increasing peanut ratio is increases the moisture content of the sample flours of the mixtures. the result indicates that the crude protein content of the SBP samples were ranged between 12.53 to 17.38% of protein concentration. the highest protein (17.38%) content was observed from the ratio of 70 gram of sorghum and 30 gram of peanut flour which assumed to be promising potential as a good source of plant protein. The crude fat content of sorghum and peanut flour recorded in this study was found in between the values 4.40-15.61% . The total carbohydrate content ranged from 54.08% to 75.33% for all the formulations. According to the finding of the study sorghum with zero peanut ration was indicated the highest carbohydrate contents and lowest carbohydrate contents was seen with peanut ration of 30 gram. The total energy content of sorghum flour, and peanut flour was shown in. The total energy content of SBP sample flours were varied from 388.86% to 423.80 kcal/100g. According to the average sensory assessments of the SBP product's color, scent, taste, mouth feel, and overall acceptability, the inclusion of peanut flours significantly changed the product's sensory attributes.

Key words: SBP product, Proximate composition, comlementary food, sorghum, Peanut.

INTRODUCTION

Food crops have continued to be an important source of human nutrition as they are the major sources of nutrients, proteins, and calories for populations, especially in developing nations. Sorghum (Sorghum bicolor) is one of the oldest known cereal grains and ranked fifth in the world after wheat, rice, maize, and barley in terms of production ADDIN EN. Sorghum (Sorghum bicolor L.) as a potential source of bioactive substances and their biological Critical Reviews in Food Science and Nutrition . It constitutes the main food grain for over 750 million people who live in the semi-arid tropics of Africa, Asia, and Latin America. The largest group of producers is small-scale subsistence farmers with minimal access to production inputs such as fertilizers, pesticides, improved seeds (hybrids or varieties), good soil and water, and improved

credit facilities for their production (Jiru & Usmane, 2021). The most important producers are the United States, Nigeria, Sudan, Mexico, China, India, Ethiopia, Argentina, Burkina Faso, Brazil, and Australia. Burkina Faso is the world leader in sorghum production and consumption per inhabitant (Dicko, Gruppen, Traoré, Voragen, & Van Berkel, 2006).

More than 35% of sorghum is grown directly for human consumption. The rest is used primarily for animal feed, alcohol production, and industrial products (Pontieri et al., 2012). This crop sustains the lives of the poorest, rural people. Availability, storage, utilization, and consumption of their food crop will significantly contribute to household food security and nutrition of the inhabitants of this area. Sorghum while playing a crucial role in food security in Africa, its also a source of income for households (Tadele, 2019). Although sorghum is grown mainly for the energy stored in its starch, the protein quality is critically important in developing countries where the human diet consists mainly of cereal (Lorenzo et al., 2017).

Sorghum protein is higher than that of rice, equal to or higher than that of maize, and roughly equivalent to that of wheat (Rooney & Serna-Saldivar, 2000). Protein content and composition varies due to genotype, water availability, soil fertility, temperature, and environmental condition during grain development (Mofokeng, Shimelis, & Laing, 2017). Sorghums are rich sources of micronutrients (minerals and vitamins) and macronutrients (carbohydrates, proteins, and fat). Sorghum-based foods have continued to be nutritionally deficient and organoleptically inferior. This is largely due to the presence of anti-nutritional factors (ANF) such as tannin and phytic acid inhibitors which bind these food ingredients into complexes making them unavailable for human nutrition (Ogbonna, Abuajah, Ide, & Udofia, 2012).

Sorghum may be an alternative food for people who are allergic to gluten. Also, Sorghum has health benefits such as inhibiting cancer tumor growth, protecting against diabetes and insulin resistance, being safe for people with celiac disease, helping manage cholesterol, antioxidants in sorghum high relative to other grains, and fruits, and also sorghum may help treat human melanoma.

Peanut (Arachis hypogeae L), is an important energy-dense source of plant protein usually consumed after roasting and typically processed into different forms such as peanut butter, sweets, chocolate, cakes, and other peanut butter and jam sandwiches are very popular with raw roasted, shelled or unshelled corms of peanut being available throughout the year (Singh et al., 2021). Peanut (Khalid et al., 2022), also known as groundnut, is one of the most important sources of vegetable oil and protein. Peanuts are believed to have originated in the Central American region where they spread to other parts of the world. Peanuts are often enriched with health-benefiting nutrients that are essential to human health. They are actually legumes but are the most frequently eaten nut and more than 300 different varieties of peanut are grown worldwide (Sobowale, Adebo, & Mulaba-Bafubiandi, 2019). In recent years, different approaches and consequent legume-based food industries have been using peanuts as alternative protein supplements to address protein deficiency in meals. This protein deficiency is still prevalent, particularly in developing countries, thus necessitating the development of dietary balanced foods to address this challenge (Meena, Das, Yadav, & Lal, 2018).

In Ethiopia, the economy is predominantly agrarian, where 95% of the farmland was cultivated by smallholder farmers and 90% of the total agricultural output comes out of them (Gebre, Workiye, & Haile, 2021). Agricultural commercialization brings about sustainable food security, and welfare and enhances vertical and horizontal market linkages (Tirkaso, 2013). In Ethiopia, cereals are the major food crops both in terms of the area they are planted and the volume of

production obtained. Out of the total grain crop area, 79.83% (11,610,331 ha) was under cereals and it contributed 87.08% (about 283,922,484 quintals) of the grain production central statistical agency (Haile, Gebre, & Workye, 2022).

In Ethiopia Sorghum is processed at a household level using traditional means, such as small grain mills. The grain is consumed in various forms, including Injera (Kimis,Loxoox), Soor(Shuuro), porridge, nefro, and local drinks. So, to improve the nutritional quality of cereal-based traditional diets in Ethiopia, the use of peanut flour as a protein supplement has often been suggestible. So, sorghum, and peanut could be exploited since they are easy to access in the region. The product could be prepared at home and it will substitutable with CSB+, especially during food pipeline breakdown to avoid relapses. Therefore, the aim of this study were the influence of different composites of sorghum and peanut flour on proximate composition and functional characteristics, after which the composites were developed into SBP flour and their sensory characteristics were evaluated.

MATERIALS AND METHOD

Raw Materials

The experimental materials were obtained from the local market from Jigjiga city. Sorghum grains and peanut were collected about 5kg of the two samples.

Sample Preparation

Preparation of sorghum flour

Preparation of sorghum flour was done according to the method developed by(Almeida-Dominguez, Serna-Saldivar, Gomez, & Rooney, 1993). Five kg of sorghum grains were cleaned, sorted, small, broken and immature grain, dust, sand, stones, and other foreign materials were removed. The cleaned sorghum was washed with tape water and milled by portable hand machine after that it packed in airtight polythene plastic bags and stored at room temperature in dry place.

Preparation of Peanut flour

Preparation of peanut flour was done according to the method developed by (Arab, Helmy, & Bareh, 2010). Defective seeds (with holes) removed, de-hulled manually, milled, sieved and packed in airtight polythene bag, and stored at room temperature until it is needed for chemical analysis.

Experimental design and formulation of composite flour

Experimental design

This study was carried out to find the appropriate ratio of sorghum, and peanut in composite flours for complementary foods. D-optimal mixture design with a total formulation of 7 (Table 2), which was obtained by inserting a range of sorghum 70-100g, and 0-30g was used to set up the experiment (Table 2). The range of thus ingredient was determined based on different literatures and trends in the study area (Mahgoub, 1999).Flour of the two basic ingredients was formulated by blending two of them using computer generating Design-Expert®, version 13. The simplex lattice design plot for the 2-components of mixture formulations (sorghum and peanut) was presented in table 3.

Table 3. Lower and upper limits of compost flours in mixture design

Ingredients	Lower limit	Upper limit
Sorghum	70	100
Peanut	0	30

Blending of sorghum based complementary food

Food formulation for infant and young children is undertaken using(Cameron & Hofvander, 1983) methods. In this experiment, a multi-mix infant formula was including two basics ingredients:

- Staple as the main ingredient (sorghum)
- Protein source from a (peanut)

In order to formulate CF, the primary criteria are to select ingredients that are rich in providing protein, energy and vitamin requirements of young children.

Table 4. Sorghum and Peanut blending ratio by using mixture D-optimum

Std	Run	A:Sorghum	B:Peanut
7	1	70	30
3	2	85	15
6	3	100	0
2	4	70	30
5	5	77.5	22.5
1	6	100	0
4	7	92.5	7.5

S:Sorghum, P:Peanut

Proximate Composition Analysis

Moisture content

Moisture contents of raw Sorghum flour and nixtamalized Sorghum flour samples were determined according to AOAC (2000), using the official method 925.05. Calculated the moisture content from Eq. (1):

$$\text{Moisture content (\%)} = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) \times 100 \qquad (1)$$

Where: M_1= mass of empty dish

M_2=mass of the empty dish plus mass of the sample before drying

M_3=mass of the empty dish plus mass of the sample after drying

Crude protein

According to AOAC method 979.09 (2000), the Kjeldahl method were used a semi-automatic (VELP SCIENTIFA nitrogen analyzer) to determine the crude protein. Then the result was calculation as follows Eq. (2) and Eq. (3)

$$\text{Total nitrogen (\%)} = \frac{((V - V_b)xNx14)}{W} \quad (2)$$

$$\text{Crude protein (\%)} = (\text{total nitrogen(\%)x6.25}) \quad (3)$$

Where: V = volume of acid consumed to neutralize the sample
V_b= the volume of acid consumed to neutralize the blank
N = normality of the acid
W = weight of the sample.

Crude fat

The crude fat analysis determined by using the Soxhlet extraction according to AOAC (2000) method 4.5.01. After that, calculate the amount of fat in nixtamalized flours were calculated by using the following formula:

$$\text{Fat(\%)} = \left(\frac{m_f - m_i}{m}\right) \times 100 \quad (4)$$

Where: mf = dried mass of fat with cup
mi = mass of the cup
m = weight of the sample

Crude fiber

Crude Fiber Content of the nixtamalized sorghum flour were determined according to AOAC (2000), using the official method 920.169. Calculated the crude fiber from Eq. (5).

$$\text{Crude fiber (\%)} = \left(\frac{M_2 - M_1}{W}\right) \times 100 \quad (5)$$

Where: M1 = the mass of the crucible, the sand, and the wet residue
M_2 = the mass of the crucible, the sand, and ash
W = sample weight dry matter basis

Total ash content

Total ash content was determined gravimetrically (AOAC, 2000) using the official method 941.12. Calculated the ash content of the sample as given by Eq. (6).

$$\text{Ash(\%)} = \frac{\text{Weight of ash(g)}}{\text{Weight of sample(g)}} * 100 \quad (6)$$

Total Carbohydrate content

Determination of the carbohydrate content of sorghum flour samples by using the difference (Qamar et al., 2017; Ciabotti et al., 2016). The carbohydrate content estimated were subtracted from the moisture, fat, protein, fiber, and ash contents.

$$\%CHO = 100 - (\%moistur + \%protein + \%fat + \%ash + \%fiber) \quad (7)$$

Where: CHO = percentage of carbohydrate.

Energy content

Determination of energy content were obtained from multiplying the mean values of crude protein, utilizable carbohydrate, and crude fat by the factors of 4, 4, and 9, respectively. Then the sum of the products and the result were expressed in kilocalories per 100g (Kcal/100g) as reported by Atwater general factors system. The below formula shown were used for calculating energy.

$$Energy(kcal/100g) = 4 \times \%\ protein + 4 \times \%\ carbohydrate + 9 \times \%\ fat \qquad (8)$$

Mineral Analysis

Calcium

Determination of calcium content by using an Atomic Absorption Spectrophotometer (AACC, 2000). Calculating the calcium content were used by the following formula:

$$Ca\ (ppm) = \frac{C \times 100}{S} \qquad (9)$$

Where: C = the concentration of the sample from a plot of absorption in µg/ml, S = weight of the sample

Iron

Determination of iron content by using an Atomic Absorption Spectrophotometer (AACC, 2000). Iron content calculated with the following formula:

$$Fe\ (ppm) = \frac{(\mu g/mL)x100}{\text{Sample mass (DB)}} \qquad (10)$$

Where: is the absorbance reading concentration

Zinc

Determination of zinc content was conducted by using an Atomic Absorption Spectrophotometer (AACC, 2000). The following formula calculated zinc content:

$$Zn\ (ppm) = \frac{(\mu g/mL)\ x100}{\text{Sample mass (DB)}} \qquad (12)$$

Where: µg/ml is the absorbance reading concentration

Functional Properties

Water absorption capacity

The WAC was determined according to the method described by Akubor (2005). WAC was determined by the following formula:

$$WAC = \frac{\text{Weight of water bound}}{\text{Weight of sample (dry basis)}} x100\% \qquad (13)$$

Water absorption index

Water Absorption Index (WAI) was assessed as described by Anderson et al. (1969). WAI was calculated from the weight of the remaining gel and expressed as g gel/g dry flour.

$$WAI = \frac{\text{weight of sediment (g)}}{\text{weight of sample (g)}} \qquad (14)$$

Determination of ant-nutrient properties of SBP flour

Tannins

Tannin content were determined according to the method described by Maxson and Rooney (1972). The condensed tannin content was calculated by using the following formula:

$$\text{Tannin in mg/100g} = \frac{\text{Abso} - \text{Intercept}}{\text{Slope x Density x weight of the sample}} \qquad (15)$$

Phytate content

Determination of the phytate content were done by using the method described by Vantraub and Lapteva (1988). Phytate content were calculated by using the following formula:

$$\text{Phytate in mg/100g} = \frac{\text{Abso} - \text{Intercept}}{\text{Slope x Density x weight of the sample}} \qquad (16)$$

.

Sensory analysis of SBP flour

Sensory evaluation of the SBP formulated from sorghum and peanut flour blended were carried out using 10 untrained panelists. The selection and screening of the panelists were based on the participant's interest to participate and evaluate the SBP. The participants were pre-informed about the evaluation and the purpose of assessing the sensory of the product. The sensory evaluation was done in a room with less noise and no other fragrance to avoid panelist disturbance and evaluated daylight brightness. Panelists were requested to test the SBP samples in appearance, aroma, taste, texture, and overall acceptance using a five-point hedonic scale. After evaluating each sample test panelist rinse their mouths with water in between two tests. Samples were evaluated based on five Point hedonic scales (1, dislike very much; 5, like very much) for one attribute.

Data analysis and Optimization

All the analyses were performed in duplicates (unless stated otherwise) and presented as mean. The statistical significance of the data obtained will be analyzed and modeled using Design expert ® version 13. The level of significance was accepted at probability ($p \leq 0.01$ and 0.05).

RESULTS AND DISCUSSION

Functional properties of SBP flour

The functional properties (bulk density, water absorption capacity and oil absorption capacity) of composite flour with the individual ingredients were summarized in table 4. Analysis of variance results is also summarized in appendix table 10. Models for functional properties were fitted indicated that the lack-of-fit p-values were not significantly different at 5% probability level or ($P<0.05$). Diagnostic tools like normality plot of residuals indicated that the residuals of all the response variables are normally distributed.

Table 5. Functional properties of SBP flour samples

Std	Run	Block	SBP		Functional properties		
			A: Sorghum (g)	B: Peanut (g)	Bulk Density (g/ml)	Water Absorption Capacity (%)	Water Absorption Index (g)
7	1	Block 1	70	30	0.68	133.95	3.71
3	4	Block 1	85	15	0.62	131.17	3.68
6	3	Block 1	100	0	0.59	128.46	3.63
2	2	Block 1	70	30	0.67	133.96	3.72
5	5	Block 1	77.5	22.5	0.63	132.99	3.70
1	6	Block 1	100	0	0.60	128.15	3.62
4	7	Block 1	92.5	7.5	0.61	129.97	3.65

SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut

Bulk Density

Table 3 indicates that the sorghum blended with peanut flour have a high significant effect ($P \leq 0.01$) on the bulk density. The functional properties of the bulk density were ranged between 0.59 to 0.68 g/ml(Table 4). The bulk density found in this study was lower than the results reported by(Alemayehu, 2014), who reported a bulk density of between 0.81-0.84 g/ml. As seen from the figure 1, the bulk density of SBP flour samples showed an increasing trend with the increment of the proportion of sorghum and peanut flour. This result agrees with Masood and (Butt & Rizwana, 2010) indicated that the bulk density was increased in the composite flour with soybean protein content. Similar results reported by (Malomo, Eleyinmi, & Fashakin, 2011) who indicated that bulk density of composite flour of yam with soybean increased as the amount of soybean increased. High energy foods have low density and high-density foods low energy, and the results of this study may be observed due to the protein and fat content found in peanut flour

was higher compared to sorghum ration. The low bulk density of the blends is an advantage in the formulation of complementary foods (Akubor & Ukwuru, 2003). The regression model for bulk density was shown by (Eq. 17) indicating in quadratic model with two variables.

$$Y = 0.67_{x_1} + 0.59_{x_2} - 0.06_{x_1x_2} \ldots\ldots\ldots\

are attributed to protein denaturation, starch gelatinization, and crude fiber swelling. Damaged/transformed starches have a high-water absorption capacity and can produce paste at room temperature via the gelatinization mechanism (Nwabueze, 2006). The regression model for WAC was shown by (Eq. 18) indicating in quadratic model with two variables.

$$Y = 128.30_{x_1} + 134.01_{x_2} + 0.94_{x_1x_2} \ldots\ldots\ldots\

dietary fiber and proteins (Andersson & Hedlund, 1990). From the figure 3, the curve line indicates that WAI increased as the peanut flour increased. The regression model for WAI was shown by (Eq. 19) indicating in quadratic model with two variables

$$Y = 3.62_{x_1} + 3.72_{x_2} + 0.02_{x_1x_2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots eq.19$$

Where Y= Water absorption index, X_1= Sorghum, X_2=Peanut, X_1X_2=Sorghum and Peanut

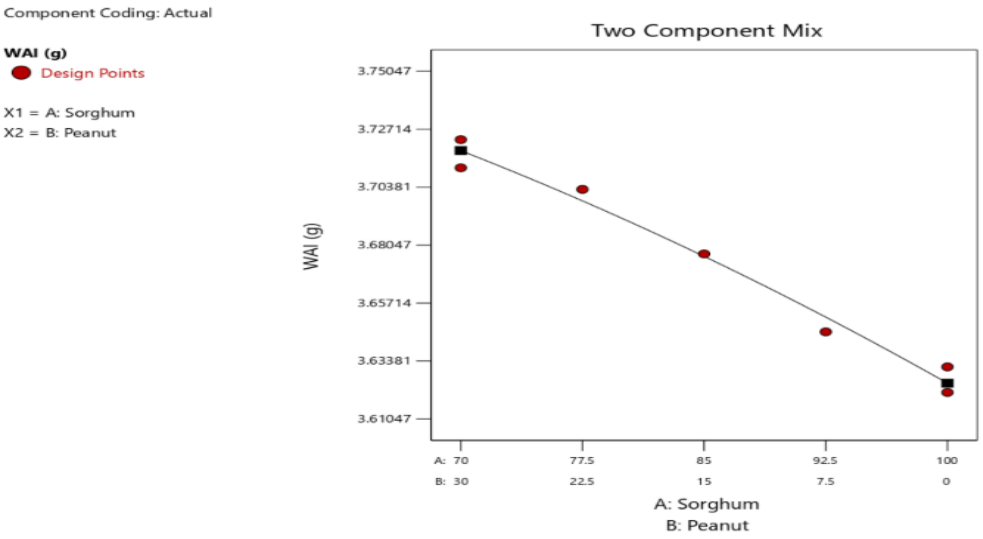


Figure 3. Contour line showing the water absorption index while the black points show the treatment formulations of the SBP flour

Proximate composition and energy content of SBP flour

Table 6 indicates the proximate composition (moisture, ash, crude protein, crude fat, crude fiber, carbohydrate and Energy content) of porridge flour from the local ingredients of sorghum and peanut. As indicated the appendix table 11, models for all proximate compositions were fitted indicated that the lack of fit p-values were not significantly different ($P<0.05$). Diagnostic tools like normality plot of residuals indicated that the residuals of all the response variables are normally distributed. The results of the chemical composition analysis of the raw materials of sorghum and peanut were presented in table 5. Components other than moisture contents are expressed on dry basis. There was a significance ($P<0.01$)difference between the difference in the values of moisture, protein, fat, ash, fiber, carbohydrate and energy contents.

Table 6. Proximate composition of SBP flour samples

Std	Run	Block	SBP		Proximate composition						
			A:	B:							
			Sorghum (g)	Peanut (g)	M.C (%)	C.P (%)	C.fat (%)	C.Fib (%)	Ash (%)	CHO (%)	Energy (kcal/100g)
7	1	Block 1	70	30	6.35	17.38	14.60	3.61	3.98	54.08	417.27
3	4	Block 1	85	15	5.75	14.70	10.52	2.84	1.98	64.21	410.32
6	3	Block 1	100	0	5.34	12.53	4.40	1.05	1.34	75.33	391.09
2	2	Block 1	70	30	6.23	16.46	15.61	3.53	3.8	54.37	423.80
5	5	Block 1	77.5	22.5	6.09	15.65	12.50	2.97	2.61	60.17	415.83
1	6	Block 1	100	0	5.41	12.43	4.42	1.59	1.32	74.83	388.86
4	7	Block 1	92.5	7.5	5.67	13.66	7.71	2.73	1.45	68.78	399.14

SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut, MC=Moisture Content, C.P=Crude Protein, C.Fib= Crude fiber, CHO=Carbohydrate, kcal=kilo calorie.

Moisture content

As indicated appendix table 11, finding of the study from the mixture proportion of the sorghum and peanut flour have strong linear significance at 1% probability level or ($P \leq 0.01$) on the moisture content of SBP flour. The moisture content of the SBP sample flour were ranged between 5.34 to 6.35%. also the mixture proportion of 70 grams of sorghum and 30 gram of peanut had the highest moisture contents compared to the other ratios of the mixture and these results indicated that increasing peanut ratio is increases the moisture content of the sample flours of the mixtures. According the FAO/WHO recommendation on the safety limit of the microbial prevention of the soft products like porridge, the results of this study indicates that the SBP product has desirable moisture content of 6.35% of the highest compared to the FAO/WHO recommended safe limit below (<10%). High moisture content in foods has been shown to encourage microbial growth (Temple, Badamosi, Ladeji, & Solomon, 1996). This is an important consideration in local feeding methods in developing countries because most mothers often prepare large quantities of dry infant foods and keep in containers, to avoid frequent processing in order to have spare time and energy for other domestic activities (Makinde & Lapido, 2012). The regression model for moisture was shown by (Eq. 20) indicating in quadratic model with two variables

$$Y = 5.39_{x_1} + 6.29_{x_2} - 0.05_{x_1x_2} \ldots\ldots\ldots\

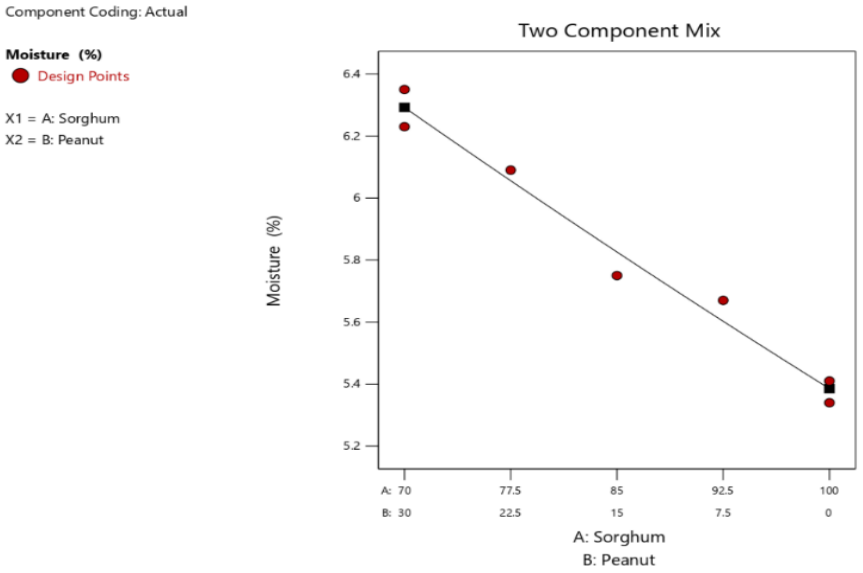


Figure 4. Contour line showing the Moisture content while the black points show the treatment formulations of the SBP flour.

Protein contents

Appendix table 11 shows that the linear mixture of the sorghum enriched with peanut flour has a strong linear significance ($P \leq 0.01$) effect on the protein content of the SBP sample flours. As indicated in table 5, the result indicates that the crude protein content of the SBP samples were ranged between 12.53 to 17.38% of protein concentration. the highest protein (17.38%) content was observed from the ratio of 70 gram of sorghum and 30 gram of peanut flour which assumed to be promising potential as a good source of plant protein. The protein contents of this study are in line with (Teshome, 2014). The results indicated that the protein contents of non-extruded protein of were ranged between 11.17 to 16.38% of protein concentration. As seen in figure 6, the curve line indicated that increasing the peanut ration results high protein contents and decreasing the peanut ratio results in declining the curve into the lowest protein concentration.

A minimum protein content of 15% is required for maximum complementation of amino acids in foods and for growth. Thus all the above formulations whose protein value contain 15% and above were satisfied the protein demand for complementary foods for older infants and young children according to (SESSION, DU COMITÉ, & LES HUILES, 2015).

The regression model for crude protein content was shown by (Eq. 21) indicating in quadratic model with two variables.

$$Y = 12.50_{x_1} + 16.89_{x_2} - 0.11_{x_1x_2} \ldots\ldots\ldots\

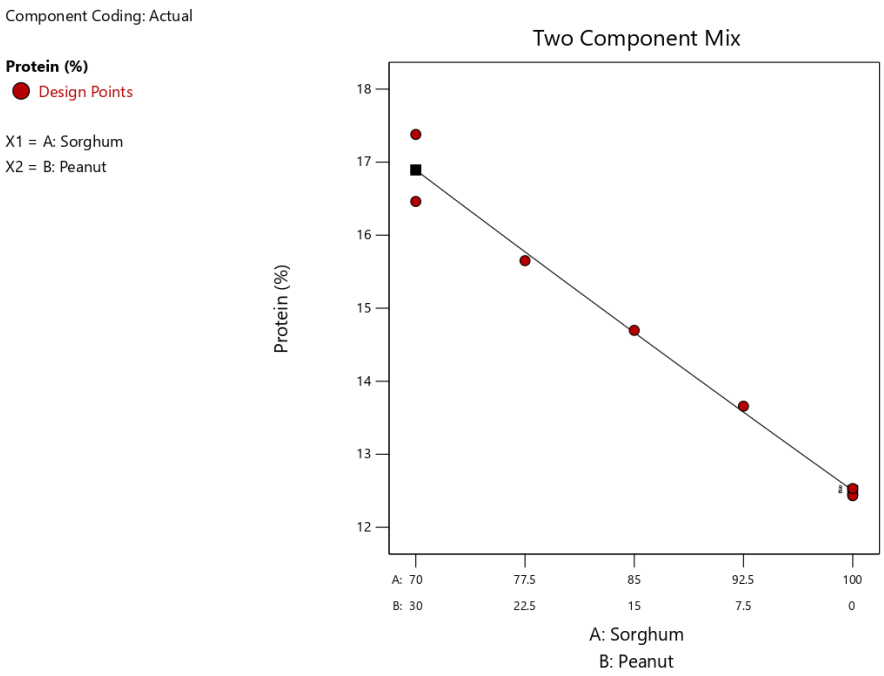


Figure 5. Contour line showing the Protein content while the black points show the treatment formulations of the SBP flour

Crude fat contents

Appendix table 11 shows that the linear mixture of the sorghum and peanut flour has a strong linear significance ($P \leq 0.01$) effect on the crude fat content of the SBP sample flours. The crude fat content of sorghum and peanut flour recorded in this study was found in between the values 4.40-15.61% . also this study has similar results with study conducted by (Teshome, 2014), the results showed that the fat contents result of the extruded blends of sorghum- peanut, sorghum-soya bean and local control samples. The results were ranged between (7.3-I8.36%), (4.42-, 10.5%) and (1.25%) for extruded sorghum-peanut, extruded sorghum, soya bean and control samples respectively. Also other similar result was reported by (Shimelis & Rakshit, 2005). On the other hand the higher crude fat content of sorghum flour (4.12%) was reported by (Makinde & Lapido, 2012). This variation may be occurring due to the variety and/or processing effects. The regression model for crude fat content was shown by (Eq. 22) indicating in quadratic model with two variables.

$$Y = 4.46_{x_1} + 15.03_{x_2} + 2.48_{x_1 x_2} \ldots\ldots\ldots\

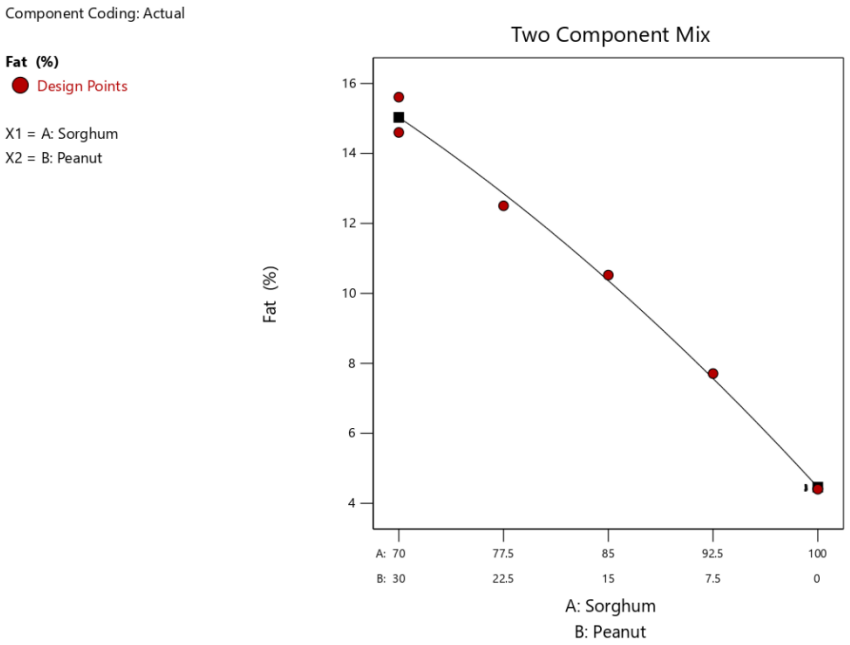


Figure 6. Contour line showing the Fat content while the black points show the treatment formulations of the SBP flour

Crude fiber contents

Appendix table 11 shows that the linear mixture of the sorghum and peanut flour has a strong linear significance ($P \leq 0.01$) effect on the crude fiber content of the SBP sample flours. The fiber content of SBP samples from seven different formulations was varied between 1.05 to 3.61% (Table 5). There was a statistically significant difference ($P \leq 0.01$) between different composite SBP sample flours. The higher fiber content was observed in SBP samples prepared from 70 grams of sorghum and 30 grams of peanut flour. The results also indicated that the fiber contents of the SBP samples showed an increase trend with parallel increase in the proportion of the peanut flours. This result was in agreement with finding (Teshome, 2014), The fiber content was ranged between (1.3 1-2.29%),(1.28-2. 18%) and (2.28 %) for sorghum peanut, sorghum-soya bean and the control samples respectively.

Acceptable fiber content of weaning foods should not exceed 5% according to the Protein Advisory Group Recommendations (1972). When the fiber content is high it decreases the digestibility of the particular food. The crude fiber contents of the sorghum-peanut were within an acceptable range. The amount of fiber content was shown in mixture contour graph (Figure 8) and the regression model for crude fat was shown as (Eq. 23) indicating quadratic model with two variables.

$$Y = 1.42_{x_1} + 3.48_{x_2} + 1.87_{x_1x_2} \ldots\ldots\ldots\

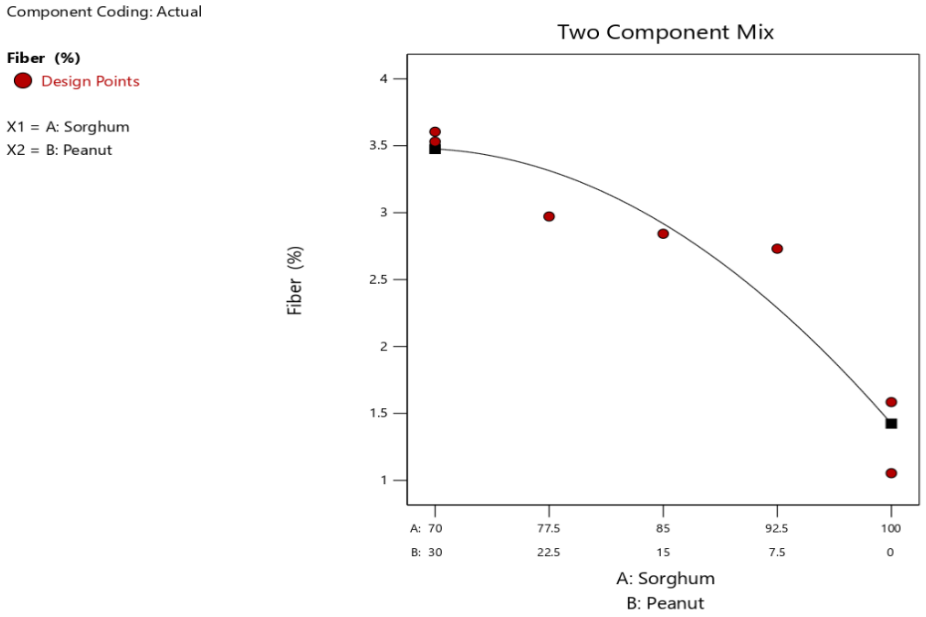


Figure 7. Contour line showing the fiber content while the black points show the treatment formulations of the SBP flour.

Total ash contents

Appendix table 11 shows that the linear mixture of the sorghum and peanut flour has a strong linear significance ($P \leq 0.01$) effect on the total ash content of the SBP sample flours. The ash contents result of the SBP blends of sorghum-peanut samples shown on(Table 6) were ranged between 1.32 to 3.98%. This result agrees with study report by (Teshome, 2014), The ash contents result of the porridge blends from sorghum-peanut, sorghum-soya bean and the control samples were ranged between(1.33- 1.91%), (1.87-3. 19%) and (1.1 0%) respectively.

$$Y = 1.42_{x_1} + 3.48_{x_2} + 1.87_{x_1x_2} \ldots\ldots\ldots\

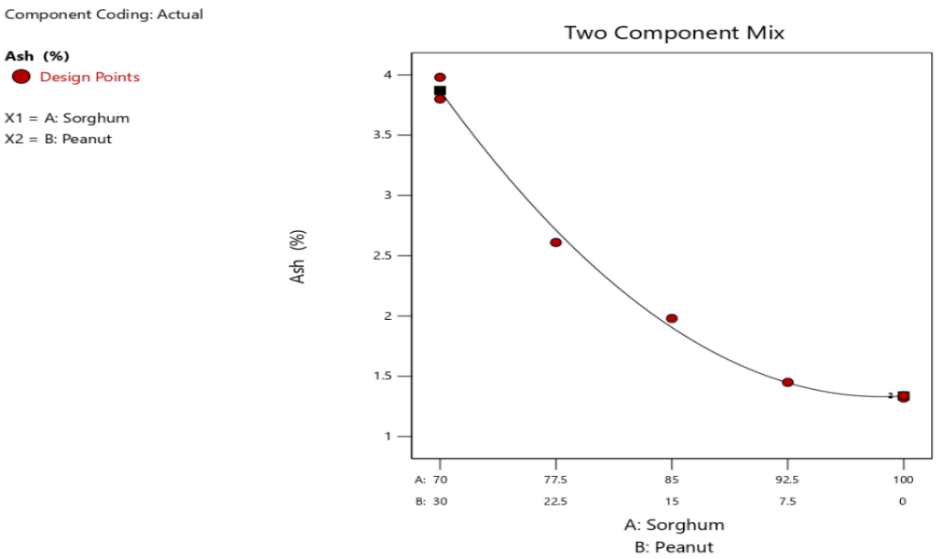


Figure 8. Contour line showing the total ash content while the black points show the treatment formulations of the SBP flour

Acceptable ash content of weaning foods which given by the Protein Advisory Group recommendations (1972) should not exceed 5%. The result of sorghum ash content was similar to the report by(Makinde & Lapido, 2012) in their study of the physico-chemical properties of sorghum based complementary food. Formulated foods studied in the current study were within this limit as well (Munasinghe, Silva, Jayarathne, & Sarananda, 2013). The highest value of ash content recorded indicates that SBP flour has a good potential to prepare a CF that supports mineral requirement of the infants' complementary feeding period. The regression model for crude fat content was shown by (Eq. 24) indicating in quadratic model with two variables.

Total Carbohydrate content

As shown in appendix table 11 the linear terms of the mixture from the sorghum and peanut flour have a strong significance ($P \leq 0.01$)on the total carbohydrate content. The total carbohydrate content ranged from 54.08% to 75.33% for all the formulations (Table 5). According to the finding of the study sorghum with zero peanut ration was indicated the highest carbohydrate contents and lowest carbohydrate contents was seen with peanut ration of 30 gram. As the number of peanuts in the formulation increased, the carbohydrate content of the raw blends reduced significantly ($p<0.05$ due to the peanut's lower carbohydrate content. This decrease in the lower total carbohydrate content could be attributed to the lower carbohydrate content in peanut flours. This study also in line with the study reported by (Teshome, 2014), the total carbohydrate content decreases due to the lower content of carbohydrate in peanut and soybean. According to the protein advisory group (1972), sorghum was used as the main carbohydrate supplier which help to maintain 65% of the carbohydrate contents. The regression model for crude fat content was shown by (Eq. 25) indicating in quadratic model with two variables.

$$Y = 74.89_{x_1} + 54.44_{x_2} - 1.38_{x_1 x_2} \ldots\ldots\ldots\

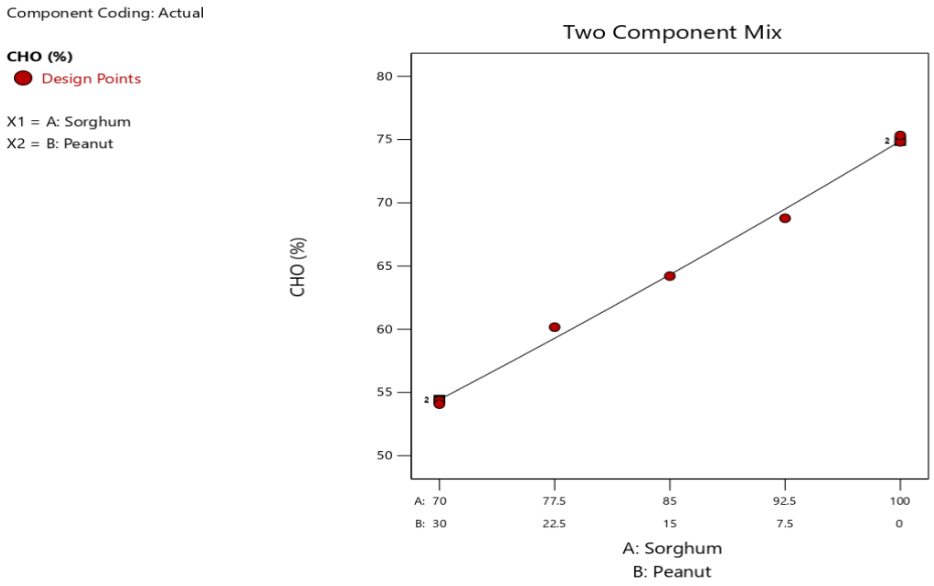


Figure 9. Contour line showing the total carbohydrate content while the black points show the treatment formulations of the SBP flour.

As indicated figure 10, the curve of the graph shown that the carbohydrate content increases the as the peanut ration decreases. The carbohydrate content of sorghum flour obtained in this study was comparable with reported 74.68% by (Mohammed, Ahmed, & Babiker, 2011). While lower than the value 76.94 % reported by (Shimelis & Rakshit, 2005). This variation may be due to the germination time and variety with different experimental condition respectively.

Total Energy content

As indicated in appendix table 11, the linear model of the mixture from the sorghum and peanut flour has strong significance ($P \leq 0.01$) on the gross energy content. The total energy content of sorghum flour, and peanut flour was shown in (Table 5). The total energy content of SBP sample flours were varied from 388.86% to 423.80 kcal/100g. The higher total energy content was observed in the SBP sample prepared from a formula sorghum 70 gram, and peanut 30 gram and the lower energy content was observed in SBP sample prepared from a formula sorghum 100 gram. As a result, this result suggested that the high protein and fat content of peanuts may be responsible for the SBP samples' high calorie content when they are made using a large amount of peanut flour. The study on complementary food characteristics found that the high-fat content of legumes and oil crop flour further boosted the energy density of the products prepared from various formulas (Onabanjo, Akinyemi, & Agbon, 2009). The regression model for total energy content was shown by (Eq.26) as indicated in quadratic model with two variables

$$Y = 389.73_{x_1} + 420.60_{x_2} + 16.27_{x_1x_2} \ldots\ldots\ldots\

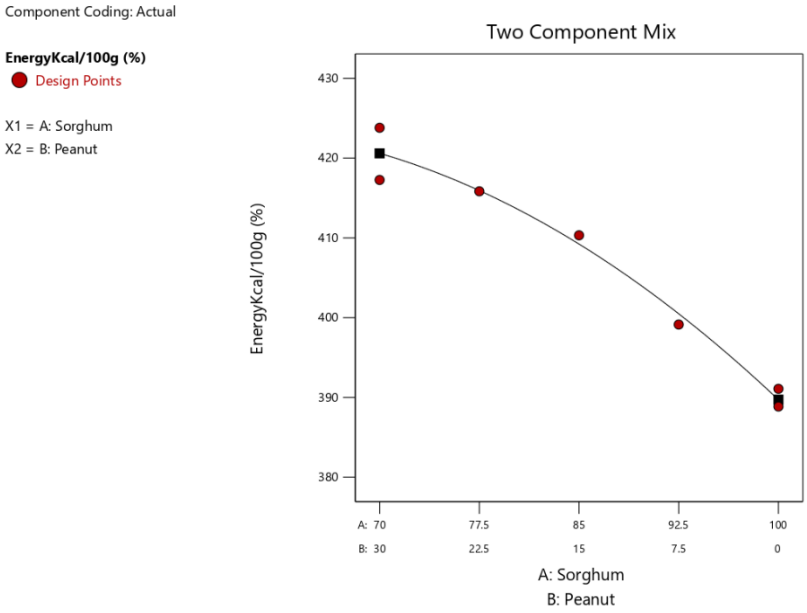


Figure 10. Contour line showing the total energy content while the black points show the treatment formulations of the SBP flour

The current total energy requirement estimated for healthy breastfed infants is of approximately 615 kcal/day from 6 to 8 months of life, 686 kcal/day from 9 to11 months and 894 kcal/day from 12 to 23 months (Dewey & Brown, 2003). Around 156-237 g per day of the complementary porridges would be required to meet the required energy for infants depending their age. Adding foods containing more lipids to the porridges would be beneficial to increase energy density and provide needed nutrients (Dewey & Brown, 2003). As indicted the figure 11, the curve indicted that the energy contents of SBP samples decreases as the peanut ratio decreases.

Mineral contents of SBP flour

Table 8 displays the mineral composition of all samples and components of SBP samples. At the 1% probability level or ($P \leq 0.01$), models that were fitted for the contents of all minerals showed that the lack-of-fit p-values were not significantly different. A normality plot of the residuals, one of the diagnostic techniques, showed that the residuals of all the response variables are normally distributed.

Table 7. Mineral content of SBP flour samples

Std	Run	Block	SBP		Mineral contents				
			A:	B:					
			Sorghum (g)	Peanut (g)	Calcium Mg/100g	Iron Mg/100g	Zinc Mg/100g	Potassium Mg/100g	Magnesium Mg/100g
7	1	Block 1	70	30	59.90	10.07	5.17	585.49	167.10
3	2	Block 1	85	15	23.84	4.16	3.42	441.56	130.43
6	3	Block 1	100	0	5.07	1.99	2.85	320.16	105.87
2	4	Block 1	70	30	58.95	10.95s	5.41	549.95	166.60
5	5	Block 1	77.5	22.5	38.68	7.65	3.91	492.34	148.73
1	6	Block 1	100	0	5.06	1.98	2.72	324.86	103.90
4	7	Block 1	92.5	7.5	10.61	2.54	3.00	397.96	122.07

SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut,

Calcium content

As shown in appendix table 12, it shows that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$) and a significant strong interaction effect ($P \leq 0.01$) on the calcium content. The calcium content of 70 gram of raw sorghum and 30 gram of peanut was 59.90 mg/100g while the lowest calcium content of 100:0 ratio raw sorghum and peanut was 5.07 mg/100g respectively (Table 6). As seen from the table 8, the results indicated that the control group of the study has the lowest calcium contents and sorghum is not commonly not a good source of calcium as seen from different literatures. According to the finding of the study, the results was shown that calcium concentration increased sharply as increased the peanut ratios, about the ratio of 70:30 gram of sorghum and peanut gives 59.90 mg/100g of calcium and the ratio of 77.5:22.5 of gram sorghum and peanut gives 38.68 mg/100g respectively, this result is inline the RDA for the infants. The RDA for 6 to 12 months was 270 mg per day (Trumbo, Schlicker, Yates, & Poos, 2002). The current blended product was meet the RDA for life stage of infant, which is 22.18% for the highest blend formulation ratio. The regression model for calcium content was shown by (Eq.27) as indicated in quadratic model with two variables

$$Y = 4.89_{x_1} + 59.44_{x_2} - 36.92_{x_1x_2} \ldots\ldots\ldots\

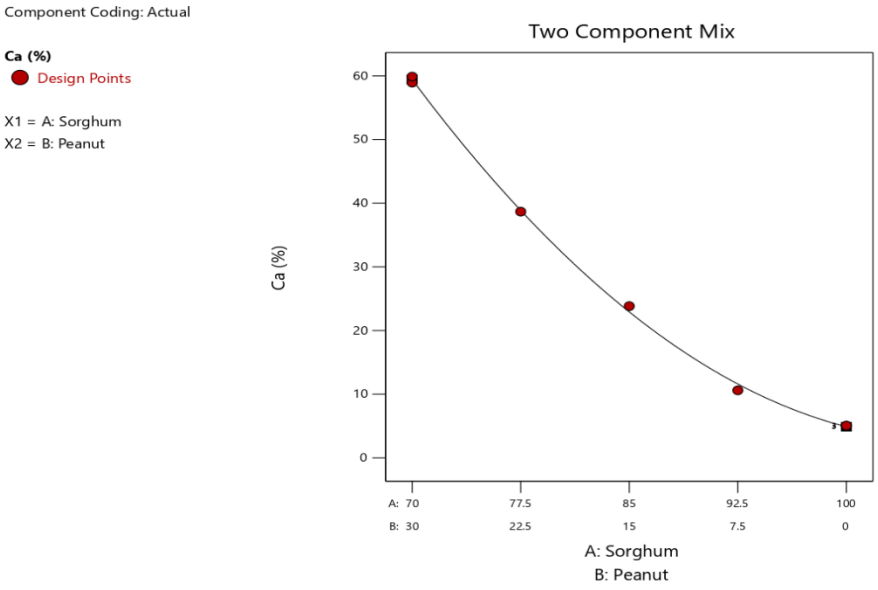


Figure 11. Contour line showing the calcium content while the black points show the treatment formulations of the SBP flour.

Iron content

As seen in appendix table12, it indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$), and a significant strong interaction effect ($P \leq 0.05$) on the iron content. The iron content of all the formulations ranged from 1.98 mg/100g to 10.95 mg/100g (Table 6). The amounts of iron of the product were within recommended level (9mg/1000kcal) for local diets formulated for malnourished children (Golden, 2009). Due to the higher amount of peanut flour, the iron content of the sorghum that has been enhanced with peanuts increased. According to the finding of the study results were within recommendations and there is a reasonable result which agrees with RDA of infants and children.

Also, this result is in line with other studies, the level of iron in sorghum based complementary food observed in this study were comparable (5.56-6.21 mg/100 g) with those reported by (Mosha, Laswai, & Tetens, 2000). The iron content of the current study was ranged from 3.89 to 21.95 mg/100g whereas the RDA for 6-to-12-month life stage infant is 11 mg/ day and 7 mg/day for 13 to 36 months life stage children respectively. The blended product was meet 18.09 to 99.54 % of the RDA for 6-to-12-month life stage infants and 28.28 to 100% for 13 to 36 months life stage children in lower and higher value respectively. The regression model for iron content was shown by (Eq.28) as indicated in quadratic model with two variables.

$$Y = 1.92_{x_1} + 10.63_{x_2} - 7.63_{x_1x_2} \ldots\ldots\ldots\

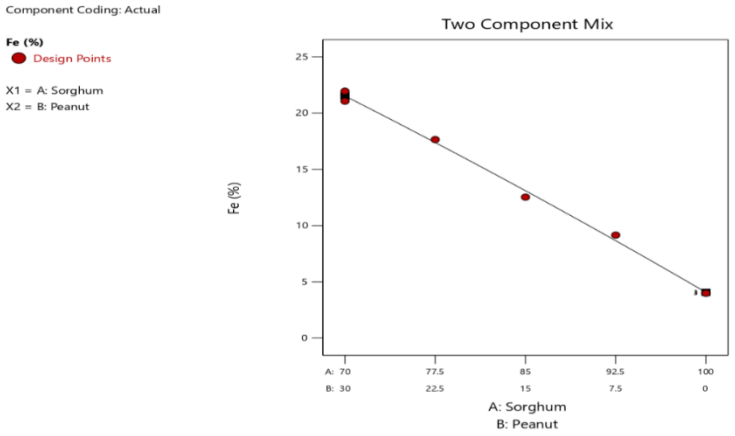


Figure 12. Contour line showing the iron content while the black points show the treatment formulations of the SBP flour

Zinc content

As seen in appendix table12, it indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$), and a significant strong interaction effect ($P \leq 0.05$) on the iron content. Zinc content of sorghum, and peanut flour samples were represented in table 8. The zinc content of SBP samples flour were ranged from 2.72 to 5.17 mg/100g, this finding agrees with similar reports by (Rasmata, Fatoumata, Wend-Bénédo, Pengdwendé, & Aly, 2023), the study indicated that nutritional and organoleptic characteristics of six formulated sorghum based complementary foods, the zinc content was ranged between 2.01 to 3.7 mg/100g.

According to the finding of this study, it agrees to RDA of the infants and children. The RDA for both 6-to-12-month, 13 to 36 months life stage infant and children are 3 mg/ day. The blended product was meet 90.67 to 100 % of the RDA for both 6-to-12-month and 13 to 36 months life stage infants and children in lower and higher value respectively. According to the existing literatures zinc is one of the most essential minerals for infants and it helps to the brain growth. As indicated in figure 14, the zinc content was decreased as the peanut ratio decreases. The regression model for iron content was shown by (Eq.29) as indicated in quadratic model with two variables.

$$Y = 2.82_{x_1} + 5.24_{x_2} - 2.79_{x_1x_2} \ldots\ldots\ldots\

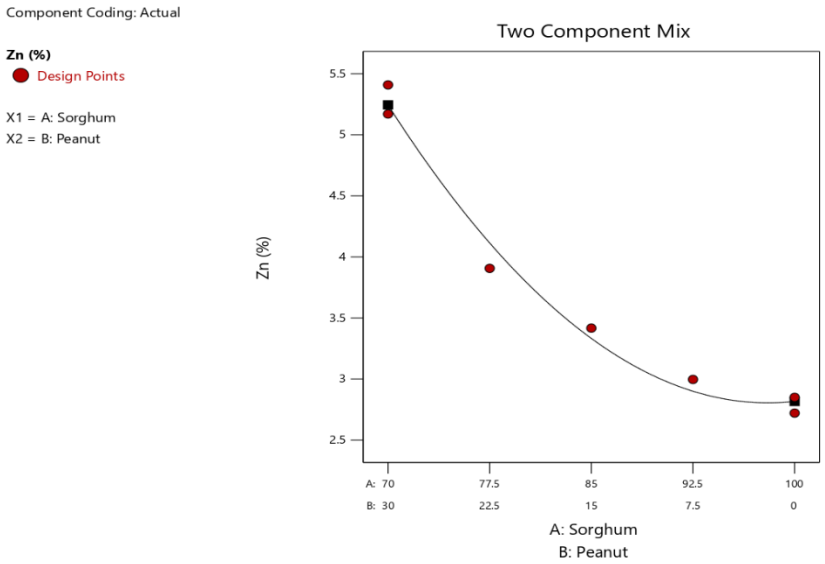


Figure 13. Contour line showing the zinc content while the black points show the treatment formulations of the SBP flour

Potassium content

As seen in appendix table 12, it indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$). According to the finding of the study, the SBP sample flours have high potassium concentration, as indicated in table 8, the potassium content of SBP samples flour were ranged from 324.86 to 585.49 mg/100g. This finding is a promising result and meets the recommendation of the RDA and the RDA of infants were met in this study but the children's requirements were not met and this may require further study on the blending ratio of the peanut amounts. The levels of potassium in both products were within the value (1400mg/100kcal) recommended by (Golden, 2009) for moderately malnourished children. Depletion of potassium takes place in all malnourished children.

Supplementary diets should contain sufficient potassium to maintain a renal excretion of 27mg/kg/day and a fecal excretion of 39mg/kg/day (Golden, 2009). The results this study agrees with the RDA of the infants and children. The RDA for both 6-to-12-month life stage infant are 860 mg/ day, and 13 to 36 months life stage infant and children are 2000 mg/ day(Trumbo et al., 2002). The blended product was meet 37.23 to 68.08 % of the RDA for 6-to-12-month life stage infants and 16.01 to 29.27 % of the RDA for 13 to 36 months life stage children in lower and higher value respectively. The regression model for potassium content was shown by (Eq.30) as indicated in quadratic model with two variables.

$$Y = 325.80_{x_1} + 564.74_{x_2} - 7.34_{x_1x_2} \ldots\ldots\ldots\

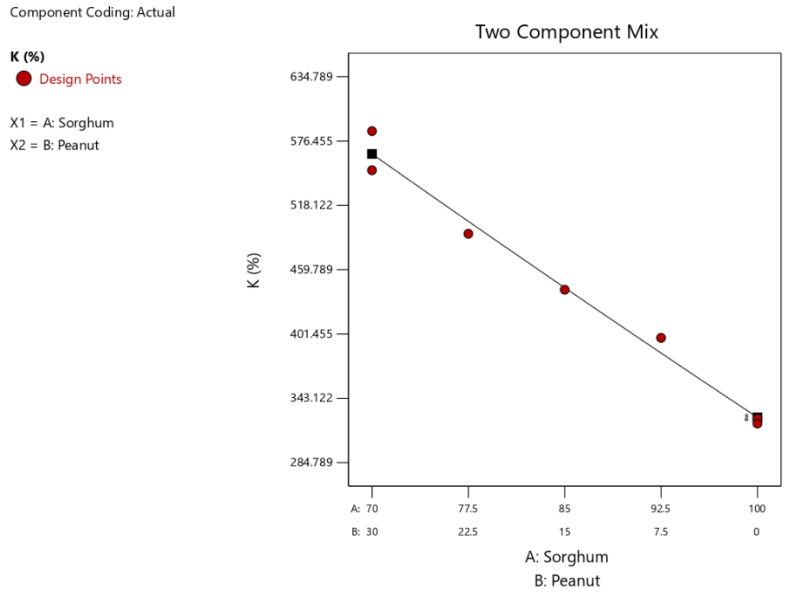


Figure 14. Contour line showing the potassium content while the black points show the treatment formulations of the SBP flour

Magnesium content

As seen in appendix table 12, it indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance ($P \leq 0.01$). Magnesium content of sorghum, and peanut flour samples were represented in table 6. The magnesium content of SBP samples flour were ranged from 103.90to 167.10mg/100g. This finding agrees with similar reports by Both products met the recommended levels of 200 mg/1000 kcal (Golden, 2009). Magnesium is a growth nutrient and deficiency have a negative influence on growth since its deficiency interferes with protein utilization. Magnesium is particularly important for stunted children who need to grow. The regression model for magnesium content was shown by (Eq.31) as indicated in quadratic model with two variables.

$$Y = 105.57_{x_1} + 166.58_{x_2} - 12.53_{x_1x_2} \ldots\ldots\ldots\

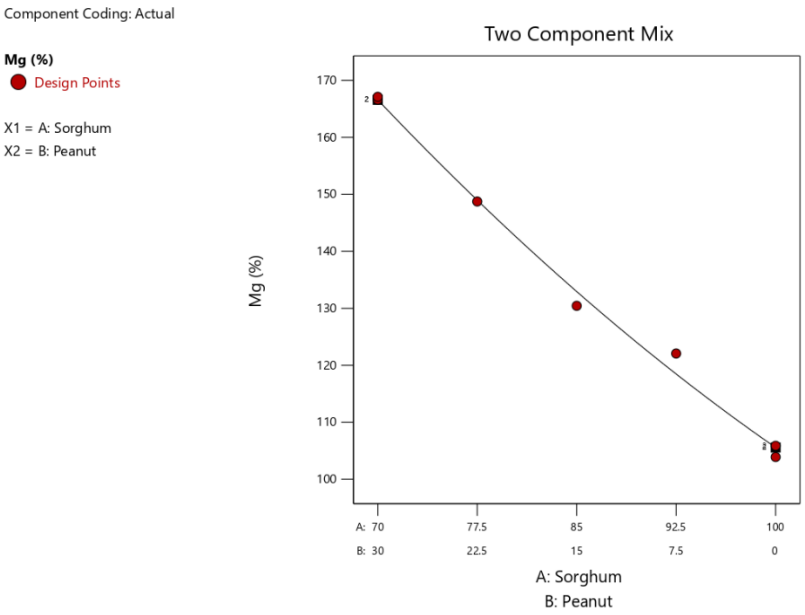


Figure 15. Contour line showing the magnesium content while the black points show the treatment formulations of the SBP flour

Major anti-nutritional contents

The analysis of the anti-nutritional components (tannin and phytate) in the ingredients and composite flour SBP samples produced the results shown in (Table 6). At the 5% probability level or (P≤0.05), models for anti-nutritional factors that were fitted showed that the lack-of-fit p-values were not significantly different. A normality plot of the residuals, one of the diagnostic techniques, showed that the residuals of all the response variables are normally distributed.

Table 8. Proximate composition of porridge and ingredients flour samples

Std	Run	Block	SBP		Anti-nutritional	
			A:	B:		
			Sorghum (g)	Peanut (g)	Phytate (%)	Tannin (%)
7	1	Block 1	70	30	98.84	0.20
2	2	Block 1	85	15	122.45	0.31
6	3	Block 1	100	0	143.95	0.45
3	4	Block 1	70	30	99.79	0.21
5	5	Block 1	77.5	22.5	117.03	0.30
1	6	Block 1	100	0	146.97	0.45
4	7	Block 1	92.5	7.5	129.70	0.33

SBP= Sorghum Blended peanut, A= Sorghum, B= Peanut

Phytate contents

As indicated in appendix table 13, it indicated that the linear model of the sorghum blended with peanut flour had a strong linear significance (P≤0.01). According to the finding of the phytates of SBP sample flour were ranged between 98.84 to 146.03%, these results indicated that the anti-nutritional factors of the SBP sample flour increased as the peanut ration decreases and indicates that the sorghum has higher anti-nutritional factors compared the peanut ration on other hand its

good ideas increasing the peanut ratio to minimize the phytates. The effect of blending ratio on phytate content was shown in mixture contour graph (Figure 17) and the regression model was shown by (Eq. 32) as indicating in quadratic model with two variables.

$$Y = 144.36_{x_1} + 100.52_{x_2} + 2.61_{x_1x_2} \ldots\ldots\ldots\

$$Y = 0.44_{x_1} + 0.22_{x_2} - 0.07_{x_1x_2} \ldots\ldots\ldots\

To determine the Optimum blending ratio of SBP Product

Optimization was carried out by setting criteria for each response to obtain the optimum levels of the responses in the experiment. The optimization was to get the maximum puffing scale, rollability scale, crude protein, crude fat, crude fiber, total ash, total carbohydrate, total energy, calcium, iron, zinc, and overall acceptability. The goal of the current research was to establish the ideal ratio for blending each ingredient to create porridge with the desired nutritious contents and sensory appeal. The carbohydrate content of the optimized sorghum flour was 74.90 grams and peanut flour was 25.10 grams. The acceptability of the overall optimum value for Moisture, protein, fat, fiber, ash, carbohydrate, energy, Mg, Ca, Fe, K, Zn, BD, WAC, Phytate, tannin, and overall acceptability varied between 16.16%, 13.65%, 6.14%, 3.08%, 3.40%, 57.59%, 417.79 Kcal/100g, 154.91, mg/100g 45.50 mg/100g, 18.85 mg/100g, 525.09 mg/100g, 4.47 mg/100g, 108.04mg/100g, 0.24%, 0.60g, 133.16%, 3.64%, and 4.81 respectively.

Table 10. Response optimization for proximate, physicochemical, and anti-nutritional contents of SBP flour

Name	**Unit**	**Lower Limit**	**Upper Limit**	**The optimum value of the SBP Flour**
A:Soghum	g	70	100	74.90
B:Peanut	g	0	30	25.10
Moisture	%	12.43	17.38	16.16
Protein	%	4.40	15.61	13.65
Fat	%	5.34	6.35	6.14
Fiber	%	1.32	3.98	3.08
Ash	%	1.05	3.61	3.40
Carbohydrate	%	54.08	75.33	57.59
Energy	Kcal/100g	388.86	423.81	417.79
Mg	mg/100g	103.90	167.10	154.91
Ca	mg/100g	5.06	59.90	45.50
Fe	mg/100g	3.99	21.95	18.85
K	mg/100g	320.16	585.49	525.09
Zn	mg/100g	2.72	5.41	4.47
BD	g/ml	98.84	146.97	108.04
WAC	%	0.20	0.45	0.24
WAI	g	0.59	0.68	0.60
Phytate	%	128.15	134.00	133.16
Tannin	%	3.62	3.72	3.64
Overall acceptability	Scale	4.501	4.861	4.81
Desirability	--	--	--	0.68

Conclusion And Recommendation

Conclusion

One third of the world's population relies heavily on cereals as a source of nourishment, particularly in underdeveloped nations. Sorghum is one of these grains that has a variety of uses that makes it one of the most significant crops and a significant source of calories for human nutrition. The findings of this study showed that adding a maximum of 30% of peanut flour to the composite flour formula greatly enhanced the product's macronutrient profile (protein, fat, carbohydrate, and energy content). Additionally, the product's level of micronutrients including calcium, iron, zinc, magnesium, and potassium dramatically rose as the quantity of peanut flour increased. As the amount of peanut flour grows to 30%, the concentration of anti-nutritional elements such phytate and tannin in the SBP product falls. According to the findings of the SBP products' overall sensory acceptability test, the color, scent, taste, and mouth feel of the goods considerably changed when the amount of peanut flour was increased. This boosted the products' overall acceptability. To improve physicochemical attributes, proximate composition, mineral concentrations, and sensory acceptance, the composition of SBP sample flours was numerically optimized. The formulation condition of 74.90% sorghum flour and 25.10% peanut flour was determined to be the best for all the tested parameters.

RECOMMENDATIONS

The following points have been proposed as potential lines of investigation for any researchers based on the study's findings.

- The microbiological analysis and shelf life of the composite flour should be the subject of further research.
- More research on roasted peanuts is needed to enhance the flavor of blended products.
- More study has to be done on how to determine the amino acid profile of composite flour.
- The complementary meals must be advertised.

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