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PHYSICOCHEMICAL PROPERTIES, PROXIMATE AND FUNCTIONAL PROPERTIES OF DIFFERENT RICE VARIETIES PRODUCED/ADAPTED UNDER SORPARI AND MARKETED RICE IN SOMALI REGIONAL STATE

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List of Acronyms

AOAC:	Association of Official Analytical Chemists
FAO:	Food & Agricultural Organization of United nations
GOs:	Government Organization
JJU:	Jigjiga University
NGOs:	Non-Government Organization
SoRPARI:	Somali Region Pastoral & Agro-Pastoral Research Institute
SRS:	Somali Regional State

Executive Summary

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.

CHAPTER ONE

1. Introduction

1.1. Background

Grains are small and hard, dry seeds, with or without a hull or fruit layer attached, harvested for animal or human consumption. Any grain-producing plant is referred to as grain crop. The two major types of commercial grain crops are legumes and cereals. After harvest, dry grains are more durable and stronger than other staple foods, like starchy fruits (breadfruit, plantains, etc.) and tubers (cassava, sweet potatoes, etc.); nutrients in tubers like sweet potatoes are often affected by salting (Awuchi and Nwankwill be, 2018). This durability made grains well suitable to industrial agriculture, as they can be harvested mechanically, transported by ship or rail, stored in silos for long periods, and pressed for oil or milled for flour. Thus, major international commodity markets exist more for rice, soybeans, wheat, canola, maize, rice and other grains than for vegetables, tubers, or other crops.

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. Indica (long grain), Japonica (round grain), and Jayanica (medium grain) are three subspecies of rice grown in world. 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.

For the designing of equipment for handling, conveying, separation, dehulling, drying, storage, and other processes, physical properties of rice need to be studied. Knowledge of principle axial dimensions of a grain is useful in power calculation for milling and sieve selection for separation

(Singh, Kaur, & Singh, 2015). They can also be useful in calculating volume and surface area of kernel which are important in modeling of grain drying, heating, cooling, and aeration. Density values are useful in sizing grain hoppers and storage facilities. Rate of heat and mass transfer during aeration and drying depends upon density values of grains (Malik & Saini, 2016).

The cooking qualities of rice determines their economic values, which can be measured in terms of cooking time, grain elongation during cooking, and length breadth ratio after cooking. Cooking quality depends upon the physical and chemical characteristics of starch, such as amylose–amylopectin ratio, gel consistency, and gelatinization temperature (Tan, Li, Yu, Xing, & Xu, 1999). Amylose content is one of the important characteristics influencing the cooking behavior (Xie, Chen, Duan, Zhu, & Liao, 2007). Rice variety with more than 25% of amylose content absorbs more water and has a fluffy texture after cooking (Frei, Siddhuraju, & Becker, 2003). Linear elongation of rice upon cooking is considered one of the major characteristics of good rice. Rice which expands only along length without increase in girth is considered high-quality rice (Sood & Sadiq, 1979). Gelatinization temperature has a direction relationship with grain elongation during cooking. Perez, Juliano, Pascual, and Novenario (1987) reported that rice with high gelatinization temperature elongates less during
cooking.

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 reginal state.

1.2. Statement of the problem.

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. All countries increased annual rice production, resulting in a bowl of higher rice the production growth rate in East Africa than in both Central and West Africa. The region's performance was primarily due to increases in rice production in Kenya, Tanzania, Uganda, and Madagascar (Childs N., 2015). 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. Aggregate rice yield averaged 2.2 MT/ha during this period (Seck, P.A., Toure, A. A., Coulibaly, J. Y., Diagne. A. and Wopereis, M. C. S., 2013).

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).
On the plus side, there is considerable interest in the large-scale commercial production of rice in all potential areas of the country. The production of rice in Ethiopian agriculture has expanded

steadily across the country, with the total land area under rice cultivation rising from about 10,000 ha in 2006, to over 50,000 ha in 2018.

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. 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 (Minilik T. et.al., 2013).

1.3. Objective

1.3.1. General Objective

The general objective of the study was to study the physicochemical properties, proximate and functional properties of different rice varieties produced/adapted under SoRPARI in Somali Region of Ethiopia and imported rice.

1.3.2. Specific Objective

The specific objectives of the study were to;

- Analyze the proximate composition of different rice varieties
- Study the physicochemical and functional properties of rice varieties
- Evaluate the cooling quality of different rice varieties

1.4. Significance of the study

This study so important as it is the first in its nature to conduct such a study on different rice varieties proximate composition, physico-chemical properties, and cooking qualities of the different varieties grown in SRS. The outcome of the study is important to get up-to-date data on the nutritional composition, physical, functional and cooking properties of the different rice varieties grown in SRS. The result obtained from this study will further be important for the future researcher as baseline information to conduct their research. Based on the recommendation come out from this study, policy maker, government, Non-Government

organization and other interested institutions working on the area will expected to get up to date information form the study.

CHAPTER TWO

2. Literature review

2.1. Introduction

Rice is a major cereal crop consumed as a staple food by over half of the world's population. Consumption of rice is very high in developing countries and nations in Asia. Almost 95% of the rice production is done in Asian countries and about half of the world's population consumes it. The cultivation of rice ranks third in the production of agricultural commodity next to sugarcane and maize. It is the predominant dietary energy source of 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. India is one of the major centres for rice production. The area for rice cultivation in India comprises about 43,388,000 hectares of land (Agricultural statistical division, 2017) and rice contributes to 780 and 689 kcal/capita/ day of the food supply in Asia and India, respectively (Kennedy G, et, al., 2019).

Rice is rich in genetic diversity, with thousands of varieties grown throughout the world and India is home to 6000 varieties, at present. Originally, India had more than 110,000 varieties of rice until 1970, which were lost during the Green Revolution with its emphasis on monoculture and hybrid crops (The Hindu Group, 2012). Paddy comes in many different colors, including brown, red, purple and even black. The colorful varieties of rice are considered valuable for their health benefits. The unpolished rice with its bran has high nutrient content than milled or polished white rice. However, rice consumers prefer to consume polished white rice, despite the fact that brown rice contains valuable nutrient content (Devi GN. Et. Al., 2015). A detailed analysis on the nutrient content of rice suggests that the nutrition value varies depending upon several factors such as the strain or variety (i.e., white, brown, red and black/purple), nutrient quality of the soil in which rice is cultivated, the degree of milling and the method of preparation before consumption.

2.2. The Origin of rice

Botanists base their evidence of the origin of rice largely on the habitats of the wild species. It is presumed that the cultivated species have developed from certain types of the wild rice (Grist, 1975). Sharma (1983) reported that the genus Oryza comprises twenty - five species distributed through the tropical and subtropical regions of Asia, Africa, central and South America and Australia.

According to Vavilov (1930), the longer a group has been established in an area, the larger will be the number of species to be found there. He concludes that the wealth of forms and varieties of rice found in the south - west Himalayes, which are closely allied to many Chinese varieties, points to this region as the centre of origin of rice. It may well be that this and other places in India, South – Bast Asia, the Philippines and Africa are centres of origin of cultivated forms of rice.

Ting (1949) concludes that in view of the number of wild rices found in southern China, rice cultivation is believed to have started in this region and to have spread north world. Ting (1960) states that rice glumes found in the Yangtse River in red burnt clay, thought to belong to the late Neolithic, have been classified as *O. saliva F. spontanea ssp. Keng* and show strong resemblances to the cultivars now grown in eastern China. Chandraratna (1964) stated that the country of origin of rice is not known, but the weight of evidence points to the conclusion that the centre of origin of *Oryza saliva* L. is South - East Asia, particularly India and Indo - China, where the richest diversity of cultivated forms has been recorded.

2.3. Rice production in the world, Africa and Ethiopia

Rice is a fundamental food in many cultural cuisines around the world. According to Ricepedia, more than 90% of production and consumption of rice in the world occur in Asia and the current share in global rice consumption is around 87%. In African countries, per capita consumption continues to increase than production (Ricepedia, 2018). The volume of international rice trade has increased almost sixfold, from 7.5 million tonnes annually in the 1960s to an average of 44.2 million tonnes during 2015–2016. Based on the global market scenario with respect to rice, the production has increased slightly with years. The use of rice as food remains predominant

compared to feed and other uses. The supply and utilization of rice have also increased slightly (FAO, 2017)

Rice is consumed by the rich and poor as well as rural and urban households. The per capita net availability of food grains increased after the Green Revolution, and rice is a part of the balanced diet along with vegetables, pulses, eggs, meat and fruits. The per capita net availability of rice increased to 69.3 kg/year in 2017 from 58.0 kg/year in 1951 (India MoA, 2017, DES, 2014). Although rice is widely consumed, with years, the expenditure on cereals decreased from 26.3% in 1987–1988 to 12.0% in 2011– 2012 and from 15% in 1987–1988 to 7.3% in 2011–2012 in rural and urban households, respectively. This overall dip in the expenditure may be due to the fact that more money is spent on non-food items in both rural and urban households (DES, 2014).

Rice has become a highly strategic and priority commodity for food security in Africa. Consumption is growing faster than that of any other major staple on the continent because of high population growth, rapid urbanization and changes in eating habits (Seck et al., 2013). It is the single most important source of dietary energy in West Africa and the third most important for Africa as a whole. Although local rice production increased rapidly after the 2007-2008 food crisis, a key problem facing the rice sector in Africa in general is that local production has never caught up with demand. The continent therefore continues to rely on importation to meet its increasing demand for rice.

Agriculture is the predominant economic sector in sub-Saharan Africa (SSA), with 70% of rural households depending on it as a source of their livelihood. Rice consumption is increasing faster than that of any other food staple in Africa at about 5.5% per year (2000–2010 average). This increase is driven by urbanization and related changes in eating habits, and population growth (Seck et al., 2012). Rice consumption was approximately 24 million tonnes (Mt) per year in SSA in 2012. With only about 60% of rice consumption being satisfied by domestic production, rice imports stand at 10–12 Mt. This is equivalent to one-third of the rice traded on the world market.

Demand for milled rice in SSA is expected to increase by 30 Mt by 2035, equivalent to an increase of 130% in rice consumption (Seck et al., 2012). With the exception of Egypt, nearly all African countries rely on the unreliable international rice market, where only 7% of the global production is traded. Africa accounts for one-third of global rice imports at a cost that surpassed US$ 5 billion in 2008. Africa can no longer afford to rely on the distorted global rice market, where major producing countries may restrict trade during periods of supply shortage. That was the case in the first quarter of 2008 when rice prices in international markets quadrupled in comparison to 2003 levels. SSA is highly vulnerable to global price shocks because 40% of rice consumed is imported. The "food riots" of 2008, with violent protests in countries such as Burkina Faso, Cameroon, Côte d'Ivoire, Mauritania and Senegal, are a testimony to Africa's vulnerability to international rice price volatility.

Current concerns are that rice prices may increase by 10 to 20 percent in 2015-2016, if the El Niño weather persists. Global ending stocks of rice are the lowest since 2007/08 and Thailand, a major rice exporter to Africa, is projected to reduce rice exports by 10% (Childs, 2015). Under this situation, if interventions are not made now, local markets in Africa may immediately experience severe shortage of rice in the future and this may be associated with socially unstable situations in rice growing areas, such as increases in poverty levels.

In recognition to the importance of rice sector to the country economy, the Government of Ethiopia (GoE) has developed a National Rice Research and Development Strategy in Ethiopia (NRRDSE) to guide the integrated and focused promotion of the rice sector in the effort to ensure food security in the country (MoA, 2010). As a result, rice received due emphasis and is considered as the "Millennium crop". Even though, introduced recently, rice has proven to be a crop that can assure food security in Ethiopia. The research and development activities so far undertaken on rice in the country, though at limited scale have shown good productivity level and also shows the existence of considerably vast suitable ecologies for production along with the possibility of growing, where other food crops do not do well.

As per the NRRDSE the country has about 20-million-hectare suitable land for the production of rice under rain-fed and irrigation conditions. The area covered by rice during 2014/15 Meher production was 46,832 hectares that is 0.37% of the grain crops with 1.318 million quintal

production volume with 118,079 small-holders engagement with a significant increase over the past years (CSA, 2015).

As per Minilik Tsega, 2013 report, the average cropped area per rice producer at national level was 0.74 and 0.76 hectares in 2010 and 2009, respectively. The total cultivated area at national level has increased from approximately 45,874 in 2009 to 49,021 hectares in 2010. The cultivated area has increased in 2010 as compared to 2009 by about 7% nationally with considerable difference across regions. According to the CSA, rice is grown in 17 administrative zones, but production is mainly concentrated in 6 zones, including: Borena (41.3%), South Gondar (28.0%), Wolayita (20.9%), PaweSpecial Woreda (2.7%), Kambata and Timbaro (2.3%), and East Gojam (2.1%).

The increase of rice consumption in Ethiopia contributes the boosting of its cultivation. Rice is consumed in various ways. According to MOARD report on the progress made in the popularization of the crop, rice is consumed as enjera, bread, porridge, soup, boiled with sauce and local drinks (like "*tela*" and "*areki*"). The domestically produced rice is consumed by the producers and consumers insmall urban areas, while the imported is distributed to major urban consumers through a network of supermarkets.

2.4. The different types of rice varieties

Among the 40,000 varieties of rice cultivated worldwide, only two major species are cultivated widely—Oryza sativa or the Asian rice and Oryza glaberrima or the African rice. The cultivation of Oryza sativa is practiced worldwide; however, the cultivation of the Oryza glaberrima is confined to Africa (Ricepedia, 2017). Oryza sativa has two major subspecies: the Indica, long-grain rice and the Japonica, round-grain rice. Japonica rice is mainly cultivated and consumed in Australia, China, Taiwan, Korea, the European Union, Japan, Russia, Turkey and the USA. Indica rice varieties are grown widely in Asia (Ricepedia, 2017). These varieties also comprise of the fragrant ones which are priced as premium. The principal fragrant varieties are Hom Mali from Thailand and the various types of Basmati exclusively grown on the Himalayan foothills of India (in the states of Haryana and Punjab) and Pakistan (in the state of Punjab) (FAO, 2006).

In Somali region different rice varieties has been adapted so far in different areas of the region. Here are some of the rice varieties. Of these varieties; Shabele1, Gode1 and Hoden are irrigated paddy rice while the others are upland paddy rice.

Table 2.1: Different rice varieties adapted and grown in Somali Region of Ethiopia.

Variety name	Released year	Yield (q/ha)		Maturity
		On station	On farm	
Shabele 1	2006	59	45	140-150
Gode 1	2006	57	43	140-150
Hoden	2006	47	40	140-150
Nerica 1	2006	61	45	90-100
Nerica 2	2006	69	47	90-100
Kelafo 1	2010	65.56	50.23	90-100
Nerica 14	2010	63.28	50	90-100
Nerica 6	2011	63.70	56.12	90-100
Nerica 15	2011	62.69	50.45	90-100

Source: SoRPARI, 2020.

2.5. Rice Parboiling

It is estimated that about one-fifth of world's rice and more than half of the Indian production undergoes parboiling process. The parboiling process has disrupted the organized constituent of rice. Rice starch was gelatinized during parboiling and the total amylose content of the rice remained unchanged (Ali and Bhattacharya, 1972).

Apart from India, Bangladesh, Pakistan, Nepal and Sri Lanka are also following the process of parboiling. Parboiled rice is also consumed in many other countries of Asia and Africa, particularly among the descendants of Indian origin (Borasio and Gariboldi, 1967).

Parboiling, literally, means partial boiling. In practice, it means boiling (i.e, cooking) of the rice within the husk (so as to retain its size and shape) after which it is dried. In other

words, parboiling (or hydrothermal treatment, as some recent workers call it) is nothing but rice precooked in paddy form. The process involves soaking, steaming and drying the rice with husk intact. About one fifth of the world production and more than half of the paddy produced in India were reported to be parboiled (Bhattacharya, 1985).

During the process of parboiling, the husk opens slightly due to swelling of the kernel. This makes the dehusking operations easier, thereby increasing the shelling capacity of the mill. As a matter of fact, the improvement in the milling quality sometimes more than off-sets the cost of processing, and often the parboiled rice is sold at a cheaper rate than raw rice. This improved milling quality arises from healing of kernal defects as a result of realignment and cementing of the grain constituents upon cooking of the starch during parboiling (Bhattacharya and Subbarao, 1966).

Parboiling also causes some minor disadvantages during milling. Firstly, due to hardening of the grains, parboiled rice requires a greater force or longer time to mill. Secondly, polishing of parboiled brown rice leads to some problem of rice stickiness and clogging of the mill screen. The resultant rice also has a rather unattractive appearance (Raghavendra et al., 1967).

Parboiled rice has also been claimed to be more resistant to infestation by insects and moulds. It is considered that the greater hardness and the smooth surface of the gelatinized grain provide a safe cover from insect attacks. After parboiling, the finished rice acquires a color varying from light yellow to medium amber. This discoloration is chiefly due to non-enzymatic browning of the maillard type, as it is largely inhibited by bisulphate. A part of the bran might be embedded in the endosperm during parboiling, which would add to the color of the rice, more so because this layer itself is darkened by maillard reaction, being rich in free sugars and amino acids. Parboiling, actually, lowers the total B1 (thiamine), content of the original, but whatever remains is much better protected against milling loss (Subbarao and Bhattacharya, 1966). Other vitamins (riboflavin, niacin), minerals (Ca, P, Fe) and even protein are also, protected in the same way.

The storage behavior of rice is improved by parboiling. Hydrolytic rancidity, due to splitting of fat to free fatty acids, is completely checked as a result of inactivation of rice lipase. However, parboiled rice is more prone to oxidative rancidity leading to deterioration of aroma and flavour (Houston, 1972).

2.6. Cooking Quality

Cooking implies hydration and gelatinization of starch. So, the two components of the process are water and heat, when starch is out in water at room temperature, it hydrates slowly, ultimately coming to an equilibrium at around 30 % moisture (wet basis). No appreciable change occurs when this slurry is heated, until at a particular temperature the granules suddenly start to swell and hydrate very rapidly. At the same time, the slurry becomes viscous and also more translucent. This phenomenon is called gelatinization temperature range. This range, usually, lies between 500C and 80oC (Gariboldi, 1984).

2.7. Nutritional value of rice

White rice

Raw, long-grain white rice is a good source of carbohydrates, calcium, iron, thiamine, pantothenic acid, folate and vitamin E when compared with maize, wheat and potatoes. It does not contain vitamin C, vitamin A, beta-carotene, lutein and zeaxanthin. It is also notably low in dietary fibre.

Colored rice

Brown rice retains its bran layer (containing vitamins, minerals and fibre), as this has not been polished more to produce white rice. The coloured rice varieties are either semi-polished or unpolished (Fig. 2). Red coloured rice varieties are known to be rich in iron and zinc, while black rice varieties are especially high in protein, fat and crude fibre. Red and black rice get their colour from anthocyanin pigments, which are known to have free radical scavenging and antioxidant capacities, as well as other health benefits. Brown rice is highly nutritious. It has low calorie and has a high amount of fibre. Furthermore, it is a good source of magnesium,

phosphorus, selenium, thiamine, niacin, vitamin B6 and an excellent source of manganese. Brown rice and rough rice are rich in vitamins and minerals; this is due to the fact that the vitamins are confined to the bran and husk of the paddy. Rice bran and husk contain a higher amount of calcium, zinc and iron. Rice is rich in glutamic and aspartic acids but has a lower amount of lysine. The antinutritional factors that are concentrated mainly in the bran are phytate, trypsin inhibitors, oryzacystatin and haemagglutinin-lectin (Lai VMF et.al., 2007).

Moisture

The moisture content plays a significant role in determining the shelf life of foods. Xheng and Lan (Ramaiah K, Rao MVBN, 1953). report that moisture influences the milling characteristics and the taste of cooked rice. The differences in genetic makeup and the climatic conditions in which they are cultivated determine the moisture content in rice varieties. The moisture content of the red rice varieties is variable from 9.3 to 12.94%, the moisture content of brown rice and milled rice is lower than other rice varieties.

Protein

Protein is the second major component next to starch; it influences the eating quality and the nutritional quality of rice. In India, the dietary supply of rice per person per day is 207.9 g, this provides about 24.1% of the required dietary protein (Kitano H, et.al., 1993). Rice has a well-balanced amino acid profile due to the presence of lysine, in superior content to wheat, corn, millet and sorghum and thus makes the rice protein superior to other cereal grains (Juliano BO, 1993) The lysine content of rice protein is between 3.5 and 4.0%, making it the highest among cereal proteins. The endosperm protein comprises of 15% albumin (water soluble), globulin (salt soluble), 5–8% prolamin (alcohol soluble), and the rest glutelin (alkali soluble) (Ebuehi QAT, et.al., 2007).

The coloured rice has high protein content than polished white rice due to the presence of bran. The Srilankan and Chinese varieties have higher protein content than the Indian varieties. Rice bran proteins are rich in albumin than endosperm proteins. The aleurone protein bodies contain 66% albumin, 7% globulin and 27% prolamin and glutelin (Tanaka N et.al., 2004).

Fat

The fat present in rice is a good source of linoleic acid and other essential fatty acids. The rice does not contain cholesterol (Xheng X et.al., 2007). The lipids or fats in rice are mainly confined to the rice bran (20%, dry basis). It is present as lipid bodies in the aleurone layer and bran. The core of the lipid bodies is rich in lipids and the major fatty acids are linoleic, oleic and palmitic acids (Juliono BO et.al.,1986 and Tanaka Y. et.al., 1978). Starch lipids present in rice is composed of monoacyl lipids (fatty acids and lysophosphatides) complexed with amylose (Choudhury NH & Juliono BO, 1980). The amount of fat present in various fractions of rice and red rice indicate that red rice varieties from Sri Lanka and India have about 1% fat, while the China red rice has almost doubled this value.

Fibre

The presence of fibre in the diet increases the bulk of faeces, which has a laxative effect in the gut. The fibre content is 0.5–1.0% for well-milled rice (Oko Ao. Et.al., 2010). Arabinoxylans, along with β-d-glucan, are the major component of soluble dietary fibre in rice. In addition, rhamnose, xylose, mannose, galactose and glucose are also present in soluble dietary fibre. Insoluble dietary fibre is made up of cellulose, hemicellulose, insoluble β-glucan and arabinoxylans. However, the quantity and amount of non-starch polysaccharide depend upon the rice cultivar, the degree of milling and water solubility (Lai VMF et.al., 2007). Among the red rice varieties, Chak-hao amubi (Manipur black rice) has a significantly lower content of crude fibre.

Ash

The variation in ash content of different cultivars of rice may be due to genetic factors or the mineral content of the soil (AO O et.al., 2012). The zinc and iron content of red rice is two to three times higher than that of white rice (Ramaiah K, Rao MVBN, 1953). The most common minerals found in rice include calcium, magnesium, iron and zinc . The proximate composition of rice and its fractions are influenced by the kind of rice and degree of milling, as milling completely or partially removes the bran layer, aleurone layer and embryo. Thus, variation occurs in the

nutrition content between the rice fractions of the same rice variety. The variations can be found in the amount of fats, fibre and minerals present in the grain.

2.8. Functional properties of rice

Functional properties characterize the structural quality, nutritional value and acceptability of food or food products. Generally, food stuffs show several functional properties like hydration properties (protein solubility, protein dispensability, water- and fat- holding capacities), surface properties (emulsion and foam), structural and textural properties (viscosity, gelation and visco elasticity). The proximal constituents of food (proteins, carbohydrates, fats, and fibre) undergo several changes during processing leading to favorable transformation in form, texture and taste of food or food product. Proteins in foods could be enzymatically modified by controlled proteolysis, which may enhance their functional properties over a wide range of pH, ionic concentration and other processing conditions (Panyam and Kilara, 1996). Protein solubility, gelling abilities, foaming properties, swelling capacity, water holding capacity, etc., are the intrinsic physicochemical properties of flours basing on the relative strength of the hydrophilic and the hydrophobic groups of the starch and protein. Proteins with comparatively higher amount of polar amino acids show very high hydrophilic strength whilst the protein hydrophobic character is based on the exposure of the non-polar amino acids (Alleoni, 2006). The pH, temperature, radiations, and ionic strength cause the denaturation of protein molecules and have effect on the functional properties of the flour. The variations in functional properties further results to the change in the quality of food products (Moses *et al.*, 2012; FAO, 2010). Bulk density of flour is influenced by the structural arrangement of the carbohydrates and other polymers present in the flour (Adejuyitan *et al.*, 2009).

2.8.1. Emulsion capacity

The emulsion activity is the ability of protein in grains responsible for emulsion formation as well as stability of newly formed emulsion. The emulsion capacity depends on the shape, charge and hydrophobicity of the protein molecules, neutrality of dipoles and hydration of polar groups (Zayas 1997). Emulsifying capacity involves several physical and chemical factors and depends on the stabilizer properties and varies with the type of protein contents, concentration, ionic strength, pH, and viscosity of the system.

2.8.2. Foaming capacity

Foam is a two-phase system consisting of air cells separated by a thin continuous liquid layer (Zayas 1997). The optimum foam formation of a material depends on speed of rotation, interval of stirring and pH (Gassmann *et al.* 1987). The foaming capacity of food products depends on the distribution of gas bubbles in semisolid or liquid phase. Foaming improves the visual appeal and the texture of foods. Food systems which require high foaming capacities and stability are breads, icing and whipped creams, cakes, and sponges (Atuonwu and Akobundu, 2010). Conversely, foods which require low foaming capacities and stability are crackers, biscuits, and cookies.

2.8.3. Oil-absorption capacity (OAC)

Oil absorption capacity (OAC) capacity represents the ability of a product to associate with oil under the conditions of oil limitation (Singh 2001). It will be usually dependent on starch and fibre contents in the given grain flour.

2.8.4. Water absorption capacity (WAC)

Water absorption capacity (WAC) is a measure of the interactions between flour and water which takes place in a lot of foods. WAC depends on the ability of a polysaccharide or protein matrix to absorb, retain, and also physically entrap water against the gravity (Traynham *et al.*, 2007). WAC has effects on flour thickness, maintenance of freshness, handling, and viscosity. Water absorption capacity is also associated with a flour ability to produce form viscoelastic dough, which leads to the flexibility and capacity of the dough to be stretched and molded. A high-Water absorption capacity is an important quality of an ingredient in food that need hydration for textural and handling properties.

2.9. Rice in the Human Diet

Since its domestication, rice has fed world population continuously through the years in as increasing manner, and along with wheat and maize are the three most grown cereals crop

worldwide (Hu and Wang 2016). It can be observed that compared to wheat and maize (as coarse grains) rice production is lower, however, it stands out since more than 80% of its production is destined to direct human consumption according to the forecast for 2018/2019 (Trade and Markets division, 2018).

Moreover, rice consumption per capita has been increasing although in the last years it has been stabilizing (Figure 1.8). Despite this, food consumption has been continuously increasing due to a concomitant growth of the world population (Mohanty, 2013; FAO 2018a). Production of rice (in milled equivalents) has also been increasing since yields were incremented during the green revolution, but are now stabilized. In the forthcoming years it will not sustain the growing population, which will lead to a production shortage (FAO, 2018a). This will impact heavily on the low – and lower-middle-income countries in the forthcoming years, where rice is the main staple food providing the main calories supplies (McLean et al. 2013; FAO 2018b)

CHAPTER THREE

3. Materials and Method

3.1. Structure of the experiment work

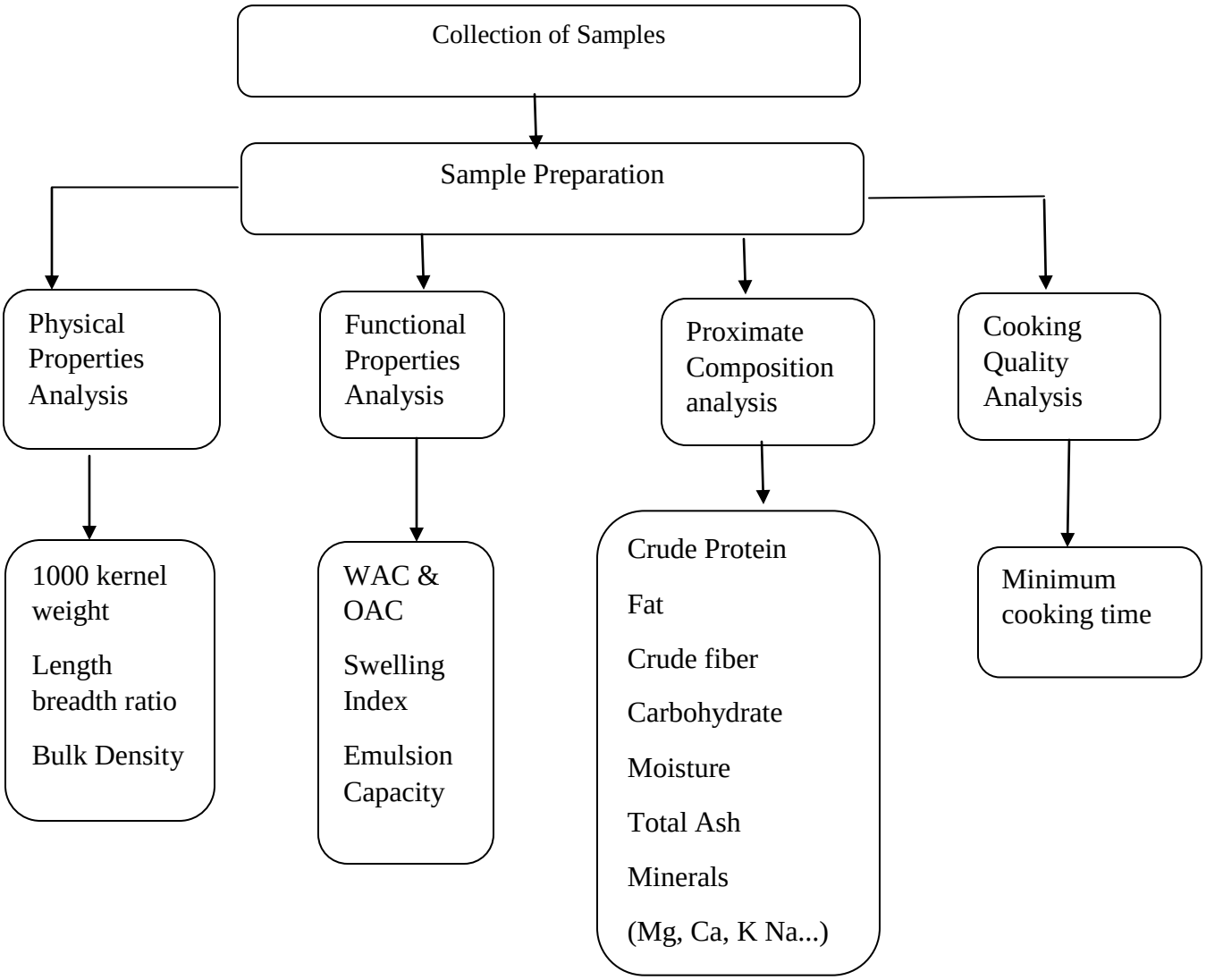


Figure 3.1: Structure of the experimental work

3.2. Materials and Equipment Used

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.

Equipment and reagent such as size reduction machine, sieve, centrifuge, measuring cylinder, test tube, digital beam balance, distilled water, oil, tap water were used.

3.3. 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).

3.4. 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.

3.5. Proximate Composition

3.5.1. 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).

3.5.2. 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.

Digestion

Fresh samples (in duplicate) of each 0.5g were added into Tecator tubes and 6ml of acid mixture (5parts of concentrated ortho-phosphoric acid and 95 parts of concentrated sulfuric acid) were added into each tube and mixed, and 3.5ml of 30% hydrogen peroxide were 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 were allowed to stand for about 10 minutes before digestion. Following the attainment of digester temperature at 370^{o}C, the tubes was low bed into the digester. The digestion was continuing until a clear solution were 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 were distilled using boric acid and the distillate were 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.

3.5.3. 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). 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:

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

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)

3.5.4. 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 were using distilled water was placed in a muffle furnace at 550^{o}C for 30 minutes. Then, the crucibles were cooled by placing it in desiccators for 30 minutes at room temperature. Following this step, they were 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 were 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 were 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).

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

(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)

3.5.5. 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)

3.5.6. 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, was

behing, drying and combustion. Following these steps, the crude fiber was calculated using the following formula:

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

Where;

W_1 = weight of the fresh sample
W_2 = weight of crucible with the sample after oven draying
W3 = weight of the crucible with the sample after ashing

3.5.7. 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.

3.5.8. Mineral analysis

Mineral composition of the samples was determined according to methods recommended by Association of Official Analytical Chemists (AOAC, 2000). Fe, and Zn content of complementary food samples were determined by atomic absorption spectrophotometer (AAS) following standard procedures.

Sample preparation for Fe and Zn

The complementary food samples were ashed following the procedure described above in the total ash analysis section. 7 mL of 6N HCl solution were added to the ash of each sample and heated on a low temperature hot plate until it dried. Then, 15 mL of 3N HCl solution were added and the mixture were heated on the hot plate till it just boils. After the solution cooled down, it was filtered through a filter paper into a volumetric flask (50 mL). Ten mL of 3N HCl was added and the crucible were heated until the solution boiled. The solution was allowed to cool and filtered through a filter paper into the volumetric flask. The crucible and filter paper were thoroughly mixed and were collected into the flask. Finally, 2.5 mL of lanthanum chloride was added into the solution and the volume was made up to the 50 mL mark with deionized water. Blank sample was also run by taking the same number of reagents. The solutions were transferred to polyethylene bottles and stored in cool place until analysis.

Calibration curve and AAS reading

In order to fit calibration curves, a series of standard solutions of the minerals was prepared from stock solutions of 20 ppm for Fe (0, 0.5, 1, 2, 3, and 4) and Zn (0, 0.5, 1, 2,3 and 4 ppm). The flame AAS was calibrated with the prepared standards for the respective minerals and the sample solutions and also the blank was run to correct the obtained values. Finally, the mineral content of the samples was calculated by using the following formula.

$$\text{Mineral content } (mg/100g) = \frac{[(cs-cb)x\,v\,x\,D]}{10\,x\,W}$$

Where,

Cs = concentration sample, Cb = Concentration of the blank, V = volume (mL) of the extract and W = weight of samples, D= dilution factors.

$$\text{Fe content } (mg/100g) = \frac{(c-D)x\,200}{w\,x\,10}$$

$$\text{Zn content } (mg/100g) = \frac{(E-F)x\,2000}{wx\,10}$$

W = weight (g) of sample

C and E = Concentration of the sample

D and F = Concentration of blank

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. 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., 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) were 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 was calibrated using standard solutions and the reagent blank solution was run with the sample.

Ashes were 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 (Whatman 42, 125mm) into a 50ml graduated flask. A 5ml of 3N HCl was added into each crucible dishes and heated until the solution just boils, cooled, and filtered into the flask. The crucible dishes were again was behed three times with de-ionized water; the will behings were 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 deionized water. A blank will be 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.

Phosphorous determination

Phosphorous was determined by the colorimetric method using ammonium molybdate (AOAC, 2000). It was converted to phosphomolybdate, which were reduced to a blue molybdenum compound by aminonaphtholsulphonic acid to give a blue molybdenum compound. A sample solution was obtained from mineral analysis (determination of Fe, Zn and Ca). 1 ml of the clear extract was taken from the sample solution and diluted to 100 ml with distilled water in a 100 ml volumetric flask.

A 5ml of the sample dilution was added into test tubes. A 0.5ml of molybdate and a 0.20ml aminonaphtholsulphonic acid was added into the test tube (sample solution) and mixed thoroughly step by step. A 0.20ml aminonaphtholsulphonic acid was added into the test tube repeatedly each time until the solution becomes clear. The solution was allowed to stand for 10 minutes. The absorbance (reading A) of the solution was measured at 660 nm against distilled water. Simultaneously with sample phosphorous, standard and blank analysis was carried out.

Standard and blank solutions were prepared as above but 5 ml of working standard (reading AS) and 5 ml of distilled water (reading AB) in place of the sample dilution was used respectively. A standard curve was made from absorbance versus concentration and the slope was used for calculation.

Calculation:

First AB was subtracted from all other readings

P mg/100g = (A-AB) x 50 x 100 x /slope x WF x 10

Where: A = Reading of the sample solution

AB = Reading of the blank solution

WF = Weight of fresh sample.

Determination of phytate and non-phytate phosphorus

Phytate and phosphorous was determined by the above methods. Phytate phosphorus was calculated with the following formula (Khetarpaul and Sharma, 1997).

Phytate phosphorous (mg*/100g) = (A*28.18)/100*

Where; A = phytate content (mg/100g)

Non-phytate phosphorous was calculated as a difference between the total phosphorus and phytate phosphorous.

Determination of molar ratio of phytate/mineral (Bioavailability)

The mole of phytate and minerals were determined by dividing the weight of phytate and minerals with its atomic weight (phytate: 660g/mol; Fe: 56g/mol; Zn: 65g/mol; Ca: 40 /mol). The molar ratio between phytate and mineral was obtained after dividing the mole of phytate with the mole of minerals.

3.6. Determination of functional properties

3.6.1. 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

3.6.3. 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.

3.6.4. 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:

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

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

3.7. 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 $P < 0.05$.

CHAPTER FOUR

4. Result and Discussion

4.1. 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.

As shown in table 4.1, 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 were 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 $P<0.05$. The 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 $p<0.05$.

4.2. Discussion

4.2.1. General Introduction

In this part of the report, we are going see details of what different results of the above tables means. Detail's discussions of each parameter especially those that have highly linked to objective the study is clearly going to see. The proximate (Nutritional) composition both macro

and micro nutrient (minerals), the functional properties and the physical properties & the minimum cooking time are those sub-topics we discuss it in this part as follows.

4.2.2. 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 indicate 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.

4.2.3. 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).

4.2.4. 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 differ 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).

4.2.5. 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.

CHAPTER FIVE

5. Conclusion and Recommendation

5.1. 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.

5.2. 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.
- Platform should be established which put all rice actors like researchers, investors, government bodies and NGOs. May be further establishment is recommended to have Rice Institute, Commission or others for the better result that can be obtained from Rice.
- Only five were included under this study from the nine rice varieties released by Somali Region Pastoral & Agro-Pastoral Research Institute (SoRPARI). Further research with full package regarding rice on different aspect should be done with fulfilment of 3Fs (Feasibility, Facility and Finance).

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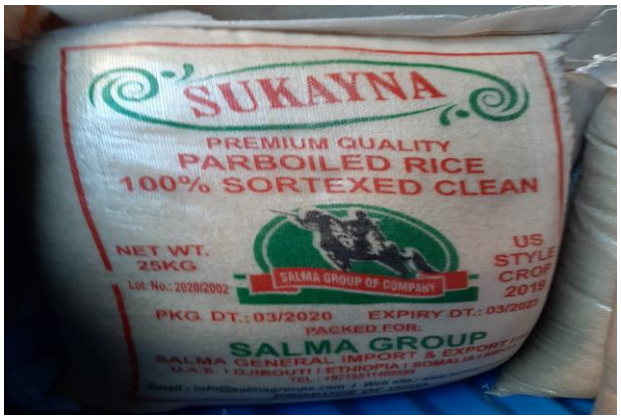
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APPENDIX

Appendix A: Photos of the experiment



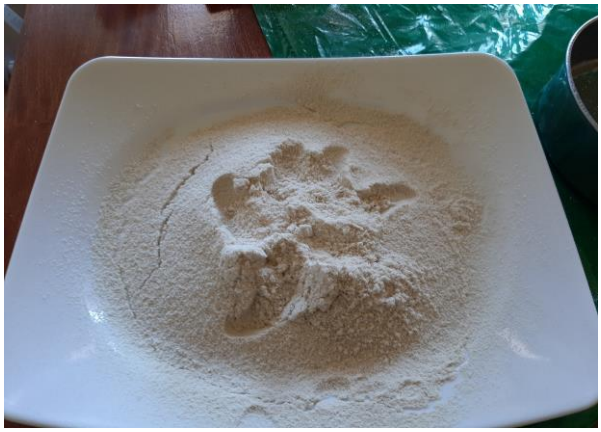








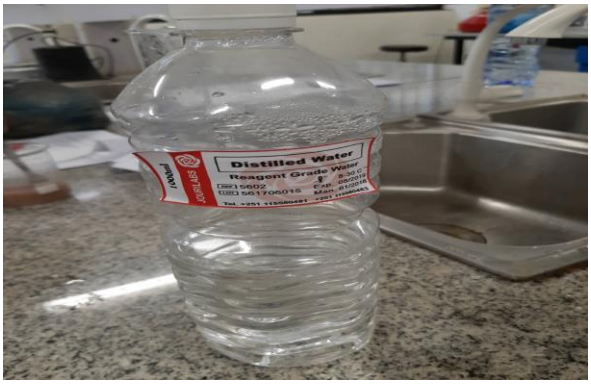









Sample pictures during sample preparation

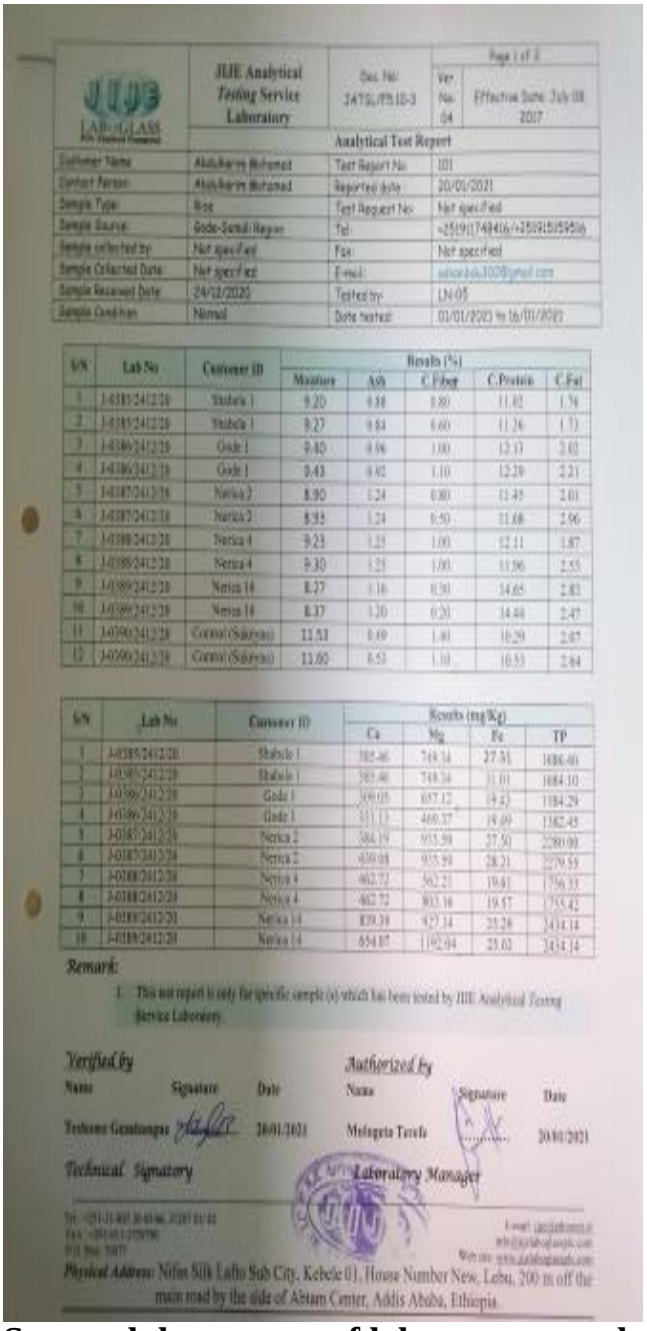









Sample pictures during Laboratory demonstration



JLIE Analytical Testing Service Laboratory

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Analytical Test Report

Customer Name	Abdulkerim Mohamed	Test Report No	101
Contact Person	Abdulkerim Mohamed	Reported date	20/01/2021
Sample Type	Rice	Test Request No	Not specified
Sample Source	Gode-Somali Region	Tel	+251911748416/+251915159516
Sample collected by	Not specified	Fax	Not specified
Sample Collected Date	Not specified	E-mail	abdorbdu3028@gmail.com
Sample Received Date	24/12/2020	Tested by	LN-05
Sample Condition	Normal	Date tested	01/01/2021 to 16/01/2021

S/N	Lab No	Customer ID	Results (%)				
			Moisture	Ash	C.Fiber	C.Protein	C.Fat
1	340385/2412/20	Shabele 1	9.20	0.88	0.80	11.02	1.76
2	340385/2412/20	Shabele 1	9.27	0.84	0.60	11.26	1.73
3	340386/2412/20	Gode 1	9.40	0.96	1.00	12.13	2.02
4	340386/2412/20	Gode 1	9.43	0.92	1.10	12.20	2.21
5	340387/2412/20	Nerica 2	8.90	1.24	0.80	11.45	2.01
6	340387/2412/20	Nerica 2	8.93	1.24	0.50	11.68	2.96
7	340388/2412/20	Nerica 4	9.23	1.25	1.00	12.11	1.87
8	340388/2412/20	Nerica 4	9.30	1.25	1.00	11.96	2.55
9	340389/2412/20	Nerica 14	8.27	1.16	0.30	14.65	2.83
10	340389/2412/20	Nerica 14	8.37	1.20	0.20	14.44	2.47
11	340990/2412/20	Control (Sakoyna)	11.53	0.49	1.40	10.29	2.07
12	340990/2412/20	Control (Sakoyna)	11.80	0.53	1.10	10.53	2.84

S/N	Lab No	Customer ID	Results (mg/Kg)			
			Ca	Mg	Fe	TP
1	340385/2412/20	Shabele 1	385.46	749.14	27.91	1686.40
2	340385/2412/20	Shabele 1	387.40	749.14	31.01	1684.10
3	340386/2412/20	Gode 1	399.05	857.12	19.42	1384.29
4	340386/2412/20	Gode 1	511.13	460.37	19.69	1382.45
5	340387/2412/20	Nerica 2	384.19	955.99	27.50	2280.00
6	340387/2412/20	Nerica 2	400.08	955.99	28.21	2279.55
7	340388/2412/20	Nerica 4	402.72	962.21	19.61	1756.33
8	340388/2412/20	Nerica 4	402.72	803.38	19.57	1755.42
9	340389/2412/20	Nerica 14	839.39	427.34	25.28	3414.14
10	340389/2412/20	Nerica 14	654.87	1192.94	25.02	3414.14

Remark:

1. This test report is only for specific sample (s) which has been tested by JLIE Analytical Testing Service Laboratory.

Verified by

Name	Signature	Date
Teshome Geshungna		20/01/2021

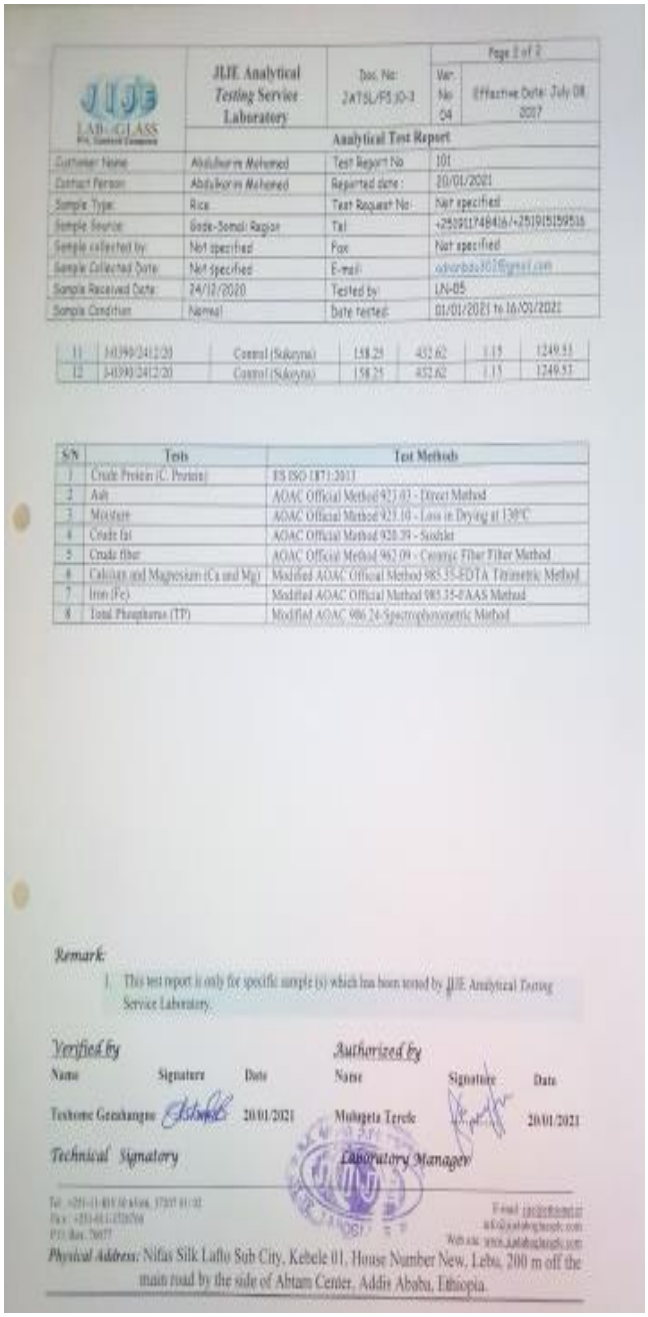
Technical Signatory

Authorized by

Name	Signature	Date
Mulugeta Tereda		20/01/2021

Laboratory Manager

Physical Address: Nifas Silk Lafto Sub City, Kebele 01, House Number New, Lebu, 200 m off the main road by the side of Abtam Center, Addis Ababa, Ethiopia.



JLIE Analytical Testing Service Laboratory

Doc. No: JATSL/FS.10-3 | Ver. No: 04 | Effective Date: July 08, 2017 | Page 2 of 2

Analytical Test Report

Customer Name	Abdulkerim Mohamed	Test Report No	101
Contact Person	Abdulkerim Mohamed	Reported date	20/01/2021
Sample Type	Rice	Test Request No	Not specified
Sample Source	Gode-Somali Region	Tel	+251911748416/+251915159516
Sample collected by	Not specified	Fax	Not specified
Sample Collected Date	Not specified	E-mail	abdorbdu3028@gmail.com
Sample Received Date	24/12/2020	Tested by	LN-05
Sample Condition	Normal	Date tested	01/01/2021 to 16/01/2021

11	340990/2412/20	Control (Sakoyna)	158.25	452.62	1.15	1249.51
12	340990/2412/20	Control (Sakoyna)	158.25	452.62	1.15	1249.51

S/N	Tests	Test Methods
1	Crude Protein (C. Protein)	ES ISO 1871:2013
2	Ash	AOAC Official Method 923.03 - Direct Method
3	Moisture	AOAC Official Method 925.10 - Loss in Drying at 130°C
4	Crude fat	AOAC Official Method 920.39 - Soxhlet
5	Crude fiber	AOAC Official Method 962.09 - Ceramic Fiber Filter Method
6	Calcium and Magnesium (Ca and Mg)	Modified AOAC Official Method 985.35-EDTA Titrimetric Method
7	Iron (Fe)	Modified AOAC Official Method 985.35-FAAS Method
8	Total Phosphorus (TP)	Modified AOAC 986.24-Spectrophotometric Method

Remark:

1. This test report is only for specific sample (s) which has been tested by JLIE Analytical Testing Service Laboratory.

Verified by

Name	Signature	Date
Teshome Geshungna		20/01/2021

Technical Signatory

Authorized by

Name	Signature	Date
Mulugeta Tereda		20/01/2021

Laboratory Manager

Physical Address: Nifas Silk Lafto Sub City, Kebele 01, House Number New, Lebu, 200 m off the main road by the side of Abtam Center, Addis Ababa, Ethiopia.

Scanned documents of laboratory result for proximate analysis