Original Research

EAST AFRICAN JOURNAL OF PASTORALISM
Volume 4 Issue 2

Physicochemical Properties, Proximate and Functional Properties of Different Rice Varieties Produced in Somali Region of Ethiopia and Imported Rice

Abdulkarim Mohammed Ali[a,*], Mohammed Dol Ateye[b], Hoodo Mohammed Jama[c] and Hoodo Mohamed Mohamud[d]

[a]*Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition Research Directorate*
[b]*Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition Research Directorate*
[c]*Somali Region Pastoral & Agro-Pastoral research institute, Food Science and Nutrition Research Directorate*
[d]*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. 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: Cooking time, Functional Properties, Physical properties, Proximate composition of Rice.

1. Introduction

Rice (*Oryza sativa L.*) stands as the paramount cereal grain cultivated worldwide, serving as the staple sustenance for almost half of the global populace (Sarowar Hossain and Kumar Singh, 2009). Constituting a fundamental element of the Asian diet, rice typically comprises 40–80% of total calorie intake, commonly consumed as whole grains following cooking, either boiled or fried, with preferences varying across cultures for taste, color, and stickiness (Sarowar Hossain and Kumar Singh, 2009). Predominantly, rice is composed of carbohydrates, chiefly in starch form, constituting 72–75% of its grain composition, alongside approximately 7% protein, predominantly glutelin, also known as oryzenin(Sarowar Hossain and Kumar Singh, 2009).

Despite its significance, Africa's rice production has struggled to keep pace with escalating demand, resulting in a heavy reliance on imports and susceptibility to international market fluctuations, thereby imperiling food security and political stability continent-wide (Alleoni, 2006). Particularly in East Africa, although production exhibited a robust upward trajectory, achieving near self-sufficiency during 2001-2005, escalating demand poses challenges, necessitating a shift from dependence on global markets, which could potentially lead to severe food insecurity and civil unrest.

Ethiopia, considering rice as the "Millennium Crop," harbors vast potential for augmenting rice cultivation to ensure food security, albeit hindered by various constraints including limited access to improved varieties, inadequate

* Corresponding author:Abdulkarim Mohammed Ali: adnanbdu302@gmail.com

Article Information:
Article Received for review: 18 April 2023
Article Reviewed: 10 June 2023
Revised Comments: 25 July 2023
Accepted for publication: 26 October 2023 Available Online: 31 December 2023
How to Cite this Article:
Abdulkarim M A, Mohammed D A, Hoodo M J,Hoodo M M (2023): Physicochemical Properties, Proximate and Functional Properties of Different Rice Varieties Produced in Somali Region of Ethiopia and Imported Rice East African Journal of Pastoralism, 4(2):15-21.
© 2023 The Authors. Published by Jigjiga University. This is an open access article under the CC By license(http://creative commons.org/licenses/by/4.0/)

postharvest techniques, pest infestation, credit constraints, labor shortages, and market inefficiencies (Ababa, 2020). Notwithstanding these challenges, rice production in Ethiopia has significantly transformed farmers' livelihoods and created employment opportunities across the nation (Tsega et al., 2013).

In the Somali region, rice production emerges as a pivotal strategy in alleviating food insecurity, necessitating enhanced quality control and livelihood enrichment through comprehensive research endeavors (Tsega et al., 2013). Notably, despite progress, literature regarding the characterization of rice varieties in the Somali region remains scarce, prompting the present study aimed at analyzing the proximate, functional, physical, and culinary attributes of various rice varieties cultivated in the Somali regional state.

2. Materials and Methods

2.1. Materials and Equipment Used

Six different rice varieties produced or adapted under SoRPARI were collected, along with one popular, widely marketed or imported variety purchased from the local market as a control. The five varieties produced or adapted under SoRPARI used for this study include Shabele 1, Godey 1, Narica 14, Narica 2, Narica 4, with Sukeyna serving as the control sample. The control rice type likely represents the most commonly used variety in the local community, possibly an imported one. Only whole rice grains without any physical damage or insect infestation were selected for analysis. Some equipment used in sample preparation was obtained from SoRPARI laboratories, while any missing equipment was sourced from local institutes such as Jigjiga University. Upon arrival at the laboratory, rice samples were individually ground to a fine powder (30 mesh size), packed in airtight polyethylene plastic bags, and stored at 4°C until further analysis. Equipment and reagents such as a size reduction machine, sieve, centrifuge, measuring cylinder, test tube, digital beam balance, distilled water, oil, and tap water were utilized.

2.2. Proximate Composition

The proximate composition of rice flours was determined according to standard AOAC methods (Abeshu and Abrha, 2017)(AOAC). Moisture content was assessed using the gravimetric method in a hot air oven at 105°C until a constant weight was achieved. The quantity of ash was analyzed using a muffle furnace at 550°C. Crude protein content was measured via the standard Kjeldahl method, employing 6.25 as the conversion factor. Flour lipids were analyzed using a solvent extraction procedure. The total carbohydrate content was determined by the difference obtained from the analysis of moisture, ash, protein, and lipids. Additionally, gross energy was calculated using 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, as per **(AOAC ,2000)** guidelines. The results were expressed in calories.

2.3. Mineral analysis

The mineral contents were determined following the procedure outlined in (Ac, 1984) ,(AOAC ,1984). Calcium, iron, and zinc were assessed using the official methods of **(AOAC. 2000)**, specifically method 985.35, utilizing an Atomic Absorption Spectrophotometer. Phosphorus was determined according to official method 986.24, employing a calorimetric method with ammonium molybdate. The analysis was conducted at [insert location where the analysis took place]. The methods and procedures were strictly adhered to as prescribed in the respective AOAC guidelines.

2.4. Determination of functional properties

2.4.1. Oil and Water Absorption Capacity Determination

In the experimental procedure, each sample weighing 2g was mixed separately with 10ml of distilled water for a duration of 5 minutes on a magnetic stirrer. Following this, the mixtures underwent centrifugation at 3500rpm for 30 minutes to separate the supernatant. Subsequently, the volume of the supernatant was measured using a 10ml measuring cylinder for each sample. It's important to note that the density of water was assumed to be 1g/ml for the calculations. The water absorption capacity (WAC) and oil absorption capacity (OAC) were then determined using the following formulas:

$$WAC = \frac{Weight\ of\ the\ sample\ used}{Volume\ of\ water\ absorbed} X100 \tag{1}$$

$$WAC = \frac{Weight\ of\ the\ sample\ used}{Volume\ of\ oil\ absorbed} X100 \tag{2}$$

2.4.2. Swelling index

In the experimental procedure, 4.0g of the sample was placed in a 100ml graduated cylinder, filling it up to the 10ml mark. Water was then added to adjust the total volume to the 50ml mark. The top of the cylinder was securely covered, and the mixture was thoroughly mixed by inverting the cylinder. After 2 minutes, the suspension was inverted again and left to stand for an additional 10 minutes. The volume occupied by the sample was measured after this 15-minute period. The volume occupied by the sample can be calculated using the formula:

$$Volume\ occupied\ by\ sample = \frac{Final\ Volume\ -\ Initial\ volume}{Dencity\ of\ sample} \tag{3}$$

2.4.3. Emulsion capacity (EC)

The experimental procedure involved dispersing 2g of flour/blend in 10mL of distilled water, after which the height of the solution in the cylinder was measured (H1). Subsequently, the solution was homogenized with 5mL of refined canola oil, and the resulting emulsion was centrifuged at 1100 × g for 5 minutes. The height of the emulsified layer was then measured (H2). The emulsifying activity was calculated as the percent increase in the height of the solution using the following equation:

$$EC\% = \frac{H1}{H2} \quad (4)$$

Where $H1$ represents the initial height of the solution before emulsification, and $H2$ represents the height of the emulsified layer.

2.5. Statistical analysis

The analyses were conducted in replication, and the results were presented as mean ± standard deviation. Statistical significance was determined using One-way analysis of variance (ANOVA) followed by Duncan's test, utilizing GenStat version 17.0 software. A significance level of $P < 0.05$ was considered for all analyses.

3. Results and Discussion

3.1. Proximate composition of different Rice

The differences in moisture and ash content among rice varieties can be attributed to several factors including genetic composition, environmental conditions during growth, post-harvest handling, and processing methods. Starting with moisture content, Nerica 14 having the lowest moisture content could be due to its inherent genetic traits or its susceptibility to drying during the post-harvest process. It's possible that Nerica 14 has been bred or selected for traits that result in lower moisture retention or that it tends to dry out more readily during storage or processing compared to other varieties. On the other hand, Sukeyna having the highest moisture content may indicate that it retains moisture more effectively or that it is less prone to drying out during storage or processing. This could be due to its genetic makeup, environmental conditions during growth, or post-harvest handling practices. Regarding ash content, the higher ash content in Nerica 4, Nerica 2, and Nerica 14 compared to other varieties suggests potential differences in mineral content or composition. These varieties may have been cultivated in soils with higher mineral concentrations or may have genetic traits that lead to increased uptake or retention of minerals. Sukeyna, being the control sample with the least ash content, could indicate differences in soil composition, cultivation practices, or genetic traits that result in lower mineral uptake or retention.

The lack of significant difference in ash content between Nerica 2 and Nerica 4, despite their differences from other varieties, suggests that these two varieties may share similar genetic or environmental factors influencing mineral content. The significant differences observed in ash content among the other varieties indicate distinct mineral profiles influenced by various factors such as soil composition, fertilizer application, and genetic traits. The differences in moisture and ash content among rice varieties can be attributed to a combination of genetic factors, environmental conditions, and post-harvest handling practices. Further research into the specific factors influencing these properties in each variety could provide valuable insights into optimizing rice production and processing techniques.

The variations observed in protein, fat, carbohydrate, and energy content among the different rice varieties can be attributed to a combination of genetic factors, environmental conditions, and processing methods. Starting with protein content, the higher protein content in Nerica 14 compared to other samples suggests genetic traits or environmental conditions that favor protein accumulation in this variety. Conversely, Sukeyna having the lowest protein content could indicate differences in genetic makeup or environmental factors that result in reduced protein synthesis or accumulation. The lack of significant difference in protein content between Gode1 and Nerica 4 suggests similarities in their protein profiles, which could be due to shared genetic traits or environmental conditions. In terms of fat content, the absence of significant differences among all samples indicates uniformity in fat composition across the tested varieties. This suggests that fat content in rice may be less influenced by genetic or environmental factors compared to other macronutrients like protein and carbohydrates. Regarding carbohydrate content, the higher carbohydrate content in Shabele 1 compared to other varieties may reflect differences in genetic traits favoring carbohydrate synthesis or storage in this variety. Conversely, Nerica 14 having the lowest carbohydrate content suggests differences in genetic makeup or environmental conditions that lead to reduced carbohydrate accumulation.

The lack of significant difference between Nerica 14 and Sukeyna, as well as between Gode 1 and Nerica 4, suggests similarities in carbohydrate composition among these pairs of varieties. When considering energy content, the absence of significant differences in energy obtained from consuming Shabele 1, Gode1, Nerica 2, and Nerica 4 suggests similar caloric values among these varieties. However, the significant difference in energy content observed in Nerica 14 and Sukeyna may be attributed to variations in their macronutrient compositions, particularly in protein and carbohydrate content, which directly influence energy yield upon consumption. In summary, the observed differences in macronutrient and energy content among the tested rice varieties highlight the complex interplay of genetic, environmental, and processing factors in shaping the nutritional composition of rice. Further research into the specific factors influencing these properties in each variety could provide valuable insights for optimizing rice breeding, cultivation, and processing techniques to enhance nutritional quality and overall consumer health.

3.2. Minerals content of different rice varieties

The variations in mineral content among the different rice varieties provide insights into their nutritional profiles and potential health benefits. Starting with calcium content, the higher calcium content in Nerica 14 compared to other samples suggests genetic traits or environmental conditions favoring calcium accumulation in this variety. Conversely,

Table 1: Proximate composition of different Rice Varieties

	Results in (%) (100g)						
Varieties	**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 2: Mineral's content of different rice varieties

	Results in mg (%)			
Varieties	**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.

Sukeyna having the lowest calcium content may indicate differences in genetic makeup or environmental factors that result in reduced calcium uptake or retention. The significant difference in calcium content between Nerica 14 and Sukeyna, as well as between Nerica 14 and the other four varieties, suggests distinct calcium profiles among these varieties, which could have implications for bone health and overall mineral balance. Regarding magnesium content, the observed differences between Nerica 14 and Sukeyna, as well as between Nerica 14 and the other four varieties, suggest variations in magnesium uptake or retention influenced by genetic or environmental factors. Magnesium plays crucial roles in various physiological processes, including energy metabolism, muscle function, and bone health, so variations in magnesium content among rice varieties could impact their nutritional value and potential health benefits. The observed differences in calcium and magnesium content among the tested rice varieties highlight the complex interplay of genetic, environmental, and agricultural practices in shaping their mineral profiles. Further research into the specific factors influencing mineral uptake and retention in rice could provide valuable insights for enhancing the nutritional quality and health-promoting properties of rice varieties.

The variations in iron and total phosphorus content among the different rice varieties offer insights into their nutritional profiles and potential health benefits, particularly regarding iron and phosphorus intake and utilization. Starting with iron content, the higher iron content in Shabele 1 compared to other samples suggests genetic traits or environmental conditions favoring iron accumulation in this variety. Conversely, Sukeyna having the lowest iron content may indicate differences in genetic makeup or environmental factors that result in reduced iron uptake or retention. The significant differences observed between Shabele 1 and Sukeyna, as well as between Shabele 1 and Gode1, Nerica 4, and Nerica 14, highlight distinct iron profiles among these varieties, which could have implications for blood health and overall iron status.

Regarding total phosphorus content, the higher phosphorus content in Nerica 14 compared to other samples suggests genetic traits or environmental conditions favoring phosphorus accumulation in this variety. Conversely, Sukeyna having the lowest phosphorus content may indicate differences in genetic makeup or environmental factors that result in reduced phosphorus uptake or retention. The significant differences observed among all rice varieties suggest distinct phosphorus profiles influenced by various factors such as soil composition, fertilizer application, and genetic traits. Phosphorus is essential for bone health, energy metabolism, and cellular function, so variations in phosphorus content among rice varieties could impact their nutritional value and potential health benefits. The observed differences in iron and total phosphorus content among the tested rice varieties highlight the complex interplay of genetic, environmental, and agricultural practices in shaping their mineral profiles. Further research into the specific factors influencing mineral uptake and retention in rice could provide valuable insights for enhancing the nutritional quality and health-promoting properties of rice varieties.

3.3. Functional Properties of Rice

The functional properties of different rice varieties, as depicted in Table 3, offer valuable insights into their potential applications in food processing and culinary practices. Starting with water absorption capacity (WAC), the higher WAC in Shabele 1 compared to other samples suggests superior water absorption properties in this variety. Conversely, Nerica 4 having the lowest WAC may indicate differences in grain structure or surface properties that result

Table 3: Functional properties of different rice varieties

	Results			
Va- ri- eties	**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}

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

in reduced water absorption capacity. The significant differences observed between Shabele 1 and Gode 1, Nerica 4, Nerica 14, and Sukeyna highlight distinct water absorption profiles among these varieties, which could influence their performance in cooking, baking, and other food preparation processes. Regarding oil absorption capacity (OAC), the higher OAC in Shabele 1 compared to other samples suggests greater oil-holding capacity in this variety. Conversely, Nerica 14 having the lowest OAC may indicate differences in grain structure or surface properties that result in reduced oil absorption capacity.

The significant differences observed between Shabele 1 and Sukeyna, as well as between Nerica 14, Nerica 4, and Gode 1, suggest variations in oil absorption profiles influenced by factors such as grain morphology and surface characteristics. These differences could impact the texture, flavor, and overall quality of food products prepared using these rice varieties. The observed variations in water absorption capacity (WAC) and oil absorption capacity (OAC) among the tested rice varieties highlight their diverse functional properties and potential applications in food processing. Further research into the underlying mechanisms influencing these properties could provide valuable insights for optimizing rice breeding and cultivation practices to enhance their functional attributes and overall culinary versatility.

The swelling index and emulsion capacity of rice varieties provide valuable insights into their functional properties and potential applications in various food products. Starting with swelling index, the higher swelling index in Shabele 1 compared to other samples suggests greater capacity for water absorption and swelling during cooking or processing. Conversely, Nerica 14 having the lowest swelling index may indicate differences in grain structure or composition that result in reduced water absorption and swelling capacity. The significant differences observed between Shabele 1 and Sukeyna, as well as between Nerica 14 and Nerica 2, highlight distinct swelling behaviors among these varieties, which could influence their performance in cooking and food preparation processes. Regarding emulsion capacity, the higher emulsion capacity in Nerica 14 compared to other samples suggests greater ability to form stable emulsions. Conversely, Sukeyna having the lowest emulsion capacity may indicate differences in grain structure or surface properties that result in reduced emulsion-forming ability. The significant differences observed between Nerica 14 and other varieties suggest variations in emulsion capacity influenced by factors such as grain morphology, protein content, and surface characteristics. These differences could impact the texture, stability, and sensory attributes of food products containing these rice varieties.

The observed variations in swelling index and emulsion capacity among the tested rice varieties highlight their diverse functional properties and potential applications in food processing and culinary practices. Further research into the underlying mechanisms influencing these properties could provide valuable insights for optimizing rice breeding and cultivation practices to enhance their functional attributes and overall versatility in various food applications.

4. Discussion

4.1. Proximate composition (Macro-nutrient)

The macronutrient composition of various rice varieties, outlined in Table 1, reveals differences in moisture content, with the varieties adapted under SoRPARI showing lower moisture levels compared to the control sample, Sukeyna. This lower moisture content indicates a potential advantage in shelf life due to reduced susceptibility to spoilage, likely stemming from drier storage conditions with lower relative humidity. Variations in moisture content among varieties are likely influenced by differences in agro-ecology and processing methods. Similar findings have been reported in research conducted in Malaysia (Thomas et al., 2013). Significant differences were also observed in ash content among the rice varieties, with those adapted under SoRPARI showing higher levels compared to Sukeyna. Variations in ash content among SoRPARI rice varieties may be attributed to differences in agro-ecology, genetic factors, and processing methods. Comparable results have been reported in studies conducted in Nigeria's Ebonyi State and Malaysia (Oko and Onyekwere, 2010; Thomas et al., 2013). Regarding protein content, the SoRPARI rice varieties, particularly Gode 1, exhibited higher protein levels compared to Sukeyna. Specifically, Nerica 14, Nerica 4, and Gode 1 demonstrated the highest protein content among the varieties. However, this higher protein content may come at the expense of other components, such as moisture. The higher moisture content is advantageous in combating protein energy malnutrition, especially in communities like the Somali population that rely on rice as a staple food. Differences in protein content among rice varieties may be influenced by agro-ecology, processing methods, and genetic factors. Similar variations in protein content among rice varieties have been observed in research conducted in India's Manipur province and in Nigeria's Ebonyi State and Malaysia (Oko and Onyekwere, 2010; Reddy et al., 2017; Thomas et al., 2013). Furthermore, differences in other main components such as fat, crude fiber, and carbohydrates are attributed to variations in processing methods, genetic differences among rice varieties, and other factors. These differences in macronutrient composition contribute to variations in energy obtained from consuming these rice varieties, as indicated in Table 1. These findings align with previous research on different rice varieties mentioned above. In summary, the variations in macronutrient composition among rice varieties, influenced by factors such as agro-ecology, processing methods, and genetic differences, underscore the importance of considering the nutritional profiles of rice varieties in addressing malnutrition and promoting food security.

4.2. Minerals Content

The mineral content of various rice varieties, as illustrated in Table 2, provides insights into their nutritional profiles and potential health benefits. Generally, mineral content is closely linked to the ash content of rice, as observed in other food types. The control sample, Sukeyna, exhibited lower mineral content compared to the other varieties studied, indicating that local varieties may offer better mineral content than the control sample. Specifically, Nerica 14 demonstrated the highest levels of calcium, magnesium, and total phosphorus, followed by Nerica 4 and other varieties, as indicated in Table 4.2. The variations in mineral content among the selected rice varieties may be attributed to several factors, including rice genotypes, agronomic practices, cultivation conditions, and different processing methods employed. These factors influence the uptake, accumulation, and retention of minerals in rice grains. Similar disparities in mineral content among different rice varieties have been reported in research conducted in India's Manipur province and in Nigeria's Ebonyi State and Malaysia (Oko and Onyekwere, 2010; Reddy et al., 2017). The understanding the mineral content of rice varieties is essential for assessing their nutritional value and potential health benefits. Further research into the factors influencing mineral composition in rice grains can inform agricultural practices and processing methods aimed at enhancing the nutritional quality of rice varieties.

4.3. Functional Properties

The functional properties of different rice varieties, as outlined in Table 3, offer insights into their potential applications in food formulations and processing. Water absorption capacity (WAC) reflects the flour's ability to absorb water and swell, contributing to enhanced consistency in food products (Twinomuhwezi et al., 2020). Variations in WAC among rice varieties may be attributed to differences in protein concentrations, their interactions with water, and their conformational characteristics (McWatters et al., 2003). Oil absorption capacity, indicating the rate at which proteins bind to fat in food formulations, is another crucial functional property (Twinomuhwezi et al., 2020). Diverse oil absorption capacities were observed among the rice varieties, as shown in Table 4.3, with significant differences ($p < 0.05$) noted through statistical analysis. This property enhances mouthfeel and flavor retention in food products (Adebowale and Lawal, 2004). Emulsion capacity, ranging from 104.8 to 115.0 among the rice varieties, also varied significantly ($p < 0.05$). Higher emulsion capacity may be associated with higher protein content, as indicated by previous research (Twinomuhwezi et al., 2020). Emulsion capacity is influenced by factors such as oil and water content, non-polar amino acid residues on protein surfaces, and other constituents in the food matrix. Swelling indices, ranging from 47.75 to 50.0, differed significantly ($p < 0.05$) among the rice varieties. This variation may be attributed to differences in variety, agronomic practices, and processing methods. Swelling capacity is considered a quality criterion in bakery product formulations, reflecting non-covalent bonding between molecules within starch granules and the ratio of -amylose to amylopectin (Reddy et al., 2017). The diverse functional properties observed among the rice varieties underscore their versatility in various food applications and formulations. Understanding these properties allows for informed decisions in food processing and product development, ultimately enhancing product quality and consumer satisfaction.

5. Conclusion and Recommendations

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 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. Therefore, government and other concerned bodies should set policy and strategy that give more emphasis to rice production at national or if possible regional level to substitute imported rice with mechanized agriculture system. Investors should be encouraged to engage in rice production and also further research with full package should be done.

Acknowledgments

Our deepest gratitude goes to Somali Region pastoral and Agro-Pastoral Research institute (SoRPARI) for funding continues follow up this research work.

Conflict of Interest

Authors declare that there is no conflict of interests involve in publishing this research paper.

References

Ababa, A. (2020). National rice development strategy-ii.

Abeshu, Y. and Abrha, E. (2017). Evaluation of proximate and mineral composition profile for different food barley varieties grown in central highlands of ethiopia. *World Journal of Food Science and Technology*, 1(3):97–100.

Ac, A. (1984). Official methods of analysis. *Dairy product cheese*, pages 281–312.

Adebowale, K. and Lawal, O. (2004). Comparative study of the functional properties of bambarra groundnut (voandzeia subterranean), jack bean (canavalia ensiformis) and mucuna bean (mucuna pruriens) flours. *Food Research International*, 37(4):355–365.

Alleoni, A. C. C. (2006). Albumen protein and functional properties of gelation and foaming. *Scientia Agricola*, 63:291–298.

McWatters, K. H., Ouedraogo, J. B., Resurreccion, A. V., Hung, Y. C., and Phillips, R. D. (2003). Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (digitaria exilis) and cowpea (vigna unguiculata) flours. *International Journal of Food Science Technology*, 38(4):403–410.

Oko, A. and Onyekwere, S. (2010). Studies on the proximate chemical composition, and mineral element contents of five new lowland rice varieties planed in ebonyi state. *International Journal of Biotechnology Biochemistry*, 6(6):949–956.

Reddy, C. K., Kimi, L., Haripriya, S., and Kang, N. (2017). Effects of polishing on proximate composition, physico-chemical characteristics, mineral composition and antioxidant properties of pigmented rice. *Rice Science*, 24(5):241–252.

Sarowar Hossain, M. and Kumar Singh, A. u.-Z. (2009). Cooking and eating characteristics of some newly identified inter sub-specific (indica/japonica) rice hybrids: Scienceasia.

Thomas, R., Wan-Nadiah, W., and Bhat, R. (2013). Physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in penang, malaysia. *International Food Research Journal*, 20(3).

Tsega, M., Alemu, D., and Kiyoshi, S. (2013). *Socioeconomic characteristics of smallholder rice production in Ethiopia*. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia.

Twinomuhwezi, H., Awuchi, C. G., and Rachael, M. (2020). Comparative study of the proximate composition and functional properties of composite flours of amaranth, rice, millet, and soybean. *American Journal of Food Science and Nutrition*, 6(1):6–19.