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Research Article

Effects of Parboiling on Improving the Proximate Compositions of "Selam" Green Super Rice, Grown in Ethiopia

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Abstract

In addition to treducing the broken rice due to the increase in hardness of the kernel through gelatinization, the parboiling process enhances the concentration of nutrients in rice grain. The husk and bran contain various nutrients, and during the soaking and steaming processes, soluble materials from these layers dissolve and migrate into the grain's endosperm, enriching its nutritional content. In this study, the Super Green 'Selam' rice variety was used with three factors evaluated having three levels. Soaking temperatures of 40 ℃, 60 ℃, and 80 ℃; soaking durations of 6, 12, and 24 hours; and steaming times of 15, 25, and 35 minutes were used, with non-parboiled rice acted as as the control group. For this study, a completely factorial design with a CRD configuration was applied. The parboiling process significantly improved the proximate components of the rice ($P < 0.05$). After 12 hours of soaking at 80 ℃ followed by 35 minutes of steaming, the starch content increased to 60.53%. Crude protein, fat, and ash levels ranged from 5.25% to 6.62%, 1.56% to 2.67%, and 0.74% to 1.28%, respectively. Additionally, the combinations of pre-heat treatment, soaking, and steaming treatments led to crude fiber levels of 1.04% to 1.48% and carbohydrate content ranging from 74.97% to 78.47%. The trend generally showed that increasing the factors levels also improved the proximate components proportionally.

Keywords

Proximate Composition, Parboiling, Sensory, Soaking, Steaming

1. Introduction

Rice (Oryza sativa L) is an edible starchy cereal grain of the grass plant, the family *Poaceae*. It is a genetically diversified crop and has thousands of varieties grown worldwide. Because of its wide distribution and nutritional value, rice has been one of the most important foods for humans [1]. Currently, this unique grain helps sustain two-thirds of the world's population [2]. Rice provides about 27% of the energy in low-and middle-income countries. It is one of the

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most rapidly growing food commodities globally in all parts of the world and Sub-Saharan Africa [3]. Rice is the single most important food commodity in West Africa and is the third most important crop for Africa as a whole. More than 750 million people in Sub-Saharan Africa consume it [4]. Rice is consumed as whole grain; hence, grain quality considerations are much more relevant compared with other food crops. The world's rice production is over 618 million tons per year approximately and of which about 50% of the production is processed by parboiling [5].

Rice introduction in Ethiopia probably started when the wild rice (*Oryza longistaminata)* was seen in the swampy and waterlogged locations of Fogera (Amhara) and Gambella plains. Rice production has expanded steadily to different parts of Ethiopia [4]. At the beginning of the 1970s, it has been increased the total land area from about 10,000 ha in 2006 to about 50,000 ha in 2018. Farmers in Fogera Plain were living by pastoral farming and a small level of crop production before the introduction of rice [6]. The first areas where rice was introduced in Ethiopia were Gambella from 1973 to 1982, Pawe from 1985 to 1988, and Fogera Plain (the early 1980s). Fogera Plain, nevertheless, continues to be one of the top rice-producing regions among them, exhibiting several agricultural changes related to rice production and its marketing. Ethiopia is currently regarded as a significant rice-growing nation in Africa [7, 8]. Ethiopia has over 39 million hectares of land suitable for rice. About 30 million hectares are upland, 3.7 million hectares are irrigated, and the rest is lowland rice. The farmers of Fogera Plain who have been engaged in rice production have improved their lives from being the poorest to the richest farmers in the region. Private business owners have emerged and become profitable in the rice processing and marketing sector [8].

Due to changes in eating patterns and its incorporation into traditional food items, rice has emerged as one of Ethiopia's most commercially significant crops. It is one of the promising crops in Ethiopia believed to ensure food security [8]. Nowadays, rice has gotten attention from the government of Ethiopia. As a result, rice is rapidly growing throughout Ethiopia. Since rice cultivation is a relatively new occurrence, research and development efforts must be further strengthened in order to lessen poverty, guarantee food security, and use less foreign money to import rice in order to meet the rising demand locally [4].

Even though rice production has increased quickly due to demand and area coverage, the majority of Ethiopia's domestically grown rice types have poor physical, compositional, and cooking properties because of ineffective processing equipment. The Ethiopian rice industry has encountered numerous difficulties, including intense competition from imported rice, which is mostly caused by the subpar performance of domestic processing equipment, a shortage of trained personnel to run it, a lack of mechanization, inadequate post-harvest rice processing technologies, and inadequate marketing channels. Therefore, improving post-harvest handling practices and bolstering smallholder farmers' and the private sector's ability can enhance the quality of rice [9].

To be consumed, rice must go through several processing stages. Because of low moisture content during milling, improper polishing machine functioning, and contaminants in the rice grain, rice may lose both quantity and quality throughout those processing stages [4]. It has been determined that parboiling, which entails soaking, steaming, and drying, is a crucial method for enhancing the cooking and milling properties of rice [10]. According to [11], when utilizing low-performance machinery and untrained workers, rice is lost at a significant rate during de-hulling and polishing. To address this issue, Ethiopia has implemented parboiling technology to harden the kernel and gelatinize the starch. Rice parboiling is a process by which the hydrothermal treatment applies to the paddy or brown rice to reduce breakage levels, improve the head rice yield, and have nutritional and organoleptic properties [12]. The gelatinization temperature of rice starch was used to develop hot water soaking at optimal temperatures, with the goal of completing water absorption by the rice kernel as quickly as possible. Higher soaking temperature and the inclusion of a steaming step significantly increase the concentration of some nutrients, such as iron is driven into the starchy endosperm [13]. Gelatinization makes it easier to remove the rice husk with less friction and breaking. As a result, this research will aid in reducing rice loss by implementing suitable parboiling processes. The National Rice Research and Training Center has released thirty-nine rice varieties till this research was done. *Selam* variety is among those adaptable in low land agroecology which was released in 2020. This variety's production in the research field is predicted to be 5.2 tons per hectare, whereas in the farmers' field it is 4.8.

Investigations into the parboiling method and related characteristics have primarily focused on Ethiopian rice cultivars. Rice processors—private business owners with de-hulling/polishing machine factories, as well as those working in the rice processing industry—who have adopted the parboiling process are uncertain about how to proceed. Furthermore, the nutritional, sensory, and cooking qualities of local rice varieties need to be investigated. Therefore, the objectives of this study were to examine the effect of parboiling conditions (soaking temperature, soaking time, and steaming time) on the proximate compositions and sensory acceptability of selected rice varieties grown in Ethiopia.

2. Materials and Methods

2.1. Experimental Materials and Experimental Plan

A 120 kilogram lowland rice of the Selam variety was obtained from the Fogera National Rice Research and Training Center. The experiment used a 3x3x3 factorial design. It had three variables, each with three levels. Pre-treatment temperatures of 40, 60, and 80 ℃ were used, along with soaking times of 6, 12, and 24 hours and steaming times of 15, 25, and 35 minutes. Three replications were used for each treatment. The experiment was carried out using a Completely Randomized Design (CRD), with non-parboiled milled rice serving as a control that went through the same method as the parboiling process. A control (untreated) sample of 20 kg paddy was sun-dried (without parboiling) with up to 14% moisture content and milled [14, 15]. The cleaned rice sample (81 kg) was divided into nine parts. The first three 9 kg divisions were soaked at 40, the second three at 60, and the last three groups soaked at 80 ℃ temperature. Regarding duration, the first three 9 kg divisions were soaked for 6, 12, and 24 hours, respectively. The second and third groups also followed the same procedure. Each of the 9 kg samples was again divided into three equal parts (3 kg each) and steamed for 15, 25, and 35 minutes, respectively.

2.2. Sample Preparation

According to [16, 17], paddy was cleaned based on different physical properties such as size, density, weight, and impurities. The experimental and control groups of collected rice variety were cleaned very well using a hand-operated winnower. Impurities that were lighter than the paddy weight were removed by aspiration. Larger impurities that the winnower could not remove were cleaned by handpicking. The immature grains of the experimental groups were removed by floating in the water. Then, according to [16], the floated grains were removed, and only the submerged grains were taken for the next process. Water-soluble dirt in the paddy was removed by washing it in water to protect the entry of pollutants into the embryo during soaking and steaming. Cares had been taken as the sediment grains might contain impurities. Then, the cleaned paddy was sun-dried and weighed 81 kg.

2.3. Parboiling Processing of Paddy Rice

2.3.1. Pre-treatment

The samples were first preheated at temperatures of 40 ℃, 60 ℃, and 80 ℃ to initiate gelatinization. Afterward, they were left to soak for a predetermined duration.

2.3.2. Soaking in Warm Water

Nine kilogram of paddy was soaked for 6 hours at 40 ℃, followed by another 9 kg for 12 hours and a third 9 kg for 24 hours. The samples were held in ambient circumstances until the stated soaking times were completed, at which point the temperature reached the desired level. The operation was repeated with soaking temperatures of 60 ℃ and 80 ℃. Each sample was put in a stainless steel soaking tank (Inox 304) that had a water-to-paddy ratio of 2:1 [16, 14]. The soaking temperatures and soaking time values used for this study were the medium values that scholars used [18, 16].

2.3.3. Steaming with Water Vapor

According to [16], the samples that had been soaked for 6, 12, and 24 hours at temperatures of 40 ℃, 60 ℃, and 80 ℃ were split into three equal sections, each weighing 3 kg. Each 3-kg sample was put in a stainless steel perforated steamer (Inox 304). The ratio of water fed to the steaming equipment was 1:2 with the paddy. This ensures the paddy did not come into direct touch with the water. Instead, the vapor from the steaming tank was used to heat it. Samples from each soaking period were steamed for 15, 25, and 35 minutes without removing the heat source. These steaming periods were determined based on the median values used in previous investigations [16, 14, 19]

2.3.4. Sun and Shade Drying

The steamed paddy was gently dried in the sun and put on a plastic sheet. It was constantly rolled over to minimize overdrying on one side and to prevent interior cracking. The paddy was dried to 18% moisture content and placed in the shade until it was gradually decreased to 14% [16, 20]. The samples were continuously rolled, and the moisture content was monitored every 15 minutes using a rice grain moisture meter (KETT J301, Japan) [10]

2.3.5. De-Husking

The dry rice was husked using a SATAKE SB 2000 husking machine from Hiroshima, Japan. According to the technical instructions, the rice was treated to a correctly set husking machine. The rice husk removed by applying the husking machine, and brown rice was obtained) [20]

2.3.6. Whitening

The husked rice, often known as brown rice, was fed into the SATAKE SB 2000 polishing machine manufactured by Satake Corporation in Hiroshima, Japan. The polishing machine began to work to remove the bran from the brown rice. The appropriately set rubber roll machine generated polished white rice [10].

2.4. Proximate Compositions

The samples in this study were analyzed for their nutritional composition using the FOSS NIRSystems-6500 machine. Rice flour from each sample was placed in a standardized cup, with the treatment code labeled on the cup's cover. The FOSS NIRSystems-6500 machine was turned on and allowed to update for approximately 30 minutes. Once the system was ready, 100 grams of the sample in the cup were fed into the machine. Samples from each treatment were processed one by one. The machine provided readings for starch content, crude protein, crude fiber, crude fat, moisture content, and total mineral/ash content within 3 to 5 minutes after sample input. The results were saved on a computer connected to the machine. Data were then transferred via an external disk and analyzed using analysis of variance. The utilizable carbohydrate content was calculated by subtracting the sum of all other components from 100. According to [30], the total carbohydrate content was determined by subtracting the combined values of moisture, ash, crude protein, crude fiber, and crude fat from 100.

%Carbohydrate=100–%(Moisture+Ash+Protein+Fiber+Fat)

2.5. Sensory Acceptability Evaluation

Thirteen (13) rice expert panelists were selected randomly from FNRRTC rice researchers to rank the rice's taste, color, and odor after cooking. They prioritized the sensory values of the parameters using their sense organs and gave the values of the treatments and control. The panelists are experts on rice and have long experience with rice properties since they are working at the rice research center, and are more exposed to rice-related recipes. The number of panelists is the medium value of the scholars used [21-23]. Seven arbitrary numbers represented the treatments' sensory values. These are 7=Excellent, 6=very good, 5=good, 4=slightly good, 3=neither good nor bad, 2=bad, 1=too bad. The treated rice varieties were coded and labeled. An orientation on the procedures and objectives was given to the panelists.

2.6. Statistical Data Analysis of the Experiment

The collected data were statistically analyzed using Statistix-10 software. Analysis of variance (ANOVA) was employed to study the effects of different parboiled treatment significance on the quality parameters of parboiled rice. The statistically significant differences between samples of means were analyzed at a 5% significance level.

3. Results and Discussions

3.1. Interaction Effects of Soaking Temperature, Soaking Time, and Steaming Time on the Proximate Compositions of Parboiled Rice

Table 1 presents the interaction effects of soaking temperature, soaking time, and steaming time on the proximate compositions of parboiled rice. Experimental results showed that the interaction of the three factors had significant effects on proximate compositions, such as the content of ash, carbohydrate, crude protein, crude fiber, crude fat content, and starch content when parboiled.

3.1.1. Starch Content

The data on starch content for parboiled and controlled rice is given in Table 1. The result showed that the content increased with the soaking temperature and times. The content had no well-defined trend for the soaking temperature and soaking time. The highest (60.53%) and the lowest (58.33%) values were recorded at a combination of 80 ℃, 12 hours, and 35 minutes; and 40 ℃, 12 hours, and 35 minutes, respectively. The parboiling process of rice might not always increase the starch content, depending on the parboiling extent, the value varies accordingly. A similar study done by a researcher said that the swelling rate of starch was more facilitated at high temperatures and times, causing an increase in its content [12].

3.1.2. Crude Protein Content

The crude protein contents of parboiled rice and control are given in Table 1 below. The result showed that the protein content was slightly decreased with the interaction of the three factors dominantly following the trend of steaming time than the other two factors. The values ranged between 5.42 and 6.62%, recorded at the interaction of soaking temperature, soaking time, and steaming time of (60 ℃, 24 hours and 35 minutes) and (60 ℃, 12 hours and 15 minutes), respectively. The overall interaction of factors along the crude protein treatments had a significant difference at $\alpha=0.05$ significance level. According to [24], soaking at 80 ℃ for 4 hours and then steaming for 10 minutes has significantly improved crude protein content. Another research also indicated that the protein content of rice is approximately 7%, which is lower compared to other cereal grains [25].

3.1.3. Crude Fat Content

The crude fat content of parboiled and non-parboiled rice is given in Table 1. The highest value of crude fat content was 2.67%, which was recorded for samples subjected to soaking at 60 ℃ for 24 hours and steaming for 25 minutes, whereas the minimum value was found to be 1.56% recorded at 40 ℃, 6 hours, and steaming time of 25 minutes. The result showed that the fat content has no clear deference with the increase in steaming time. The overall interaction of factors for all treatments of crude fat content was significantly different at $\alpha=0.05$ significance level. Authors [13] studied similar work and found that soaking at 80 ℃ for 4 hours, and then steaming for 10 minutes has significantly ($p<0.05$) improved the content of crude fat.

3.1.4. Crude Fiber Content

Table 1 presents the data showing proximate compositions of parboiled and non-parboiled rice, including crude fiber content. For the combination of the three factors, the fiber content ranged from 1.04 to 1.48% recorded at 60 ℃, 24 hours, and 25 minutes; and 60 ℃, 24 hours, and 15 minutes soaking temperature, soaking, and steaming times, respectively. The interaction of soaking temperature, soaking time, and steaming time slightly affected the crude fiber content at $\alpha=0.05$ significance level. A similar study also showed that the parboiling process significantly ($P<0.05$) increased the crude fiber content [26].

3.1.5. Ash Content

The ash content had no significant change with changes in soaking temperature, soaking time, and steaming time. The maximum (1.28%) and minimum (0.64%) values of ash content (total mineral) were recorded at 40 ℃, 12 hours, and 35 minutes, and 80 ℃, 12 hours, and 35 minutes, respectively. The overall interaction of factors for all treatments showed that the ash content was significantly different at α=0.05 significance level. According to [24] soaking at 80 ℃ for 4 hours and steaming for 10 minutes significantly improved total ash content.

3.1.6. Utilizable Carbohydrate Content (CHO)

The carbohydrate content was slightly increased with the steaming time, but no visible trend along with the change of the other two factors. The content ranged from 74.39 to 78.47%. The highest and the minimum values were 78.47 and 74.39%, recorded at 40 ℃, 6 hours and 35 minutes; and 60 ℃, 24 hours and 15 minutes, respectively. The overall interaction of factors of the treatments for carbohydrates was significantly ($P<0.05$) different. A similar study that has been done in Nigeria for different rice varieties showed that the imported rice varieties had higher contents of carbohydrates (72.20-76.21%), and the domestic rice varieties had high carbohydrate content (67.72-76.21%) [27]. Similar studies also reported that the carbohydrate content of selected rice varieties of *Digang, NERICA-1, and NERICA-2* were 78.25%, 78.12%, and 78.03% [28]. The percentage of carbohydrates in Ethiopian non-parboiled rice samples ranged between 74.36-78.87% [29]. The differences in the results with the literature's conclusion may be due to a variety of differences.

Table 1. *Interaction effect of soaking temperature, soaking time, and steaming time on proximate compositions.*

SkTp	SkTm	SmTm	Starch	CP	CF	Ash	CFb	CHO
	6	15	59.19^{ijk} ±23	6.06^{efgh} ±0.05	2.20^{hij} ±0.01	0.94^{def} ±0.01	1.24^{cdefgh} ±0.04	74.97^{j} ±0.14
	6	25	59.56^{efgh} ±0.07	6.05^{fgh} ±0.04	1.56^{n} ±0.17	0.78^{hij} ±0.04	1.25^{cdef} ±0.05	77.10^{cd} ±0.46
	6	35	60.51^{a} ±0.03	5.53^{klm} ±0.07	2.19^{hij} ±0.06	0.75^{ijk} ±0.04	1.07^{lm} ±0.06	78.47^{b} ±0.48
	12	15	59.337^{hijk} ±0.02	6.16^{ef} ±0.06	2.33^{defgh} ±0.07	0.93^{def} ±0.06	1.22^{defghi} ±0.01	75.91^{gh} ±0.05
40	12	25	59.47^{ghi} ±0.45	5.53^{klm} ±0.21	1.70^{mn} ±0.22	0.74^{jk} ±0.08	1.21^{efghi} ±0.02	77.23^{cd} ±0.29
	12	35	58.33^{l} ±0.08	5.48^{mn} ±0.12	2.44^{cdefg} ±0.11	1.28^{a} ±0.11	1.19^{efghi} ±0.04	76.33^{fg} ±0.22
	24	15	59.82^{de} ±0.04	5.84^{hij} ±0.19	1.90^{l} ±0.04	1.05bc ±0.10	1.38^{b} ±0.07	75.00^{ij} ±0.37
	24	25	59.42^{hij} ±0.15	5.57^{klm} ±0.17	1.63^{n} ±0.08	0.86^{fgh} ±0.03	1.30^{bcd} ±0.13	76.48^{ef} ±0.09
	24	35	60.35^{abc} ±0.06	6.22^{cdef} ±0.09	1.92^{l} ±0.08	0.65^{l} ±0.02	1.14^{ijkl} ±0.07	77.08^{cd} ±0.19
	6	15	59.12^{jk} ±0.11	5.91^{ghi} ±0.06	2.64^{ab} ±0.08	1.10^{b} ±0.12	1.17^{efghij} ±0.02	75.34^{ij} ±0.30
	6	25	59.76^{efg} ±0.13	5.51^{klm} ±0.27	1.64^{n} ±0.11	1.05^{bc} ±0.16	1.25^{cdefg} ±0.02	76.02^{fgh} ±0.39
	6	35	59.11^{k} ±0.07	5.47^{lmn} ±0.31	2.54^{abc} ±0.08	0.98^{cd} ±0.13	1.17^{efghij} ±0.04	76.09^{fg} ±0.66
	12	15	59.573^{efgh} ±0.28	6.62^{b} ±0.25	2.49^{bcd} ±0.06	0.95^{de} ±0.04	1.16^{ghijk} ±0.01	75.53^{hi} ±0.44
60	12	25	60.30^{abc} ±0.05	5.65^{jklm} ±0.34	2.47^{cde} ±0.06	0.84^{ghi} ±0.07	1.04^{m} ±0.03	77.51^{c} ±0.48
	12	35	60.41^{ab} ±0.29	5.84^{ghij} ±0.11	1.57^{n} ±0.22	0.77^{ij} ±0.04	1.17^{fghijk} ±0.02	77.28^{cd} ±0.28
	24	15	58.467^{l} ±0.09	5.73^{ijk} ±0.12	1.61^{n} ±0.04	1.12^{b} ±0.17	1.48^{a} ±0.06	74.38^{k} ±0.70
	24	25	60.09^{cd} ±0.13	5.74^{ijk} ±0.10	2.67^{a} ±0.04	0.93^{def} ±0.04	1.04^{m} ±0.01	77.28^{cd} ±0.33
	24	35	59.74^{efg} ±0.10	5.42^{mn} ±0.07	2.26^{hij} ±0.03	0.86^{fgh} ±0.03	1.04^{m} ±0.01	77.47^{c} ±0.24
	6	15	59.807^{def} ±0.07	6.07^{efgh} ±0.04	1.97^{kl} ±0.14	0.94^{def} ±0.01	1.26^{cde} ±0.04	75.36^{ij} ±0.21
	6	25	59.61^{efgh} ±0.21	6.28^{cde} ±0.07	2.15^{ij} ±0.07	0.87^{efg} ±0.06	1.16^{hijkl} ±0.02	76.04^{fgh} ±0.58
	6	35	59.57^{efgh} ±0.12	5.25^{n} ±0.04	1.69^{mn} ±0.16	0.68^{kl} ±0.04	1.20^{efghi} ±0.04	76.88^{de} ±0.30
	12	15	59.83^{de} ±0.05	6.28^{cdef} ±0.04	2.29^{fghij} ±0.03	0.92^{defg} ±0.01	1.14^{ijkl} ±0.02	76.27^{fg} ±0.01
80	12	25	60.07^{cd} ±0.07	6.41^{bc} ±0.05	2.31^{efghi} ±0.12	0.89^{efg} ±0.04	1.09^{jklm} ±0.02	76.34^{fg} ±0.24
	12	35	60.53^{a} ±0.09	6.07^{efg} ±0.05	2.13^{jk} ±0.12	0.64^{l} ±0.04	1.09^{jklm} ±0.03	77.07^{cd} ±0.30

SkTp	SkTm	SmTm	Starch	CP	CF	Ash	CFb	CHO
	24	15	59.51^{fgh} ±0.54	6.40^{bcd} ±0.13	2.46^{cdef} ±0.07	0.87^{efg} ±0.06	1.16^{hijkl} ±0.04	76.09^{fg} ±0.34
	24	25	60.2^{bc} ±0.11	6.17^{def} ±0.13	2.26^{hij} ±0.07	0.89^{defg} ±0.03	1.18^{efghij} ±0.13	76.21^{fg} ±0.20
	24	35	60.09^{cd} ±0.13	5.67^{jkl} ±0.18	2.27^{ghij} ±0.05	0.74^{jk} ±0.02	1.31^{bc} ±0.10	76.32^{fg} ±0.09
Control			59.16^{jk} ±0.06	7.05^{a} ±0.05	1.85^{lm} ±0.14	0.89^{defg} ±0.03	1.08^{klm} ±0.03	80.25^{a} ±0.22
CV (%)			0.31	2.52	5.00	8.54	4.55	0.46
$LSD_{0.05}$			0.3	0.24	0.17	0.12	0.09	0.58

Note: SkTp: soaking temperature (℃), SkTm: soaking time (hour), SmTm: steaming time (minute), CP: crude protein, CF: Crude Fat, CFb: Crude Fiber, CHO: Carbohydrates; Means of the same letters are not significantly different; values in the table are mean ±SD.

3.2. Sensory Acceptability Evaluation of Parboiled Rice

Table 2 presents the color, taste, and odor scores based on panelists' perceptions. The color of the parboiled rice was assessed and compared with the spectroscopy colorimeter values. There was a strong correlation between the colorimeter readings and the panelists' perceptions. The colorimeter results indicated that samples soaked at 40 ℃ for 24 hours and steamed for 35 minutes exhibited the highest overall color value for parboiled rice. Panelists ranked the color of the treatments by visually inspecting the parboiled and milled rice. The highest score (5.92) was recorded for the treatment with a 60 ℃ soaking temperature, 6-hour soaking time, and 25-minute steaming time.

According to [13], Soaking at 80 ℃ significantly affected the kernel color, as well as palatability characteristics such as taste and odor. Overall, the sensory values of the parboiled rice showed a noticeable decrease. Ten panelists selected the samples subjected to a 60 ℃ soaking temperature, 6 hours of soaking time, and 35 minutes of steaming time as having the second-best taste, just after the control. These samples received a score of 5.77, while the control scored 5.87. All treatments were rated as "slightly good" or higher, with most treatments falling in the "good" and "very good" categories.

The odor of the treatments was evaluated after the parboiling, milling, and cooking processes. Panelists used their sense of smell to provide ratings based on their perceptions. The highest odor score (5.92) was recorded for the treatment with a 60 ℃ soaking temperature, 6-hour soaking time, and 25-minute steaming time. However, the control sample's odor was more widely accepted than the treatments. Most panelist scores for odor fell within the "slightly good" and "good" categories.

Table 2. *Panelists sensory evaluation result of rice.*

SkTp	SkTm	SmTm	Color	Taste	Odor
	6	15	4.32^{p} ±0.01	5.45^{fg} ±0.01	4.32^{r} ±0.01
	6	25	4.54^{n} ±0.01	5.31^{i} ±0.01	4.55^{p} ±0.00
	6	35	4.69^{m} ±0.00	5.15^{j} ±0.01	4.69^{m} ±0.00
	12	15	4.37^{o} ±0.01	5.45^{fg} ±0.00	4.37^{q} ±0.01
40	12	25	4.31^{p} ±0.00	5.31^{i} ±0.01	4.31^{s} ±0.00
	12	35	4.54^{n} ±0.01	5.45^{fg} ±0.01	4.54o ±0.01
	24	15	5.07^{i} ±0.00	5.38^{h} ±0.00	5.07^{i} ±0.00
	24	25	5.01^{j} ±0.01	5.07^{k} ±0.00	5.01^{j} ±0.00
	24	35	5.07^{i} ±0.00	5.31^{i} ±0.00	5.07^{i} ±0.01
	6	15	4.37^{o} ±0.01	5.46^{f} ±0.00	4.37^{q} ±0.00
	6	25	5.92^{b} ±0.00	5.69^{c} ±0.11	5.92^{b} ±0.00
	6	35	5.54^{e} ±0.00	5.77^{b} ±0.01	5.54^{e} ±0.03

SkTp	SkTm	SmTm	Color	Taste	Odor
	12	15	5.84^{c} ±0.01	5.46^{f} ±0.01	5.84^{c} ±0.00
60	12	25	5.61^{d} ±0.01	5.61^{d} ±0.01	5.61^{d} ±0.01
	12	35	5.61^{d} ±0.01	5.45^{fg} ±0.01	5.61^{d} ±0.01
	24	15	5.61^{d} ±0.01	5.45^{fg} ±0.00	5.61^{d} ±0.00
	24	25	5.31^{g} ±0.01	5.46^{f} ±0.02	5.32^{g} ±0.00
	24	35	5.38^{f} ±0.00	5.44^{g} ±0.01	5.38^{f} ±0.01
	6	15	5.22^{h} ±0.01	5.15^{j} ±0.02	5.23^{h} ±0.00
	6	25	5.53^{f} ±0.01	5.31^{i} ±0.00	5.54^{e} ±0.01
	6	35	5.61^{d} ±0.01	5.37^{h} ±0.01	5.62^{d} ±0.00
	12	15	5.22^{h} ±0.01	5.31^{i} ±0.01	5.23^{h} ±0.00
80	12	25	5.37^{f} ±0.01	5.54^{e} ±0.00	5.37^{f} ±0.01
	12	35	4.67^{m} ±0.02	5.15^{j} ±0.00	4.67^{n} ±0.01
	24	15	4.85^{k} ±0.01	4.82^{m} ±0.01	4.85^{k} ±0.01
	24	25	4.77^{l} ±0.00	5.00^{l} ±0.01	4.77^{l} ±0.00
	24	35	4.53^{n} ±0.01	5.00^{l} ±0.01	4.54^{o} ±0.00
Control			5.96^{a} ±1.02	5.87^{a} ±2.10	4.32^{r} ±0.01
CV (%)			0.19	0.16	0.18
$LSD_{0.05}$			0.01	0.01	0.02

Note. SkTp. soaking temperature (℃), SkTm. soaking time (hours), SmTm. steaming time (minutes), means represented by the same letter are not significant, values are in mean±

4. Conclusions

Rice is becoming a major crop commodity in the Lake Tana area, the Amhara region, and western Ethiopia. Rice can be consumed directly by boiling milled rice, or it can be used to make Injera. The NIRSystem-6500 advanced equipment was used to examine the proximate compositions, which included starch, crude fat, crude protein, crude fibre, ash (total mineral) content, and utilizable carbs. The nutritious constituents of parboiled rice were not damaged by heat and water treatment; rather, most proximate compositions improved, while a few remained unchanged from untreated. When the samples were treated to an 80℃ soaking temperature, a 12 hour soaking period, and a 35-minute steaming time, the maximum value of starch content was found, which was 60.53. The result for non-parboiled rice was 59.16, with a low value of 58.33 achieved when samples were soaked at 40℃ for 12 hours and then steamed for 35 minutes. The crude protein level ranged from 5.42 to 6.62%, the fat content from 1.56 to 2.67%, the ash content from 0.64 to 1.28%, the crude fiber content from 1.07 to 1.48%, and the carbohydrate content from 74.97 to 77.10%. When compared to non-parboiled rice, the protein and carbohydrate levels were somewhat reduced, but others improved.

Abbreviations

CF	Crude fat
CFb	Crude fiber
CP	Crude protein
CHO	Charbohydrate
FNRRTC	Fogera National Rice Research and Training Center
NIR	Near Infrared
SkTm	Soaking time
SkTp	Soaking temperature
SmTm	Steaming time

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Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

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