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EFFECT OF MILLING PROCESS AND STORAGE PERIOD ON THE PROXIMATE CHARACTERISTICS OF RICE GRAINS

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Abstract: The effect of milling and storage period on the proximate composition of rice grains where studied. Two rice varieties (MAS and IRR I8) commonly produced in Ebonyi State were used for the study. Results revealed that at first month (freshly milled rice) the moisture contents of MAS rice was 40.40%, while the protein content, fat, ash and carbohydrate content respectively, recorded 6.90%, 0.50%, 0.90% and 79.30%. It recorded a total nutritional content of 98% at first month storage period. As the month progresses, it was observed from the results that the proximate profile of the rice continued to decrease in value. After two months of its storage, the moisture content of the rice dropped to 7.40% while the available protein reduced to 6.60%, the fat, ash and carbohydrate contents dropped to 6.0%, 0.89% and 78.86%, respectively. The reduction in the proximate composition of MAS rice continued until 14 to 18th month of its storage and then maintained constant values of 3.43%, 5.90%, 0.1%, 0.51% and 53.06%, respectively for moisture content, protein, fat, ash and carbohydrate contents. Furthermore, at first month of the storage, the IRRI8 rice recorded the moisture content, protein, crude fat, ash and carbohydrate content of 9.61%, 6.90%, 0.60%, 0.90% and 78%, respectively. It had a total nutritional content of 97%. With time, the proximate status of the IRRI8 rice was observed to depreciate in values. The moisture contents, available protein, crude fat, ash and carbohydrates after two months of storage dropped to 9.50%, 6.70%, 0.59%, 0.87% and 76.43%, respectively. The decrease in the nutritional values maintained constant values of 3.15%, 5.80%, 0.20%, o.47% and 50.39%, respectively for moisture contents, protein, fat, ash and carbohydrate. The variation in the rice proximate composition was attributed to the differences in the variety, milling process and nutritional losses resulting from length of storage period.
Keywords: Rice, proximate composition, milling, storage period

INTRODUCTION

Rice (*oryza Sativa*) is consumed in different forms around the world such as brown rice, milled rice, parboiled milled rice etc. (Zubair et al., 2015). According to IRR (2013) rice is the most important and extensively grown food crop in the world. It is a staple food for nearly half of the world's seven billion people and of all the staple crop, rice has risen to position of incomparability. Since 1970's, rice consumption in Nigeria has risen tremendously at about 10% per annum due to changing consumer preferences. Rice is a food that is very rich in carbohydrate and also an important cereal crop that supplies a quarter of the entire caloric intake of the human race (Cecelia et al., 2004). The nutritional components of rice include the following: Carbohydrates, fat, water, ash, and protein. Rice cultivars are sometimes classified according to the conditions under which they are grown such as upland rice – grown as rain-fed crop where there is adequate rainfall (3-4 months). Swamp rice or lowland rice – grown on flooded land.

The rice grain is comprised of the endosperm and seed coat. Most rice is consumed as white polished grain. A lot of nutrients are lost when bran is removed in milling. It can only be consumed in milled form. The consumer acceptance and preference of rice depend on the quality of the milled rice. Among the many forms which is processing; parboiling of rice is widely used which is the hydrothermal treatment of paddy rice prior to milling. The quality of milled parboiled rice is being assessed based on physical parameter like degree of milling, broken grain, grain size, colour and shape. The amount of impurities (stones) also affects the overall quality of milled rice. Those qualities are not only dependent on the rice varieties, parboiling process and storage changes the physical properties and reduces nutrient loss during milling.

According to (Oko et al., 2012) the milling process produces four fractions in rice: brown rice, hull, white rice and bran. Each of these fractions can vary in chemical content according to the variety of rice and the type of milling performed. They noted that unmilled rice contains a significant amount of dietary fibre and contain more nutrients than milled or polished white rice. Most rice is consumed as white polished grain despite the valuable food content of brown rice. The complete milling and polishing that converts brown rice into white rice destroys 67 % of the vitamin B3, 80 % of the vitamin B1, 90 % of the vitamin B6, half of the manganese, half of the phosphorus, 60 % of the iron, and all of the dietary fibre and essential fatty acids (Ensminger and Ensminger, 1986). These nutrients are lost when bran is removed during milling.

Rice grains are bagged and stored in warehouse at ambient conditions, which ranges from 29^{0} – 33^{0}C and 65 – 75% relative humidity (Donahaya et al., 2004). It is the conventional storage system where most cereals are exposed to ambient air. Thus, paddy and its main products are susceptible to reduction in its nutrients value and insect attack. Storage of milled rice for a long period reduces its nutrients. Houston, (1972) investigated the influence of temperature, moisture content and milling degree on the development of off-odours during air tight storage of milled rice and observed that high temperature, high moisture content and low milling degree enhance odour deterioration. According to Anonymous (1997) nearly twenty percent of the world's dietary energy is provided by rice alone which is higher than either wheat or maize. The crude fibre reduces the risk of bowel disorders. The high proportion of unsaturated fatty acids such as oleic and linoleic acid present in rice bran lowers blood cholesterol. Whole grains are good source of iron, thiamine, niacin and riboflavin. Bran is rich in micronutrients such as oryzanols, tocopherols, tocotrienols, phytosterols and dietary fibres like betaglucan, pectin and gum which have hypolipidemic, anti-tumor, anti-oxidant, ergogenic and laxative properties (Devi, 2015). However rice consumers often prefer to have polished white rice despite the valuable food content of brown rice which is lost when bran is removed while polishing.

Knowledge about the nutritional values of milled and stored rice is important among consumers in view of nutritional paucity and/or disorder. For health reasons, consumers are conscious of having rice with good cooking quality, eating quality and also nutritional quality (Devi, 2015). Therefore, the objective of this study is to investigate the impact of milling and storage period on the proximate characteristics and/or composition of rice.

MATERIAL AND METHOD

— Research Materials

Two varieties of rice grains (MAS and IRRI8), commonly grown in Ebonyi State (freshly milled) were obtained from Abakaliki rice milling industry and used for the study. The two varieties were grinded to obtain the same particle size of flours for proximate analysis. The varieties were kept in two different bags for the period of study. The rice grains samples were further bagged and stored for a period of eighteen months to assess the changes in their nutritional composition based period of storage.

— Determination of moisture content

Five grams (5g) of each sample was weighed, transferred into an oven and dried at 50°C for 5 hours. Re-weighing at intervals of 30 minutes, thereafter, allowed to cool in a desiccator. Equation 1 according to (Waheed, 2014) as adopted by Agu et al. (2016) was used to obtain the moisture contents of the rice samples

$$M.C = \frac{WS - W0}{W1 - W0} \text{ X } 100\% \quad (1)$$

where, M.C = Moisture content, % (w.b); Weight of empty moisture can = W_0; Weight of can + Sample = W_1; Weight of can + Oven dried sample = W_3

— Determination of crude ash

The crude ash was determined using the following steps adopted by Agu et al. (2016): Crucible was washed, dried in the oven and allowed to cool in the desiccator; 2g of dried material was placed in an empty porcelain crucible which has been previously ignited and weighed; Ignite the material over a low flame or on a hot plate in the fume cupboard to char organic matter; Crucible was placed in a muffle furnace maintained at a temperature of 60°C for six (6) hours; The crucible was transferred directly to a desiccator, cooled and weighed immediately. Then equation 2 was used to evaluate the ash content of the rice samples

$$\text{Percentage ash} = \frac{W_{CA} - W_C}{W_S} \times 100 \quad (2)$$

where, W_{CA} = weight of crucible + Ash (g); W_C = weight of empty crucible (g); W_S = weight of sample (g)

— Determination of crude fat

Fat was determined by washing a 250-300ml extraction flask, allowed to dry in the oven, cooled in a desiccator and weighed according to Feri and Becker (2003).

The following procedure was used to determine the fat content of the rice samples: The soxletextractor was flitted up with reflex condenser and water flow started; 5g of dried sample on a filter paper was folded, and transferred into a fat-free extraction thimble and plugged tightly with a cotton wool; The thimble was placed into the extraction barrel and added petroleum ether/hexane until it siphons over once in the flask directly; Flask and reflux sample was heated for 5 hours; After the extraction the thimble was removed from the extraction barrel and dried; The flask containing the fat was dried in the oven at low temperature. Then the flask plus fat was weighed and calculated using the expression

$$\text{Fat (\%)} = \frac{\text{Weight of dry sample}}{\text{weight of sample}} \times 100 \quad (3)$$

— Determination of protein

The protein content of the rice sample was determined by the routine of semi- micro kjeldal procedure which consists of three (3) techniques of analysis, namely: Digestion, Distillation and Titration. 0.2g sample in a digestion flask was weighed. 0.8g of mixed catalyst powder was added. 10ml of concentrated H_2SO_4 was fixed in the flask into the digester for 3 hours until a clear solution was obtained.

The digest was cooled and transferred into a 100ml volumetric flask and make up to mark with distilled water; 5ml of 4% boric acid was pipette into a conical flask and 2 drops of indicator added; The conical flask and distillation flask was fixed in a place and 7ml of 40% NaOH was added through the glass funnel into the digest. The steam exit was closed and timing started until when the solution of the boric acid and indicator turns blue. (75ml distillate was collected). Distill was done for 15minutes. The distillate was titrated with 0.01 NHCl and calculated thus; (Agu et al., 2016)

$$\text{Nitrogen (\%)} = \frac{14.01 \times \text{sample titre} - \text{blank titre} \times N \times 6.25}{\text{sample weight}} \quad (4)$$

where, N = normality of acid

— Determination of Carbohydrate

Twenty milligrams (20mg) of the rice sample was transferred to 100ml graduated cylinder. 10ml of water was added and stirred, also 13 ml of perchloric acid was added and stirred with glass rod for about 15 minutes, then the

mixture was transferred into a 250ml volumetric flask. The cylinder was washed and stirrer into the flask and make up to 250ml mark and shacked thoroughly. 5mls was filtrated into a test tube and Pipette 1ml of the filtrate into a test tube in duplicate. 1ml of distilled water was pipette in duplicate as a blank. 1ml of glucose standard solution was pipetted.
5mls of freshly prepared anthrone reagent was pipette into all the tubes and mix thoroughly. It was placed in a boiling water bath for exactly 12 minutes and then cools quickly to room temperature. The cuvettes were matched by reading distilled water in both and note the differences in reading for correction in the calculation.
The solution was transferred in turn, to one glass cuvette washing the cuvette in between readings. The percentage carbohydrate was obtained from reading the optical densities of the sample and standards at 630mm against the reagent blanks using the expression

$$\text{Carbohydrate } (\%) = \frac{2.5 \times b}{a \times W} \quad (5)$$

where, w = weight of sample; b = optical density of sample; a = optical density of standard

RESULT AND DISCUSSIONS

Table 1 presents the variation in the nutritional values of milled MAS rice variety stored between the storage periods of 1 – 18 months. Results as recorded in this table revealed that at first month of storage (freshly milled) the moisture contents of MAS rice was 40.40%, while the protein content, fat, ash and carbohydrate content of the rice respectively recorded 6.90%, 0.50%, 0.90% and 79.30%. It recorded a total nutritional content of 98% at first month of storage period.
The drop in the total nutritional composition of the rice from 100% to 98% was attributed to the loss resulting from the effect of milling and polishing process. This is evidence that rice loses nutrients (bran content) which is highly nutritional during the process of milling as observed by Oko et al. (2012). The proximate values obtained at first month storage period of MAS rice fall within the range of proximate values obtained for milled miniket rice by Zubair et al. (2015). As the month progresses, it was observed from the results that the proximate profile of the rice continued to decrease in value. After two months of its storage, the moisture content of the rice dropped to 7.40% while the available protein reduced to 6.60%, the fat ash and carbohydrate contents dropped to 6.0%, 0.89% and 78.86%, respectively.
The reduction in the proximate composition of MAS rice continued until 14 to 18th month of its storage and then maintained constant values of 3.43%, 5.90%, 0.1%, 0.51% and 53.06%, respectively for moisture content, protein, fat, ash and carbohydrate contents. The variation (reduction) in the proximate values showed that milled rice loses its nutritional values during storage periods.

Table 1. Variation in nutritional status of MAS variety between 1 – 18 months of storage period

Period (month)	Water (%)	Protein (%)	Fat (%)	Ash (%)	CHO (%)	Total (%)
1	10.40	6.90	0.50	0.90	79.30	98.00
2	7.40	6.60	0.60	0.89	78.86	94.05
6	6.58	6.20	0.40	0.75	74.07	88.00
10	3.64	5.90	0.20	0.81	70.75	81.00
14	3.43	5.90	0.10	0.51	53.06	63.00
18	3.43	5.90	0.10	0.51	53.06	63.00

Table 2 revealed the variation in the proximate composition of milled IRRI8 rice stored between the periods of 1 – 18 months. At first month of the storage, the IRRI8 rice variety recorded the moisture content protein, crude fat, ash and carbohydrate content of 9.61%, 6.90%, 0.60%, 0.90% and 78%, respectively. It had a total nutritional content of 97%, shorting 3% of its total food content during milling process resulting from the removal of bran (during polishing).
Oko et al. (2012) reported that the nutrients content of rice are lost when bran is removed during milling and that is why health conscious people prefer brown rice to milled rice. Results of the proximate values obtained within the first month of the storage of the milled IRRI8 fall within the values obtained by Devi et al.(2015) for 92 rice genotypes and slightly lower than the values obtained by Zubair et al. (2015) for milled miniket rice. The variation in the rice proximate composition according to Pomeranz (1992) is attributed to the differences in the variety and mostly to processing method used in which milling is paramount.
Furthermore, as storage period progresses, the proximate status of the IRRI8 rice was observed to depreciate in values. The moisture contents, available protein, crude fat, ash and carbohydrates after two months of storage dropped to 9.50%, 6.70%, 0.59%, 0.87% and 76.43%, respectively. The decrease in the nutritional values maintained constant values of 3.15%, 5.80%, 0.20%, o.47% and 50.39%, respectively for moisture contents, protein, fat, ash and carbohydrate. Finally, rice is a good source of insoluble fibre, insoluble fibre reduces the risk of bowel disorders and fights constipation. Dietary fibre is highest in the bran layer and lowest in the milled rice. Unfortunately, this bran layers are being removed during the process of milling (Oko et al., 2012).

Table 2. Variation in nutritional status of IRRI8 variety between 1 – 18 months of storage period

Period (month)	Water (%)	Protein (%)	Fat (%)	Ash (%)	CHO (%)	Total (%)
1	9.61	6.90	0.60	0.90	78.00	97.00
2	9.50	6.70	0.50	0.87	76.43	94.00
6	8.03	6.40	0.30	0.77	65.80	81.00
10	6.60	5.90	0.21	0.48	50.80	71.00
14	3.15	5.80	0.20	0.47	50.39	60.01
18	3.15	5.80	0.20	0.47	50.39	60.01

Figure 1-6 present the effect of storage period on the nutritional composition of milled rice. Figure 1 revealed that MAS rice had the highest moisture content of 10.4% at first month of storage period as compared to IRRI8 with moisture content of 9.61% at first month of storage period. The curves in this figure steeped downwards from the maximum value of the nutrient (10.4% for MAS and 9.61% for IRRI8) at first month (drop in moisture content) up to 14th - 18th month in which it maintained constant and minimum values of nutritional contents (3.43% for MAS and 3.14% for IRRI8).

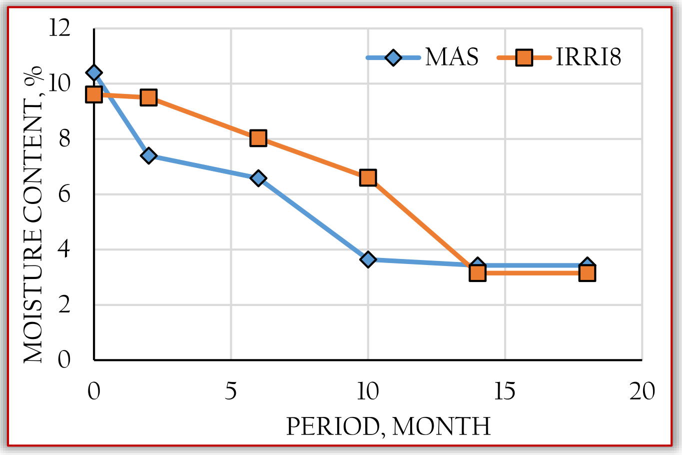

Figure 1. Effect of storage period on moisture content of milled rice

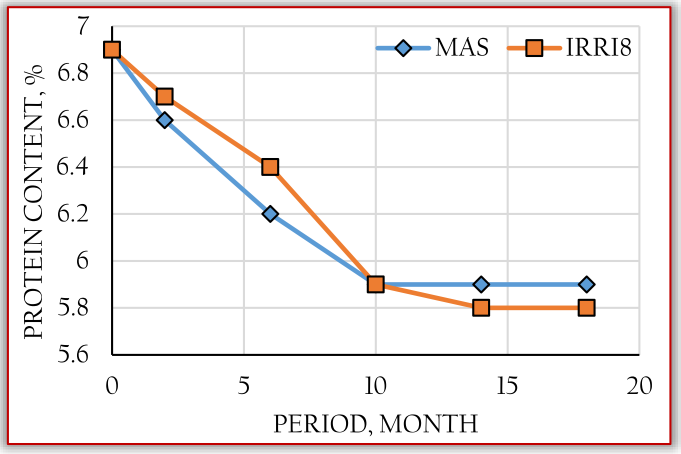

Figure 2. Effect of storage period on period content of milled rice

However, the percentage moisture losses across the varieties were not the same; the moisture content of MAS dropped at faster rate than the IRRI8 within the store periods. This variation was attributed to the differences that exist among different varieties of milled rice as observed by Pomeranz (1992) and Oko et al. (2012).

The curves of protein content of the rice varieties (fig. 2) steeped downward from the maximum value of 6.90% to 5.90% within the storage period of 1 to 18 months for MAS while the curve of IRRI8 followed the same trend, dropping from maximum proximate value of 6.90% in the first month of storage period to 5.80% within 14 – 18 months of the storage period. The variation in the rate at which both varieties lost their available protein content was almost at the same range.

Figure 3 presents the effect of storage period on the crude fat content of the rice varieties. The curves in this figure revealed that the IRRI8 recorded the highest crude fat content of 0.60% at first month and 0.20% within 14 – 18th month while the MAS steeped from 0.50% at first month down to 0.10% within 14 – 18th months of its storage. Both varieties lost about 0.4% of their crude fat at different rates during the storage period.

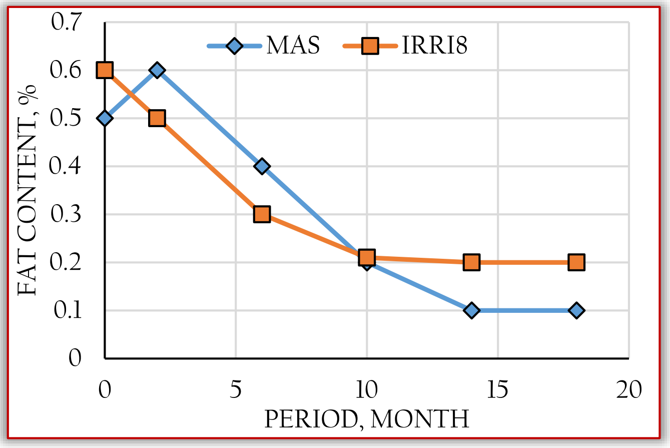

Figure 3. Effect of storage period on fat content of milled rice

Figure 4 presents the effect of storage period on the crude ash composition of MAS and IRRI8 rice varieties. Both curves in the figure steeped downward from 0.90% at first month of storage period where they had the same maximum nutritional ash, to minimum values of 0.50% for MAS and 0.47% for IRRI8 at the storage period of 14 – 18 months. Within the storage period of 18 months, the MAS rice lost total ash content of 0.47% while IRRI8 lost about 0.43% of its ash content.

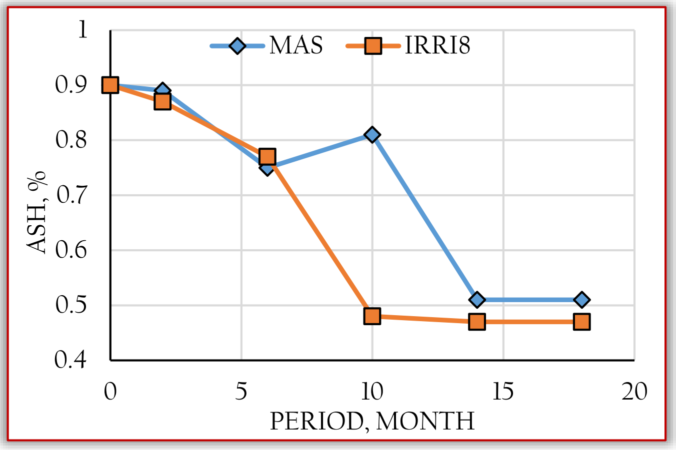

Figure 4. Effect of storage period on ash content of milled rice

Figure 5 revealed the effect of storage period on the carbohydrate composition of the rice varieties. According to this curves, the MAS rice with the highest carbohydrate value of 79.30% at first month of storage period as compared to IRRI8 with carbohydrate content of 78.00% at first month of storage period steeped downward from the maximum value (79.30%) and dropped gradually to a minimum carbohydrate value of 53.06% within the storage period of 14 – 18th month. On the other hand the IRRI8 rice variety steeped downward from its maximum carbohydrate content of 78.00% at first month of storage period to a minimum value of 50.39% within the storage period of 14 -18th month.

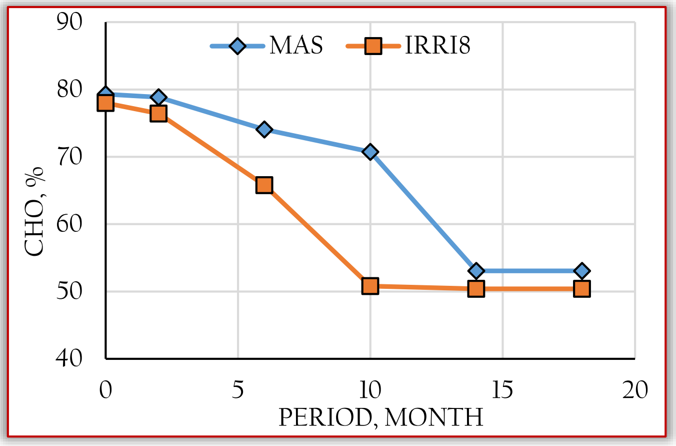

Figure 5. Effect of storage period on carbohydrate content of milled rice

Figure 6 showed the curves of the total food on nutritional content at a given storage period of the rice varieties. The curves steeped downward from the maximum value of food content where the MAS rice with the highest nutritional content of 98% at first month of storage to the minimum nutritional content of 63% within the storage period of 14 – 18th month while the curve of the total food content of IRRI8 rice steeped downward from its maximum value of 97% at first month to minimum value of 60.01% within the storage period of 14 – 18 months. Results of these curves indicated that rice under storage lose their nutritional composition from first month of their storage after milling and/or polishing up to 13th months of the storage period and from the 14th month, the deterioration in the nutritional value maintain constant values. It is therefore not a good practice to store rice for a very long period especially after milling.

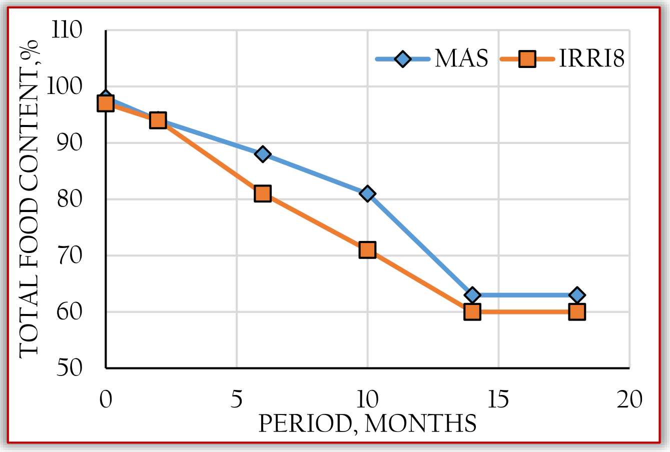

Figure 6. Effect of storage period on the total food content of milled Rice

CONCLUSION

From the findings made, the following conclusions can be made about the study:

- Milled rice has its highest nutritional content at zero month of its storage period. Thereafter, as the storage time progresses, the rice begins to lose its nutritional composition.
- The bran layer of rice grain contains the dietary fibre which is very nutritious and medicinal. This component of rice is removed during the milling and polishing process of rice grains.
- The variation in the proximate composition of rice is attributed to the differences in the varieties, processing method in which milling is paramount and nutritional loss resulting from length of storage period.
- Milled rice under storage gradually loses its nutritional composition from 0 – 13th month of its storage and from 14th month they maintain constant nutritional values till the rest of the period.

It is therefore recommended that rice should not be stored for a very long period after milling to be able to retain its nutritional content. Finally brown rice is preferred to milled and polished rice for consumption because of its bran content which embodied the fibre that is very nutritious and also medicinal in value.

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