DELTA AGRICULTURIST 16 (No. 1, 2024)
Published by Faculty of Agriculture, Rivers State University,
P.M.B.5080, PORT HARCOURT, Nigeria Since 1981
Email: deltaagriculturist@gmail.com www.deltaagriculturist.com ISSN 1115-6813

Research Paper Pp 15-28

PRODUCTION AND EVALUATION OF SNACK BAR PRODUCED FROM BLENDS OF SPROUTED RICE, DATE AND GROUNDNUT

EKE-EJIOFOR, J. AND IMBU, D.J.
Department of Food Science and Technology, Rivers State University, Nkpolu-Oroworukwo
*Corresponding author, email: dangoimbu@gmail.com

ABSTRACT

The study investigated the production and evaluation of snack bar produced from flour blends of sprouted rice, date and groundnut. Three rice varieties (white, red, and brown) were subjected to soaking, sprouting, drying to obtain flour which was used for the production of snack bars. The snack bars were evaluated for proximate, mineral and sensory properties. Proximate analysis of the snack bars showed varying levels for moisture (6.08-12.57%), ash (0.55-1.70%), fat (13.20-18.88%), crude protein (5.40-7.50%), crude fibre (0.20-10.60%), and carbohydrate (54.50-71.63%). The sprouted rice snack bars contained significantly (p<0.05) higher ash content than the soaked samples. Soaked white rice bar also contained significantly (p<0.05) higher protein (7.98%) than all the other rice bars. Mineral analysis of the snack bars showed varying levels for iron (3.84-61.86 mg/100g), potassium (111.24-396.62mg/100g), calcium (131.86-203.88mg/100g), zinc (1.23-192.50mg/100g), phosphorus (32.17-72.50mg/100g). Similarly, the sprouted rice bars had significantly (p<0.05) higher potassium (209.45-336.92 mg/100g), calcium (163.06-203.88 mg/100g), magnesium (127.55-153.78 mg/100g), zinc (1.74-192.50 mg/100g), and phosphorus (39.19-67.19 mg/100g), respectively more than the soaked samples. Sensory analysis result revealed that the oat bar was the most liked among all the tested samples and this was followed closely by the soaked white rice bar. The findings indicate that sprouted rice bars tended to have higher ash content and mineral content compared to soaked rice bars. However, the production of snack bar products using soaked white rice as the main ingredient is recommended since the products were organoleptically acceptable.

Keywords: Snack bar; rice; groundnut; wheat; oat; date flour

INTRODUCTION

Snack bars, commonly known as cereal bars, are popular light meals made from cereals, nuts, and dried fruits, bound together with substances like sugar, honey, and chocolate (Sharma *et al*., 2014; Silva *et al*., 2013). They come in various types, including fibrous, energy, diet, and protein bars, each offering distinct nutrition (Sharma *et al*., 2014). Fibrous bars provide around 100 kcal per unit due to their high fibre content, while energy bars offer 280 kcal with low fiber (Sharma *et al*., 2014). Diet bars contain 65 calories and are sugar-free, catering for health-conscious individuals, while protein bars have around 17 g of protein per unit with less fat (Degaspari *et al*., 2008). Snack bars are versatile, durable, convenient, and highly nutritious, making them a popular choice as a meal component, dessert, or meal replacement (Padmashree *et al*., 2013). The main ingredient is typically soft wheat flour. However, in countries like Nigeria, where wheat cultivation faces limitations due to unfavourable climatic conditions, the dependence on imported wheat flour results in expensive snack bar production (Okpala *et al*., 2012). This highlights the pressing need for research into suitable wheat substitutes, particularly in developing countries grappling with prevalent malnutrition.

Rice, as a vital staple food, serves as an excellent source of energy, protein, vitamins, and minerals (Alaka *et al*., 2011; Bhattacharjee and Das, 2020; Yadav and Jindal, 2007). Rice flour, with its gluten-free nature and 6.5-7% protein content, finds use in baking and as a thickening agent. It has diverse commercial applications, including rice flakes, starch, cakes, milk, and various byproducts such as rice husk and bran (Nyamekye *et al.*, 2016). Colored rice varieties, like red, brown, purple, and black rice, contain polyphenols concentrated in the outer kernel layers (Abdel-Aal *et al*., 2006). Red rice, enriched with anthocyanin, exhibits antioxidant, anti-tumor, anti-obesity, hypoglycemic, and anti-allergic effects (Deng *et al*., 2013). However, these colored varieties also contain anti-nutritional factors, particularly in the bran, which can reduce nutrient bioavailability. Sprouting or germination of rice can enhance its palatability and nutrient bioavailability (Megat Rusydi, 2011; Ghavidel and Prakash, 2007).

Groundnut, also known as peanut, is a legume renowned for its high oil, protein, mineral, and vitamin content. Its protein profile, notably high in lysine, makes it an excellent complement to cereals in snack bar production (Ayoola *et al*., 2012). Groundnuts can be used whole or processed into peanut butter, oil, soups, stews, and other products. The cake remaining after oil extraction also finds application in animal feed and complementary food formulations (Amoniyan *et al*., 2020). Dates, derived from the date palm tree, are delectable fruits rich in essential nutrients. They predominantly contain carbohydrates in the form of inverted sugars, such as glucose and fructose, accounting for approximately 65-80% of their dry weight (Alghamdi *et al*., 2018). Additionally, dates contain proteins, fats, vitamins, dietary fiber, fatty acids, polyphenols, antioxidants, and amino acids (Chandrasekaran and Bahkali, 2013). Traditional medicine has employed dates for various purposes, including the control of glycemic and lipid indexes in diabetic patients (Khalid *et al*., 2016). Date seeds can also be processed into flour, which, when mixed with wheat flour, finds use in the production of cakes, breads, pastries, biscuits, and snacks (Vinita and Punia, 2018).

Wheat flour used in the production of snack bars is mainly starchy and lacking in other nutrients such as protein, fiber and other micronutrients. In the process of refining, some nutrients are lost because all the wheat bran is removed (Florence *et al*., 2014). Snack bar consumption is increasing; however, most of the snack bars available in the market are of high sugar, glycemic index and low in protein and minerals. Excess of sugar in foods has been implicated with weight gain, blood sugar problems, and an increased risk of heart disease. Red rice has shown to be rich in protein, fiber, and minerals yet underutilized. The inclusion of alternative ingredients such as red rice flour, groundnut, and date flour presents an opportunity to enhance the nutritional value of snack bars and potentially serve as substitutes for expensive ingredients like wheat flour. This study aims to explore and investigate the successful incorporation of red rice, groundnut, and date flour in snack bar production.

MATERIALS AND METHOD

Materials

Red, Brown and white rice were obtained from Ebonyi State, Nigeria. Other ingredients such as salt, margarine, caramel, seed oil, sodium bicarbonate and honey were obtained from Mile 3 market, Port Harcourt, Rivers State, Nigeria. Chemicals and equipment used for this study were of analytical grade and obtained from the Food Analysis Laboratory, Department of Food Science and Technology, Rivers State University, Port Harcourt.

Preparation of Rice flour

The semi-dry grinding method as described by Eke-Ejiofor and Nwiganale (2016) was used to produce rice flour. In this method, one and half kilogram (1.5 kg) of white, red and brown rice were sorted manually, washed and, soaked for 5 hours at 28°C. The soaked grains were decanted and wet-milled using a hammer mill. Thereafter, it was oven-dried at 60°C for 24 hrs., grinded into powder using a hammer mill and sieved using 125 µm mesh size to obtain fine flour. The flour from white, red and brown rice were packaged differently in zip lock bags and stored for further use (Fig 1).

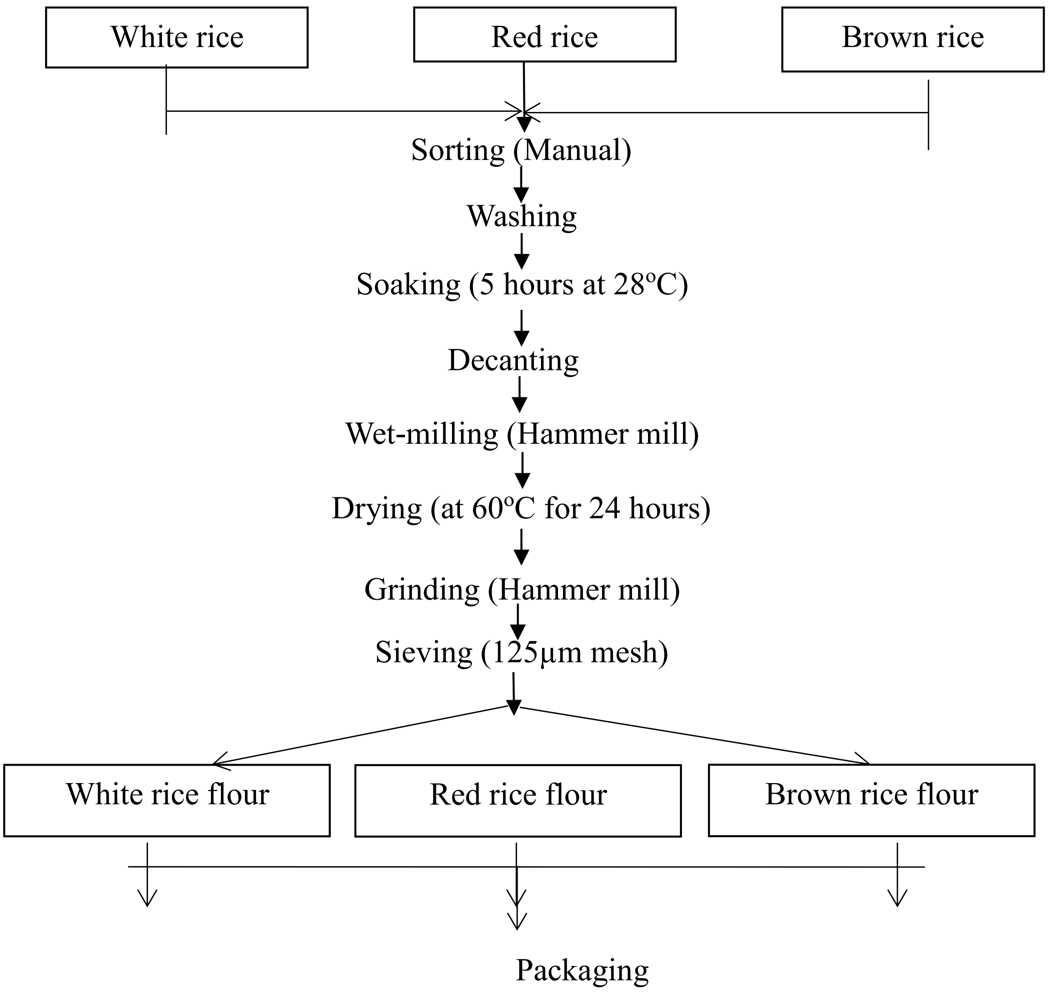

Fig 1: Production of flour from white, red and brown rice grains
Source: Eke-Ejiofor and Nwiganale (2016)

Preparation of sprouted white, red and brown rice flour

The method as described by Eke-Ejiofor and Nwiganale (2016) with slight modifications was used to produce sprouted rice flour. 1.5 kg of rice grain was manually sorted, washed, and wet steeped for 24 hrs at 28°C for water absorption. The steeped grains were left to sprout for 5 days at room temperature (28°C) to induce seedling growth. After sprouting, rootlets and coleoptiles were removed, and the grains were oven-dried at 60°C for 24 hrs to remove moisture. The dried grains were ground into fine powder using a hammer mill and sieved through a 125 µm mesh size. The resulting white, red, and brown rice flours were separately packaged in zip lock bags for storage and future use (Fig 2).

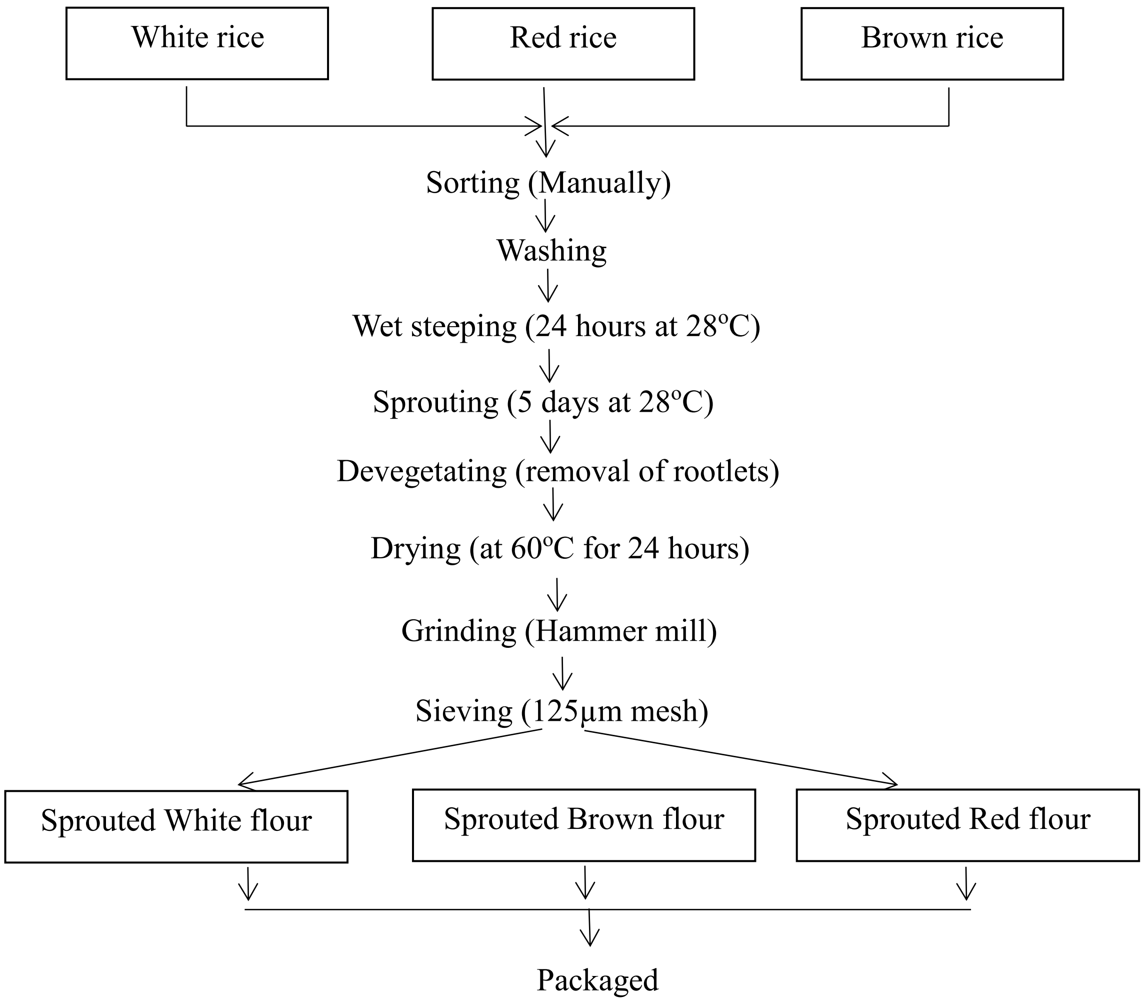

Fig 2: Production of sprouted rice flour from white, red and brown rice grains
Source: Eke-Ejiofor and Nwiganale (2016) Modified

Preparation of date grits

Date fruits were processed into date powder using the method by Nadeem *et al*. (2017). Fresh date fruit was sorted, washed to remove dirt, and manually deseeded. The fleshy pulp was then sliced into small pieces with a knife and evenly spread in a thin layer on stainless steel trays. The trays were placed in a hot air oven and dried at 65°C overnight. Subsequently, the dried pulp was milled using a loose hand grinder, and packed in an airtight container for storage until needed (Fig 3).

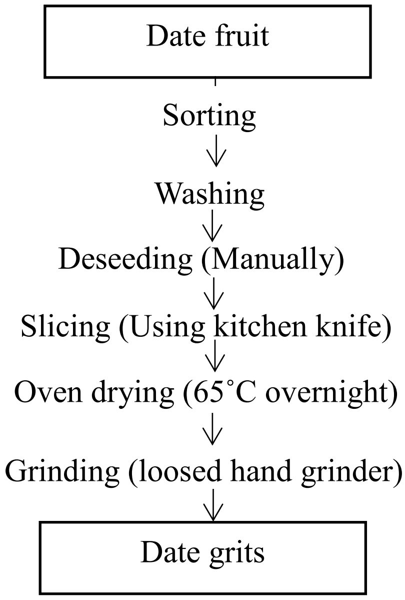

Fig.3: Processing of date fruit into date grits
Sourced: Nadeem *et al.* (2017).

Preparation of groundnut grits

Groundnut seeds were sorted to remove extraneous materials and subjected to roasting in an aluminum pot over charcoal fire and stirred at intervals to ensure proper roasting for 20-25min. Roasted seeds were allowed to cool to room temperature (28°C) and dehulled manually by rubbing and winnowing. The roasted seeds were grinded into grits using loosed hand grinder, packaged in zip lock bags and stored for further use (Fig 4).

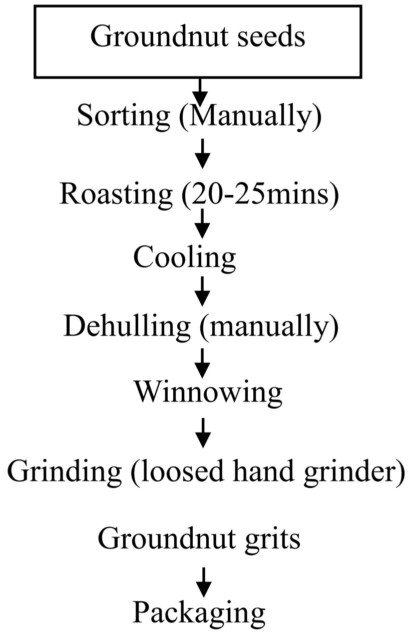

Fig.4: Production of groundnut grıts
Sourced: Eke-Ejiofor and Okoye(2018).

Production of snack bars

Snack bars were produced following the method described by Edima-Nyah *et al*. (2019). Dry ingredients (comprised of the rice flour, 5 g of date, 20 g of groundnut grits, 2 g of baking powder, 5 g milk powder, 0.2 g salt and 15 g margarine) were manually mixed in a stainless-steel bowl for about 3 min to achieve uniformity. Caramel (15 ml) and seed oil (10 m) were added and mixed for 3 min, followed by the gradual incorporation of 40 ml of water and thoroughly mixing for about 5 min to obtain a uniform dough. The dough was then transferred into greased aluminium pans and compressed with a spatula to form a uniform mass. Pan covers were used to smoothen the top and shape the bars as desired. The dough was baked in an oven at 150°C for 25 min. After baking, the bars were cooled to about 60°C, depanned, and cut into predetermined size and shape. To reduce moisture content, the bars were further dried in a hot air oven at 60°C for 6 hours. Once cooled to ambient temperature (27±2°C), they were packaged in high-density polyethylene and stored until needed for further analysis.

Proximate Analysis

Proximate composition of the snack bars was determined following established procedures (AOAC, 2012). Moisture content was assessed by drying 5 g of milled samples in an air oven at 130°C for 1 hour using the NAAFCO BS Oven (model: OVH-102). Ash content was gravimetrically measured in a muffle furnace (Sanyo Gallenkamp, Weiss Technik, West Midlands, UK) at 550°C for 24 hours. To determine protein content, 0.5 g of material was exhaustively extracted with petroleum ether in a micro Soxhlet extraction apparatus (Gerhardt, Bonn, Germany). The Kjeldahl method, involving distillation and titration with a factor of 5.7, was used for protein determination. Carbohydrate content was calculated by difference.

Mineral Analysis

Mineral content (calcium, iron, zinc, magnesium, potassium, and phosphorus) of the samples was determined by atomic absorption spectrometry, flame photometry and spectrophotometry according to standard methods (AOAC, 2012).

Sensory Analysis

Snack bars were subjected to sensory evaluation within 24 hours after production. The following attributes namely, color, taste, texture, mouth feel and flavor were assessed on the samples and this was carried out using a 9-point hedonic scale with 9 as like extremely and 1 as dislike extremely (Iwe, 2010) while overall acceptability was deducted as mean values of all the other sensory attributes assessed. Twenty panellists familiar with snack bars, who are neither sick nor allergic to baked product, were involved in the assessment. The panellists were instructed to rinse their mouth with water after tasting each sample.

Experimental Design and Statistical Analysis

A 3×2 factorial design was run for the samples. Analyses were carried out in replicate of each set up. Data obtained was subjected to Analysis of Variance (ANOVA) using Minitab software. Differences between means were evaluated using Duncan Multiple Range Test and significance accepted at 5% level of probability (Wahua, 1999).

RESULTS AND DISCUSSION

Proximate Composition of Snack Bars Produced from Rice, Groundnut and Date Flour Blend

Proximate composition of snack bars produced from rice, groundnut and date flour blends is shown in Table 2. Moisture content varied from 6.08% in soaked red rice bar (SRRB) to 12.57% in soaked white rice bar (SWRB). Snack bars made from red rice had significantly lower moisture content than those from white and brown rice varieties ($p<0.05$). However, there was no significant difference in moisture content between snack bars made from sprouted and soaked rice varieties. The moisture content of the bars (6.08-12.57%) was comparable to findings by Mendes *et al*. (2013) for cereal bars produced from roasted baru nuts, apple, and papaya. The high moisture content in the bars made from soaked and sprouted white rice could be attributed to their initial moisture content which affected the starch structure. According to Sanni *et al*. (2006), the lower the moisture of a product to be stored, the better the shelf stability of such product; hence soaked red rice and sprouted brown rice bars with low moisture content would have better shelf life than other rice bars.

Ash content ranged from 0.55-1.75%, with soaked white rice bar (SWRB) having the lowest value and sprouted brown rice bar (SPBRB) having the highest. Snack bars prepared from sprouted rice samples had significantly higher ash content than the soaked samples ($p<0.05$). This could be attributed to the sprouting process, which led to hydrolysis of complex organic compounds, releasing more nutrients (Kilja *et al*., 2016). The obtained values were within the range reported by Eke-Ejiofor and Okoye (2018) for snack bars made from locally available cereals and nuts (1.54-1.90%). The percentage of ash in a sample provides an idea of its inorganic content and mineral concentration, which can enhance metabolic processes and growth.

Fat content of the snack bars ranged from 13.20% in sprouted brown rice bar (SPBRB) to 18.88% in the oat bar (OB). There was no significant difference in the fat content of the snack bars ($p<0.05$). The values obtained were lower than the range reported by Eke-Ejiofor and Okoye (2018) for snack bars made from locally available cereals and nuts (23.3-29.40%). Dietary fats play essential roles in the body, such as being structural components of tissues, providing essential fatty acids, and aiding in the absorption of fat-soluble vitamins. However, higher lipid content could increase susceptibility to rancidity (Odibo *et al*., 2008).

Crude protein content ranged from 5.40-7.50%, with the lowest value recorded in sprouted brown rice bar (SPBRB) and the oat bar having the highest. While sprouted white rice snack bar had higher protein content than the soaked samples, sprouted red and brown rice bars had higher protein content than the soaked samples. These changes were only significant for the white rice snack bars ($p<0.05$). The values obtained were lower than the range reported by Eke-Ejiofor and Okoye (2018) for snack bars made from locally available cereals and nuts (21.3-23.90%). The values of protein obtained in the present study appear less than the recommended daily requirement for protein (25–30 g/day) for ages 15 and 19 years as recommended by WHO (2005) cited in Kiin-Kabari *et al*. (2021). This indicates that the frequent eating of this snack may serve to alleviate the problem of protein deficiencies in children, of which are the targets for production of this nutritionally improved product, and for adults who may want to snack on healthy food products.

Crude fibre ranged from 0.20% in soaked red rice bar (SRRB) to 10.60% in the oat bar. Sprouted red and white rice bars had higher crude fibre content than their soaked counterparts, but these differences were not significant ($p<0.05$). The fibre content in this study was lower than the findings of Mendes *et al*. (2013) for cereal bar produced from roasted baru nuts, apple, and papaya (8.97-9.16%). The dietary fiber intake recommendations for children and adolescents vary between 10 to 40 grams per day, contingent upon factors such as age, gender, and energy intake (WHO, 2005). Notably, the fiber content observed in the snack bars examined in this study falls below the stipulated range, signifying that regular consumption of this snack may carry significant health implications such as adding bulk to stool and contributing to the maintenance of internal distensions for a normal peristaltic movement (Tosh and Yada, 2010).

Carbohydrate content of the snack bars ranged from 54.50-71.63%, with the lowest value in the oat bar and the highest in the soaked red rice bar (SRRB). While sprouted brown and white rice bars had lower carbohydrate content than their soaked counterparts, the differences were not significant among the sprouted and soaked samples (p<0.05). The result was within the findings of Mendes *et al*. (2013) for cereal bar produced from roasted baru nuts, apple, and papaya (61.61%). The snack bars could be considered as a potential source of carbohydrates, contributing to meeting daily carbohydrate requirements of children n adolescents which is about 45-65% of their total daily energy intake (WHO, 2009).

Table 1; Proximate composition (%) of snack bars prepared from rice, groundnut and date flour blend.

Samples	Moisture	Ash	Fat	Crude Protein	Crude fibre	Carbohydrate
OB	7.03^{c}±0.76	1.50^{ab}±0.14	18.88^{a}±0.11	7.50^{ab}±0.57	10.60^{a}±0.29	54.50^{c}±0.52
SRRB	6.08^{c}±0.34	1.15^{bc}±0.07	13.76^{a}±3.09	7.20^{ab}±0.01	0.20^{b}±0.01	71.63^{a}±2.69
SWRB	12.57^{a}±0.59	0.55^{d}±0.07	13.88^{a}±1.42	5.65^{c}±0.21	0.51^{b}±0.15	66.86^{ab}±2.02
SBRB	9.37^{b}±0.27	0.95^{cd}±0.07	13.82^{a}±1.51	5.90^{c}±0.57	3.49^{b}±1.28	66.48^{ab}±0.59
SPRRB	7.01^{c}±0.01	1.70^{a}±0.14	13.84^{a}±0.42	6.83^{bc}±0.00	2.99^{b}±1.97	68.09^{ab}±2.54
SPWRB	11.57^{a}±0.37	1.15^{bc}±0.21	13.36^{a}±0.91	7.98^{a}±0.00	1.96^{b}±0.06	63.98^{b}±0.38
SPBRB	9.33^{b}±0.49	1.75^{a}±0.07	13.20^{a}±1.41	5.40^{c}±0.00	3.10^{b}±0.71	67.22^{ab}±1.70

Mean values are of triplicate determinations. Mean values within a column with different superscripts are significantly different at (p <0.05).
KEYS:
OB= Oat bar; SRRB= Soaked red rice bar; SWRB= Soaked white rice bar
SBRB= Soaked brown rice bar; SPRRB= Sprouted red rice bar;
SPWRB= Sprouted white rice bar; SPBRB= Sprouted brown rice bar

Mineral Composition of Snack Bars Produced from Rice, Groundnut and Date Flour Blend

Mineral composition of snack bars produced from rice, groundnut and date flour blends is shown in Table 3. The iron content of the samples ranged from 1.86 to 3.84 mg/100g, with the lowest value recorded in the sprouted white rice bar (SPWRB), and the highest value in the sprouted brown rice bar (SPBRB). The iron content of the sprouted red and brown rice bars (3.66 and 3.84 mg/100g, respectively) was higher than that of the soaked samples (2.67 and 2.24 mg/100g), while the sprouted white rice bar had lower iron content (1.86 mg/100g) than the soaked sample (3.83 mg/100g). The high iron content in the sprouted red and brown rice bars is beneficial since regular consumption of iron-rich food can help prevent anemia. Potassium content ranged from 111.24 mg/100g in the soaked white rice bar (SWRB) to 396.62 mg/100g in the oat bar. The results also showed that the sprouted rice bars had higher potassium content than the soaked varieties. Similarly, magnesium content ranged from 21.26 mg/100g in the soaked white rice bar (SWRB) to 153.78 mg/100g in the sprouted red rice bar (SPRRB).

The magnesium content of the sprouted rice bars was higher than that of the soaked samples. The high magnesium, iron, and potassium contents in the sprouted rice bars are due to the hydrolysis of complex organic compounds by endogenous enzymes, releasing more nutrients while leaving the anti-nutrients to leach into the sprouting medium (Kajla *et al*., 2016). These results for potassium and magnesium are higher than the findings of Eke-Ejiofor and Okoye (2018) for cereal bars produced from locally available cereals and nuts, with magnesium content of 19.36-27.78 mg/100g and potassium content of 10.08-18.94 mg/100g. A varied diet should provide the recommended daily allowance (RDA) for magnesium (75-240 mg/100g for children 7-13 years), and magnesium helps in the proper functioning of the muscles. It also serves as an activator in many enzyme systems (Okoye and Egbujie, 2018).

Calcium content ranged from 131.86-203.88 mg/100g, with the oat bar recording the lowest value and the sprouted red rice bar (SPRRB) having the highest value. In this study, the calcium content of the sprouted rice bars was higher than that of the soaked samples. The same trend was observed for phosphorus and zinc contents, and these changes were also significant ($p<0.05$) among the sprouted and soaked rice bars. The results obtained for calcium and phosphorus fall within the range (6.17-12.32 mg/100g and 5.70-8.01 mg/100g, respectively) reported by Eke-Ejiofor and Okoye (2018) for cereal bars produced from locally available cereals and nuts. Zinc content is also within the range (6.97-12.32 mg/100g) reported by Eke-Ejiofor and Okoye (2018). The high calcium, phosphorus, and zinc contents in the sprouted rice bars are due to the sprouting process, which leads to the hydrolysis of bonds between mineral-protein enzyme complexes, releasing free minerals. Phosphorus is essential for cell membranes and bones, while calcium is vital for bone and teeth development, muscle and nerve function, blood clotting, and immune defence, especially in infants and young children.

Table 2: Mineral composition (mg/100g) snack bars prepared from rice, groundnut and date flour blend

Samples	Iron	Potassium	Calcium	Magnesium	Zinc	Phosphorus
OB	2.23^{d}±0.04	396.62^{a}±0.13	131.86^{g}±0.03	127.82^{d}±0.04	7.98^{c}±0.02	72.50^{a}±0.71
SRRB	2.67^{c}±0.04	183.25^{f}±0.05	195.83^{b}±0.01	138.03^{b}±0.02	2.23^{d}±0.03	58.75^{d}±1.06
SWRB	3.83^{a}±0.01	196.44^{e}±0.04	171.82^{d}±0.03	84.03^{f}±0.01	1.68^{d}±0.02	34.53^{f}±0.04
SBRB	2.24^{d}±0.04	111.24^{g}±0.04	145.57^{f}±0.03	21.26^{g}±0.05	1.23^{d}±0.04	32.17^{g}±0.24
SPRRB	3.66^{b}±0.01	336.92^{b}±0.04	203.88^{a}±0.06	153.78^{a}±0.01	192.50^{a}±0.71	67.19^{b}±0.27
SPWRB	1.86^{e}±0.02	306.51^{c}±0.08	163.06^{e}±0.05	129.56^{c}±0.03	10.65^{b}±0.06	39.36^{e}±0.21
SPBRB	3.84^{a}±0.00	209.45^{d}±0.02	176.84^{c}±0.01	127.55^{e}±0.01	1.74^{d}±0.02	62.06^{c}±0.08

Mean values are of triplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).
KEYS:
OB= Oat bar; SRRB= Soaked red rice bar; SWRB= Soaked white rice bar
SBRB= Soaked brown rice bar; SPRRB= Sprouted red rice bar;
SPWRB= Sprouted white rice bar; SPBRB= Sprouted brown rice bar

Sensory Properties of Snack Bars Produced from Rice, Groundnut and Date Flour Blend

Table 4 shows the mean sensory scores of snack bars produced from rice, groundnut and date flour blends. The mean scores for colour ranged from 5.10-7.70, with the soaked brown rice bar (SBRB) being the least preferred and the oat bar being the most preferred. For taste, the mean scores ranged from 4.50 to 7.20, with the sprouted red rice bar (SPRRB) being the least preferred and the oat bar being the most preferred. In terms of appearance, the mean scores ranged from 4.50-7.65, with the sprouted brown rice bar (SPBRB) being the least preferred and the oat bar being the most preferred. The colour of the oat bar was significantly different from the rice bars ($p<0.05$). However, the taste of the oat bar was not significantly different from the soaked rice bar and sprouted white rice bar ($p>0.05$). The lower scores for colour and taste in the snack bars from red and brown rice could be attributed to the pigmentation in these varieties, which might have affected the colour and taste scores. Colour and taste are crucial sensory attributes that significantly influence the acceptability of food products. With the exception of soaked white rice, the rest of the samples were rated well in terms of colour and taste by the panellists. Hence, snack bars with acceptable colour can be produced using white rice rather than oat.

The mean scores for texture of the snack bars ranged from 4.35 in sample SPBRB to 7.35 in the control sample. The texture of the oat bar was significantly different from the rice bars ($p<0.05$). Sprouted brown rice bars had lower textural scores than the soaked samples, whereas the texture scores for sprouted red rice were higher than the soaked samples. This could be attributed to the water absorption capacity of the sprouted rice samples due to enzymatic starch modification during sprouting. The mean texture score of the soaked white rice bar was above the average (<6), indicating that, based on this test parameter, this sample was liked by the panellists and comparable to the control sample. The overall acceptability scores ranged from 4.75 in the sprouted brown rice SPBRB to 7.48 in the oat bar. Similarly, the sprouted rice bars had lower acceptability scores than the soaked samples. The overall acceptability of the oat bar was also significantly higher than all other rice bars except for the soaked white rice bar ($p<0.05$). The sensory evaluation results indicate that soaked white rice could be used to produce an organoleptically acceptable snack bar product.

Table 3: Mean sensory scores of snack bars produced from rice, groundnut and date flour blend

Samples	Colour	Texture	Appearance	Taste	Overall Acceptability
OB	$7.70^{a}\pm1.49$	$7.35^{a}\pm1.35$	$7.65^{a}\pm1.23$	$7.20^{a}\pm2.17$	$7.48^{a}\pm1.31$
SRRB	$5.30^{b}\pm2.13$	$4.95^{b}\pm2.24$	$5.60^{bc}\pm2.04$	$5.55^{ab}\pm2.68$	$5.35^{bc}\pm1.94$
SWRB	$7.05^{ab}\pm1.64$	$6.00^{ab}\pm1.72$	$7.00^{ab}\pm1.69$	$6.50^{ab}\pm2.16$	$6.64^{ab}\pm1.24$
SBRB	$5.10^{b}\pm2.29$	$4.95^{b}\pm2.11$	$5.25^{c}\pm1.92$	$4.60^{b}\pm2.28$	$4.98^{c}\pm1.74$
SPRRB	$5.15^{b}\pm2.54$	$5.30^{b}\pm2.34$	$6.05^{abc}\pm1.54$	$4.50^{b}\pm2.35$	$5.25^{bc}\pm1.47$
SPWRB	$5.65^{b}\pm2.06$	$5.15^{b}\pm2.39$	$5.10^{c}\pm1.62$	$4.95^{b}\pm1.93$	$5.21^{bc}\pm1.51$
SPBRB	$5.40^{b}\pm2.19$	$4.35^{b}\pm2.08$	$4.50^{c}\pm2.01$	$4.75^{b}\pm2.63$	$4.75^{c}\pm1.56$

Mean values within a column with different superscripts are significantly different at ($p<0.05$) (n=20)

KEYS:

OB= Oat bar; SRRB= Soaked red rice bar; SWRB= Soaked white rice bar

SBRB= Soaked brown rice bar; SPRRB= Sprouted red rice bar;

SPWRB= Sprouted white rice bar; SPBRB= Sprouted brown rice bar

CONCLUSION

The results of this study demonstrated that snack bars produced from sprouted red, brown, and white rice exhibited favourable nutritional profiles, with higher protein, potassium, magnesium, iron, calcium, and zinc contents compared to their soaked counterparts. However, the red and brown pigmentation in the bars may have contributed to lower colour and taste scores during sensory evaluation. Due to their low fibre content and high carbohydrate, the snack bars can be classified as energy bars. This study has also shown that all three rice varieties have capacity to replace oat for snack bar production with sprouted white rice being outstanding for snack bar production. The production of snack bar products using soaked white rice as the main ingredient is recommended since the products were organoleptically acceptable.

REFERENCES

Abdel-Aal, E.M., Young, J.C. & Rabalski, I. (2006). Anthocyanin composition in black, blue, pink, purple, and red cereal grains. *J Agric Food Chem*, 54(13):4696-4704.

Alaka, I.C., Ituma, J.O.S & Ekwu, F.C (2011). Physical and Chemical Properties of Some Selected Rice Varieties in Ebonyi State. *Nigerian Journal of Biotechnology*, 22: 40- 46

Alghamdi, A.A., Awadelkarem, A.M., Hossain, A.N.M.S., Ibrahim, N.A., Fawzi, M. & Ashraf, S.A. (2018). Nutritional assessment of different date fruits (*Phoenix dactylifera* L.) varieties cultivated in Hail province, Saudi Arabia. *Bioscience Biotechnology Research Communications,* 11(2): 263-269.

Amoniyan, O.A., Olugbemi, S.A., Balagun, O.M. & Salako, B.O. (2020). Effect of processing methods on the proximate and mineral compositions in groundnuts for consumption. *European Journal of Nutrition and Food Safety*, 12(9): 87-93.

AOAC. (2012). Official Methods of Analysis of the Association of Official Analytical Chemists, 20th ed,.

Ayoola, P.B., Adeyeye, A. & Onawumi, O.O. (2012). Chemical evaluation of food value of groundnut (*Arachis hypogaea*) seeds. *American Journal of Food and Nutrition*, 2(3): 55-57.

Bhattacharjee, S. & Das, P. (2020). Changes in proximate composition during processing of a few rice products of Assam having ethno-economic importance. *International Journal of Current Microbiology and Applied Sciences*, 9(4): 713-725.

Chandrasekaran, M. & Bahkali, H. A. (2013). Valorization of date palm (Phoenix dactylifera) fruit processing by-products and wastes using bioprocess technology – Review. *Saudi Journal of Biological Sciences*, 20:105–120.

Degaspari, C.H., Blinder, E.W., & Mottin, F. (2008) Perfil nutricional do consumidor de barras de cereais. *Viso AcadÍmica*, 9(1): 49-61.

Deng, G.F., Xu, X.R., Zhang, Y., Li, D., Gan, R.Y. & Li, H.B. (2013). Phenolic compounds and bioactivities of pigmented rice. *Critical Reviews in Food Science and Nutrition*, 53(3):296-306.

Edima-Nyah, A.P., Ojimelukwe, P.C. & Nwabueze, T.U. (2019). In vitro nutrient analysis of high fibre snack bars produced from blends of African breadfruit, maize and coconut. *Journal of Environmental Science, Toxicology and Food Technology*, 13(10): 52-61.

Eke-Ejiofor, J. & Nwiganale, L. (2016). The effect of variety and processing methods on the functional and chemical properties of rice flour. *International Journal of Nutrition and Food Sciences*, 5(1): 80-84.

Eke-Ejiofor, J. & Okoye, C. (2018). Nutrient composition, lipid profile and sensory properties of cereal bar made from locally available cereals and nuts. *International Journal of Biotechnology and Food Science*, 6(1): 1-8.

Eke-Ejiofor, J., Wordu, G.O. & Bivan, S.K. (2018). Functional and pasting properties of acha, defatted soybean and groundnut flour blends. *American Journal of Food Science and Technology*, 6(5): 215-218.

Florence, S.P., Asna, U., Asha, M.R. & Jyotona, R. (2014). Sensory, physical and nutritional qualities of cookies prepared from pearl millet (*Pennisetum typhoideum*). *Food Processing and Technology*, 5(10): 377.

Ghavidel, R.A. & Prakash, J. (2007). The impact of germination and dehulling on nutrients, antinutrients, in vitro iron and calcium bioavailability and in vitro starch and protein digestibility of some legume seeds. *LWT- Food Science and Technology*, 40 (7): 1292-1299.

Iwe, M. O. (2010). *Handbook of Sensory methods and analysis*. Enugu, Nigeria: Rejoint Communication Science Ltd. Pp. 75-78.

Kajla, P., Sharma, A. & Sood, D.R. (2016). Effect of germination on proximate principles, minerals and antinutrients of flaxseeds. *Journal of Dairying, Foods & Home Sciences*, 36(1): 1-9.

Khalid, S., Ahmad, A., Masud, T., Asad, M. J., & Sandhu, M. (2016). Nutritional assessment of Ajwa date flesh and pits in comparison to local varieties. *The Journal of Animal & Plant Sciences*, 26(4):1072-1080.

Kiin-Kabari, D.B., Anijekwu, P.O. & Eke-Ejiofor, J. (2021). Production and evaluation of breakfast meals from germinated and ungerminated blends of sorghum and soybean by cold extrusion process. *Asian Food Science Journal*, 20(8): 52-65.

Kiin-Kabari, D.B., Mbanefo, C.U. & Akusu, M.O. (2021). Production, nutritional evaluation and acceptability of cookies made from a blend of wheat, African walnut, and carrot flours. *Asian Food Sci. J.* 20 (6): 60–76

Megat Rusydi, M.R., Noraliza, C.W., Azrina, A. & Zulkhairi, A. (2011). Nutritional changes in germinated legumes and rice varieties. *International Food Research Journal*, 18: 705-713.

Mendes, N.R., Gomes-Ruffi, C.R., Lage, M.E., Becker, F.S., Melo, A.A.M., da Silva, F.A. &

Damian, C. (2013). Oxidative stability of cereal bars made with fruit peels and baru nuts packaged in different types of packaging. *Food Sci. Technol, Campinas*, 33(4): 730-736

Nadeem, M., Qureshi, T.M., Ahmad, M.M., Riaz, M.N., Ameer, A. & Qurat-ul-An. (2017).

Development of free flowing date powder and its utilization in muffins to enhance nutritional value. *Journal of Agricultural Research*, 55(4): 671-677.

Nyamekye, I., Fiankor, D.D. & Ntoni, J.O. (2016). Effect of human capital on maize productivity in Ghana: a quantile regression approach. *International Journal of Food and Agricultural Economics*, 4(2): 125-135.

Odibo, F.J.C., Ezeaku, E.O. & Ogbo, F.C. (2008). Biochemical change during fermentation of

Prosopis Africana seeds for ogiri-okpei production. *Journal of Industrial Microbiology and Biotechnology*, 35: 947-952

Okpala, L., Okoli, E. & Udensi, E. (2012). Physico-chemical and sensory properties of cookies made from blends of germinated pigeon pea, fermented sorghum and cocoyam flours. *Food Science and Nutrition*, 1(1): 8-14.

Padmashree, A., Sharma, G.K. & Govindaraj, T. (2013). Development and evaluation of shelf stability of flaxoat nutty bar in different packaging materials. *Food and Nutrition Sciences*, 4(5): 538-541.

Sanni, L.O., Maziya-Dixon, B., Onabolu, A.O., Arowosafe, B.E., Okechukwu, R.U., Dixon, A.G.O., Lemchi, J., Akoroda, M., Ogbe, F., Tarawali, G., Okoro, E. & Geteloma, C. (2006). Cassava Recipes for Household food security. *International Institute for Tropical Agriculture* (*IITA*). *Integrated Cassava Project*; Ibadan, Nigeria.

Sharma, C., Kaur, A., Aggarwal, P. & Singh,Y. (2014). Cereal bars in a healthful choice a review. *Arpathian Journal of Food Science and Technology*, 6(2): 29-36.

Silva, V.S., Sobrinho, V.S. & Cereda, M.P. (2013). Stability of cassava flour-based food bars. *Food Sci. Technol. Campinas*, 33: 192-198.

Tosh, S.M. & Yada, S. (2010) Dietary Fibre in Pulse Seeds and Fractions: Characterization, Functional Attributes, and Applications. *Food Research International*, 43: 450-460

Vinita & Punia, D. (2018). Proximate and sugars composition of seeds of four date palm (*Phoenix dactylifera* L.) cultivars grown in Haryana, India. *International Journal of Chemical Studies*, 6(2): 362-364.

Wahua, T.A.T. (1999). Applied Statistics for Scientific Studies. African Link Press, Aba, Nigeria.

World Health Organization. *Infant and Young Child Feeding: Model Chapter* *for Textbooks for Medical Students and Allied Health Professionals*. Geneva: WHO Press (2009). Available from: http://apps.who.int/iris/bitstream/10665/44117/1/9789241597494_eng.pdf

World Health Organization (2005). Make Every Mother and Child Count, World Health Organization, Geneva, Switzerland.

Yadav, B.K & Jindal, V.K (2007). Modeling varietal effect on the water uptake behaviour of milled rice (*Oryza sativa* L) during soaking. *Journal of Food Process Engineering*, 30:670-684