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Research Paper

Nutrient composition, lipid profile and sensory properties of cereal bar made from locally available cereals and nuts

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Abstract. Cereal bar was produced using five different cereal grains namely, oat (control), millet, guinea corn, yellow and white maize. The developed samples were subjected to sensory evaluation, proximate analysis, mineral assay and fatty acid/lipid profile assessment. Sensory analysis result showed a significant difference ($p \leq 0.05$) in color/appearance, texture/crispness, taste, aroma and overall acceptability with the yellow maize based cereal bar having the highest values in all the parameters evaluated and therefore more acceptable compared to other treatments. Proximate analysis result showed that moisture, ash and protein contents ranged from 5.09 to 6.78%, 1.54 to 1.90% and 21.3 to 23.9% respectively with sample E (guinea corn bar) having the highest values. Fiber content ranged from 3.89 to 6.08% while total available carbohydrate (TAC) ranged from 36.64 to 41.42% with sample D (millet bar) and sample B (yellow maize bar) as highest respectively. Fat content ranged from 23.27 to 29.38%, while energy ranged from 452.6 to 505.2 kcal with the control as the highest in both cases. Mineral analysis showed that potassium and magnesium ranged from 10.08 to 18.94 mg/kg and 12.88 to 22.82 mg/kg respectively with sample A (oat bar/control) has the highest in both cases. Phosphorus and zinc ranged from 5.70 to 8.01 mg/kg and from 6.17 to 12.32 mg/kg respectively, with sample B (white maize bar) as the highest and sample E (guinea corn bar) as the lowest in both cases, while calcium content ranged from 38.47 to 59.93 mg/kg with sample D (millet bar) as the highest and sample C (yellow maize bar) as the lowest. Lipid profile showed a significant difference ($p \leq 0.05$) between the control and the newly developed cereal bars in terms of essential fatty acids (EFA). The highest linoleic acid content was found in sample E (millet bar) with 4% and the lowest in sample B (white maize bar) with 2.11%. Eicosarienoic acid and docosahexanoic acid had 6.51 and 11.68% respectively with sample E (millet bar) as the highest. Oleic and erucic acids content ranged from 1.64 to 11.68% and from 3.11 to 20.47% with the control having the highest values in both cases. The study showed an improvement in the nutritional and sensory qualities of the alternative cereal bar over the control sample.

Keywords: Cereal bars, nutrient composition, sensory properties, lipid profile.

INTRODUCTION

Around the world, adults consume energy outside of traditional meals such as breakfast, lunch, and dinner, which is occasioned by either hunger or habit. This can be defined as "snack" based on the time of day and eating occasion (Ma, 2003; Ng *et al*., 2011), type of food consumed (Lipoeto *et al*., 2013) amount of food consumed, location of food consumption, or a combination of several of these factors (Garriguet, 2007). Snacking when hungry tends to be associated with the consumption of health-promoting foods. Snacking in the absence of hunger leads to the consumption of fat, sugar and sodium-rich foods (Bellisle, 2014). Unnecessary snacking promotes "weight gain and poor nutrition" (Bellisle, 2014) and the results of studies by Chapelot (2011) support this hypothesis. However, healthy snacks have been an issue of interest.

Cereal bar is a dry granulated cereal based product which has a low water activity (Macedo *et al*., 2013) and made from a compressed mixture of cereals, dried fruits and nuts (Silva *et al*., 2013). It is a snack made from oats, walnut, almond nut, dried fig, dried raisins (*Vitis vinifera*), coconut (*Cocos nucifera*), honey and sesame seed (*Sesamum indicum*) which is usually baked until crisp and consumed as snack. They are among the most sophisticated ready to-eat products due to their natural ingredients and the fact that they are healthy (Grden *et al*., 2008). However, little is known of cereal bars, since most of the raw material for its production are high in cost due to unavailability and as a result have impacted high cost on the product, leading to reduced consumption in this part of the world.

There has been increased consumer awareness on the dangers associated with high calorie carbohydrate based snacks and their attendant health challenges such as increased weight gain amongst others. This has necessitated the need for an improvement on the current trend in snack products. Cereal bars have been developed out of the need to have a product that could bring together nutritional, sensory and quality satisfaction to a large proportion of the population who are desirous to have rich and wholesome snack that would meet the body's need.

Therefore some locally available cereals such as yellow and white maize (*Zea mays*), millet (*Penniselum americana*) and guinea corn (*Sorghum bicolor*) which are of low cost was substituted for oat (*Avens sativa*), while cashew nut (*Anacardium occidentale*), groundnut (*Arachis hypogea*), date (*Phoenix dactylifera*) were substituted for walnut (*Juglans regia*), almond nut (*Prunus dulcis*) and fig (*Ficus carica*) respectively for the production of cheap, available, nutritious and healthy cereal bar. Since there is an ongoing consumer and researcher interest on food that would help maintain human health.

Therefore, the objectives of the study are to produce different cereal bars from locally available and cheap raw materials such as maize, millet or guinea corn meal, with blends of cashew nuts, groundnuts and date palm; and to evaluate the nutrient composition, lipid profile and sensory properties of the product.

MATERIALS AND METHODS

Materials

Oat (*Avena sativa*), maize (*Zea mays)*, millet (*Penniselum americana*), guinea corn (*Sorghum bicolor*), peanut (*Arachis hypogea),* coconut *(Cocus nucifera),* sesame seed (*Sesamum indicum)*, walnut (*Juglans regia)*, almondnut (*Prunu dulcis)*, cashewnut (*Anacardium occidentale),* date palm (*Phoenix dactylifera*), common fig (*Ficus carica),* raisin (*Vitis vinifera),* honey and seed oil were purchased from fruit market in Port Harcourt, Rivers State, Nigeria.

Chemicals

Chemicals used for this analysis were of analytical grade and were all obtained from the Biochemistry laboratory, Department of Food Science and Technology, Rivers State University Port-Harcourt.

Preparation of maize, millet and guinea corn meal

Maize (yellow and white), millet and guinea corn were sorted to remove spoiled grains. They were cleaned and winnowed. The grains were milled into meals separately using a dry milling machine. The meals obtained were then stored differently in an air-tight container for preparation of cereal bar.

Preparation of cereal bars

Preparation of cereal bars are shown in Figure 2.

Sensory evaluation

Cereal bar samples were subjected to sensory evaluation within 24 h of production. The sample was evaluated for color/appearance, crispness/texture, aroma, taste and overall acceptability. The above mentioned attributes were assessed using a 9 – point hedonic scale (Onwuka, 2005), with 9 = Like extremely and 1 = Dislike extremely. Twenty (20) semi trained panelists (comprising of 12 females and eight males) drawn from within and outside the Department of Food Science and Technology, who were neither sick nor allergic to any component raw material, were involved in the assessment. The panelists were instructed to rinse their mouth with water after tasting each cereal bar sample.

Chemical analysis of cereal bar samples

The moisture content of the sample was determined using moisture analyzer AMB-ML-50 at 130°C. Ash, fat and crude protein contents were determined according to the method described by AOAC (2012), while total available carbohydrate (TAC) was calculated by difference.

Mineral element assay (AOAC 2012)

Mineral element analysis of the cereal bars were

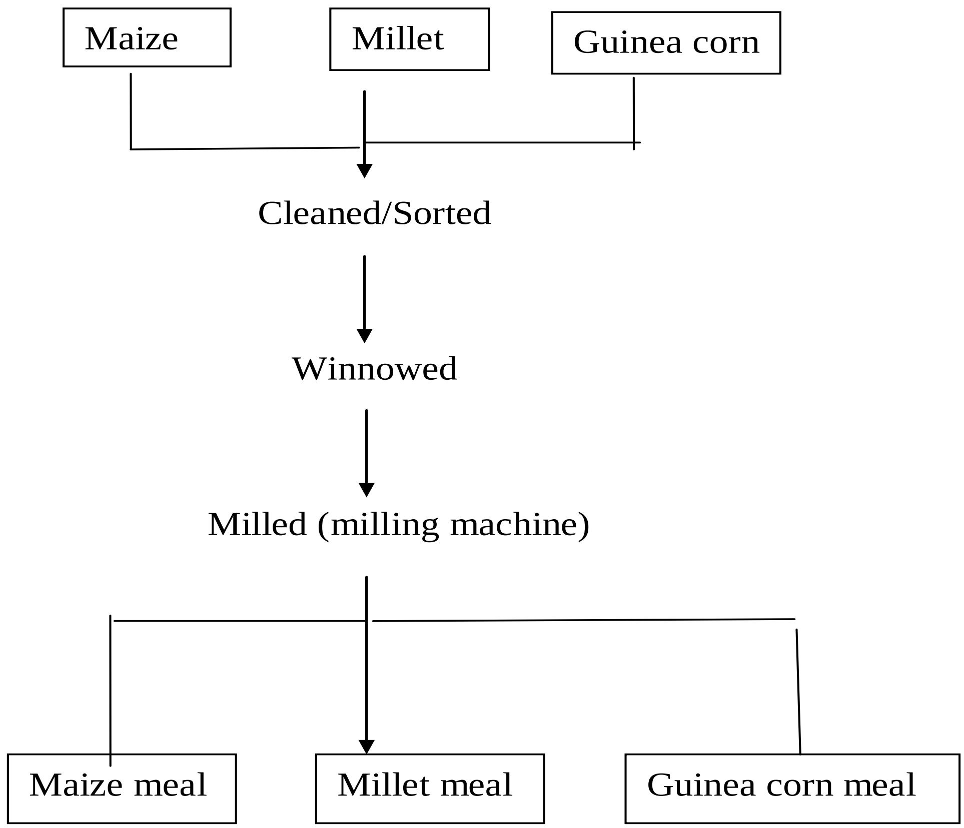

Figure 1. Flow diagram for cereal meal preparation. Source: Eke-Ejiofor *et al*. (2016).

determined by preparing solutions of ash and quantitatively measuring each of these elements - zinc, magnesium, calcium, potassium and phosphorous using UNICAM SOLAAR 32 Atomic Absorption Spectrophotometer (AAS).

Fatty acid profile

The individual total fat/oil in the cereal bars were extracted using the AOAC (2012) methods and Gas chromatograph (GC) analysis (model 7890A Agilant, USA) used to determine the individual fatty acid present.

Statistical analysis

Results were statistically analysed by using analysis of variance technique. Level of significance within means was calculated by using Ducan Multiple Range Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Sensory analysis results of cereal bars

Sensory properties of products are the most vital attributes, as they are most apparent to consumers. Table 2 shows the sensory evaluation result of dry cereal bar samples prepared from five (5) different cereals namely oat, white maize, yellow maize, millet and guinea corn meals. The results obtain from the present study showed that there were significant differences ($P \leq 0.05$) in the sensory parameter evaluated for the cereal bar samples.

Color of samples ranged between 5.20 and 7.10, with sample D (millet bar) as the least and sample B (white maize bar) as the highest, while taste ranged between 5.60 and 7.10 with sample D (millet bar) as the least and sample C (yellow maize bar) as the highest. Color and taste are important sensory attribute which to a large extent determines the acceptability of food products. Therefore, cereal bars of acceptable color can be produced from the locally available and cheap cereals order than oat.

Aroma ranged between 5.60 and 6.70 with sample D (millet bar) as the lowest and sample C (yellow maize bar) as the highest, while texture/crispness of cereal bar samples ranged between 5.60 and 7.15 with sample D and E (millet and guinea corn bars) as the least and sample C (yellow maize bar) as the highest. Overall acceptability ranged between 6.05 and 7.50 with sample D (millet bar) as the least and sample C (yellow maize bar) as the highest.

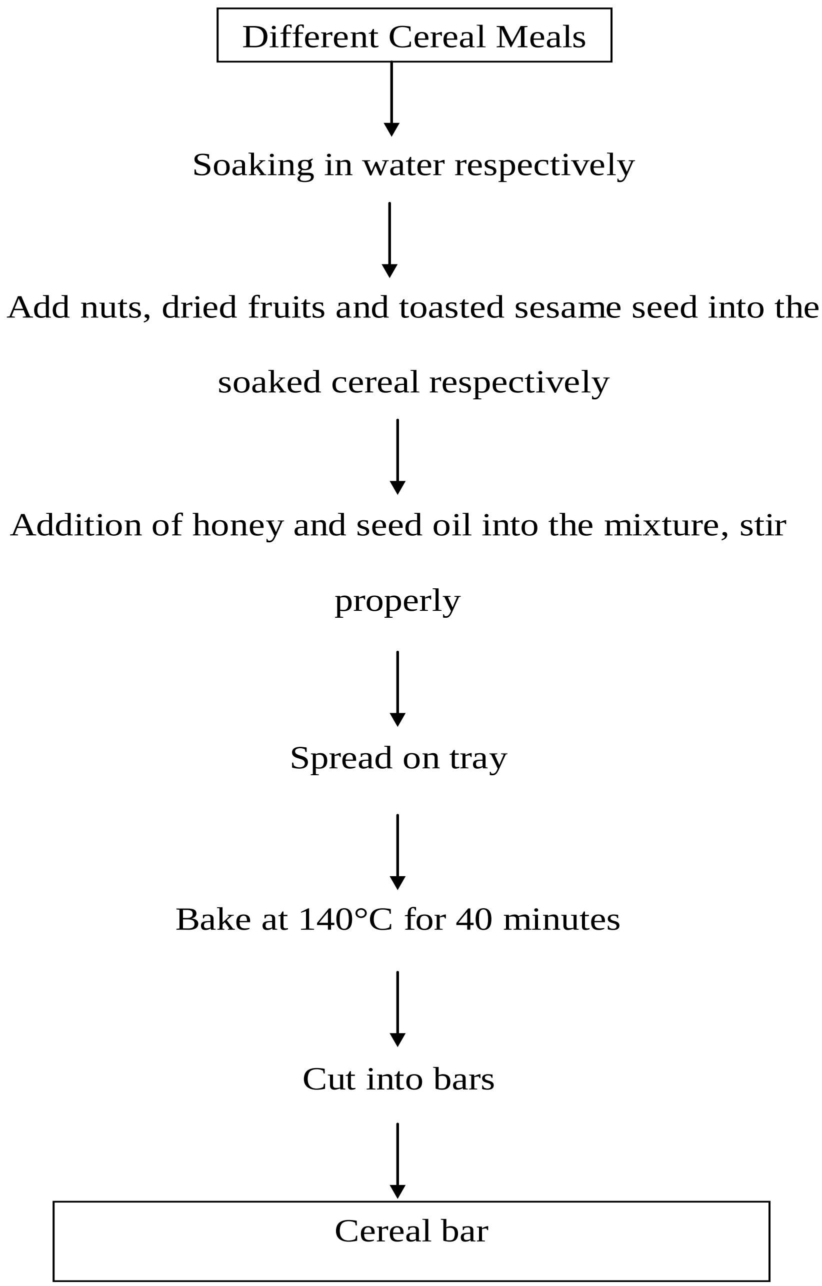

Figure 2. Flowchart for preparation of cereal bar. Source: Source: George *et al*. (2008).

The results obtained showed that millet and guinea corn (samples D and E) containing cereal bars had lower values while maize (sample B and C) had higher values in appearance, overall acceptability and texture and did not significantly different ($P \geq 0.05$) from the control made from oat (sample A).

Nutritional composition of cereal bars

Table 3 shows the chemical evaluation result of cereal bar prepared from five different cereals namely oat, white maize, yellow maize, millet and guinea corn.

Moisture content ranged between 5.09 and 6.78% with sample A (oat bar) as the least and sample E (guinea corn bar) as the highest. This result is lower than the findings of Nathalia *et al*. (2013) who reported a value of 11.85% for cereal bar produced from roasted baru nuts, apple and papaya. The low moisture content of these products indicates an extended storability and shelf life. Water is present in virtually all foods, and it is important for a number of chemical and microbial activities.

Table 1. Recipe for the production of cereal bars.

Ingredients	Quantities	
	Standard cereal bar	Alternative cereal bar
Rolled oat	100 g	-
Yellow maize	-	100 g
White maize	-	100 g
Millet	-	100 g
Guinea corn	-	100 g
	Muesli (chopped nuts and dried fruits)	
Raisin	25 g	25 g
Fig	25 g	-
Date	-	25 g
Walnut	25 g	-
Cashew nut	-	25 g
Almond	25 g	-
Groundnut	-	25 g
Coconut	25 g	25 g
Sesame seed	50 g	50 g
Honey	15 ml	15 ml
Seed oil	15 ml	15 ml
Water	250 ml	250 ml

Source: George *et al*. (2008).

Table 2. Sensory evaluation result of cereal bars samples.

Sample	Colour	Taste	Aroma	Texture	Overall acceptability
A	6.40^{c}	6.30^{c}	6.10^{b}	6.40^{b}	6.70^{b}
B	7.10^{a}	6.70^{b}	6.00^{b}	6.20^{b}	6.70^{b}
C	7.05^{b}	7.10^{a}	6.70^{a}	7.20^{a}	7.50^{a}
D	5.20^{c}	5.60^{d}	5.60^{c}	5.60^{c}	6.05^{b}
E	5.70^{d}	6.00^{c}	6.10^{b}	5.60^{c}	6.30^{b}

Means with the same superscript in the same column are not significantly different (P≥ 0.05). Key: A = Oat bar (control); B = white maize bar; C = yellow maize bar; D = millet bar; E = guinea corn bar.

Table 3. Proximate composition result of cereal bar samples.

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Carbohydrate (%)	Total energy (Kcal)
A	$5.09^{c} \pm 0.05$	$1.64^{b} \pm 0.04$	$29.4^{a} \pm 0.34$	$21.3^{b} \pm 0.42$	$3.89^{d} \pm 0.05$	$38.8^{b} \pm 0.70$	505.0 ± 0.01
B	$6.77^{a} \pm 0.06$	$1.64^{b} \pm 0.05$	$23.3^{d} \pm 0.73$	$21.7^{b} \pm 0.00$	$5.44^{c} \pm 0.11$	$41.4^{a} \pm 0.78$	462.1 ± 0.00
C	$5.46^{c} \pm 0.02$	$1.54^{c} \pm 0.05$	$26.1^{b} \pm 0.32$	$21.9^{b} \pm 0.85$	$5.86^{b} \pm 0.06$	$39.1^{b} \pm 0.41$	478.9 ± 0.02
D	$6.16^{b} \pm 0.08$	$1.54^{c} \pm 0.05$	$23.8^{d} \pm 0.26$	$21.6^{b} \pm 0.00$	$6.08^{a} \pm 0.10$	$38.5^{b} \pm 0.61$	452.6 ± 0.01
E	$6.78^{a} \pm 0.04$	$1.90^{a} \pm 0.10$	$24.8^{c} \pm 0.79$	$23.9^{a} \pm 0.43$	$5.95^{b} \pm 0.05$	$36.6^{c} \pm 1.12^{c}$	465.2 ± 0.01

Means with the same superscript in the same column are not significantly different (P ≥ 0.05). Key: A = Oat bar (control); B = white maize bar; C = yellow maize bar; D = millet bar; E = guinea corn bar.

Moisture determination is one of the most common tests in foods since the water content in foods has an important relationship between conservation and the chemical, physical and microbiological changes during storage (Sampaio *et al*., 2009).

Ash content ranged between 1.54 and 1.90% with sample C and D (yellow maize and millet bars) as the least and sample E (guinea corn bar) as the highest. This is in close agreement with the findings of Nathalia *et al*. (2013) with a value of 2.09 for cereal bar produced from

Table 4. Mineral (mg/kg) assay result of cereal bar samples.

Sample	Potassium	Calcium	Phosphorus	Magnesium	Zinc
A	18.94 ± 0.10	42.01 ± 0.12	7.16 ± 0.00	22.82 ± 0.00	9.44 ± 0.01
B	15.91 ± 0.20	52.89 ± 2.39	8.01 ± 0.00	19.36 ± 0.00	12.32 ± 0.01
C	10.08 ± 0.04	38.47 ± 0.08	6.60 ± 0.00	27.78 ± 0.00	6.98 ± 0.00
D	13.86 ± 0.19	59.93 ± 0.18	6.10 ± 0.00	22.24 ± 0.00	9.85 ± 0.00
E	16.30 ± 0.10	46.70 ± 0.12	5.70 ± 0.00	12.88 ± 0.00	6.17 ± 0.12

Key: A = Oat bar (control); B = white maize bar; C = yellow maize bar; D = millet bar; E = guinea corn bar.

roasted baru nuts, apple and papaya. The percentage ash of a sample gives an idea on the inorganic content of the samples from where the mineral content could be obtained. Sample with high ash contents is expected to have high concentration of various mineral elements, which are expected to speed up metabolic processes, improve growth and development.

Fat content ranged between 29.38 and 23.27% with sample B (yellow maize bar) as the least and sample A (oat bar) the as highest. Result of fat in the present study is higher than the findings of Nathalia *et al*. (2013) with a value of 14.55% for cereal bar produced from roasted baru nuts, apple and papaya. All the cereal bars analyzed showed significantly high levels of fat, which explains why this kind of food is so high in calories. This large difference may be related to the inevitable varying composition of the raw materials.

Protein content ranged between 21.28 and 23.96% with sample A (oat bar) as the least and sample E (guinea corn bar) as the highest. This result is higher than the findings of Nathalia *et al*. (2013) with a value of 9.91% for cereal bar produced from roasted baru nuts, apple and papaya, while fiber content ranged from 3.89 and 6.08% with sample A (oat bar) as the least and sample D (millet bar) as the highest.

The fiber content in this study is lower than the findings of Nathalia *et al*. (2013) with a value of 8.97 to 9.16% for cereal bar produced from roasted baru nuts, apple and papaya. The importance of fiber intake is largely due to its physiological effects that have beneficial health implications (Tosh and Yada, 2010). Dietary fiber presence in food is of great interest for health (Menezes *et al*., 2009; Lee *et al*., 2008).

Total available carbohydrate (TAC) content of cereal bars ranged between 36.64 and 41.42% with sample E (guinea corn bar) as the least and sample B (white maize bar) as the highest. This result is lower than the findings of Nathalia *et al*. (2013) with a value of 61.61% for cereal bar produced from roasted baru nuts, apple and papaya. The maximum total available carbohydrate content of the snack is found to be 41.42%. The sample would not be considered as potential source of carbohydrate when compared to the content of some conventional sources like cereals with 72 to 90 g/100g Carbohydrate (Adewusi *et al*., 1993).

Energy value of cereal bar ranged between 452.6 and 505.2kcal which is higher than the findings of Nathalia *et al*. (2013) with a value of 416.99% for cereal bar produced from roasted baru nuts, apple and papaya.

Mineral analysis

According to the Brazilian Legislation, foods containing at least 15% of daily recommended intake (DRI) per 100 g of a given mineral can be considered a mineral source (BRASIL, 1998).

Table 4 show the mineral assay of cereal bar prepared from three different cereal varieties namely oat, white maize, yellow maize, millet and guinea corn. Potassium ranged between 10.03 and 18.94 mg/kg with sample C (yellow maize bar) as the least and sample A (oat bar) as the highest, while calcium ranged between 38.47 and 59.93 mg/kg with sample C (yellow maize bar) as the least and sample D (millet bar) as the highest. Calcium consumption is generally very low in most populations considering the recommended values. Phosphorus ranged between 6.10 and 8.01 mg/kg with sample D (millet bar) as the least and sample A (oat bar) as the highest. Phosphorus is an important element in every cell of the body because it is part of cell membranes and bone. Magnesium content ranged between 12.88 and 27.78 mg/kg with sample E (guinea corn bar) as the least and sample C (yellow maize bar) as the highest. Magnesium is present in almost all foods; consequently, a varied diet should provide the RDA for magnesium (Jodral-Segado *et al*., 2003)

Zinc ranged between 6.17 and 12.34 mg/kg. The highest zinc content was found in sample B (white maize bar) and the lowest in sample E (guinea corn bar). The result obtained from this study is lower than the findings of Rafiu *et al*. (2014). Campos-Vega *et al*. (2010) observed that there is a direct correlation between the dietary copper and zinc ratio and the incidence of cardiovascular disease. Zinc deficiency in humans is recognized as a public health problem of global proportions (Ramirez-Cardenas *et al*., 2010).

Lipid profile

Fatty acids represent a substantial part of lipids in human

Table 5. Lipid profile result of cereal bar samples.

Sample	Linoleic (%)	Linolenic (%)	Eicosarienoic (%)	Arachidonic (%)	Docosahexanoic (%)	Oleic (%)	Erucic (%)
A	-	-	-	-	-	11.68 ± 0.01	20.47 ± 0.01
B	2.11 ± 0.01	8.99 ± 0.02	-	4.50 ± 0.01	-	2.57 ± 0.00	2.75 ± 0.01
C	3.26 ± 0.01	-	-	4.16 ± 0.02	-	2.85 ± 0.00	3.11 ± 0.01
D	3.41 ± 0.01	6.14 ± 0.03	4.68 ± 0.00	5.68 ± 0.01	-	1.64 ± 0.01	6.03 ± 0.01
E	4.00 ± 0.00	7.37 ± 0.01	6.51 ± 0.00	6.51 ± 0.01	1.00 ± 0.00	2.25 ± 0.01	3.66 ± 0.00

Key: A = Oat bar (control); B = white maize bar; C = yellow maize bar; D = millet bar; E = guinea corn bar.

body and are important sources of energy. Considering that fat is the nutrient that provides the major caloric value and are integral part of all most all foods, natural and processed, it is important to know the fatty acid profile of a snack food like cereal bar, since a high intake of saturated fats contributes to the development of coronary heart disease, and trans fatty acids have also been associated with adverse effects, such as raising low density lipoprotein cholesterol (LDL) and lowering high density lipoprotein cholesterol (HDL) (Martin *et al*., 2005; Tavella *et al*., 2000).

Table 5 show the lipid profile of cereal bar prepared from different cereals namely oat, white maize, yellow maize, millet and guinea corn.

Linoleic acid ranged between 2.11 and 4.00% with sample B (white maize bar) as the least and sample E (guinea corn bar) as the highest while linolenic acid ranged between 6.14 and 8.99% with sample D (millet bar) as the least and sample B (white maize bar) as the highest. Two main fatty acids essential in the diet are linoleic (or omega6) fatty acid and alphalinolenic (or omega3) acid. Both of them are polyunsaturated fatty acid and have been detected in the alternative cereal bars, but not found in the control.

Arachiodonic acid ranged between 4.16 and 6.51% with sample C (yellow maize bar) as the least and sample E (guinea corn bar) as the highest. The three fatty acids above, namely linoleic, linolenic and arachiodonic acids were not detected in the oat containing sample which is the control.

Eicosarienoic acid ranged between 4.68 and 6.51% with sample D (millet bar) as the least and sample E (guinea corn bar) as the highest. This fatty acid was not detected in oat and maize containing samples.

Sample E (guinea corn bar) was the only sample that contained 1.00% docosahexanoic acid.

Oleic acid ranged between 1.64 and 11.68% with sample D (millet bar) having the lowest and the control sample A (oat bar) having the highest.

Erucic acid ranged between 2.75% in sample B (white maize bar) to 20.47% in the control sample A (oat bar). Erucic acid is a monounsaturated omega-9 fatty acid. Amy (2004) reported that studies done on laboratory animals showed that erucic acid appeared to have toxic effects on the heart at high enough doses. This finding necessitates the moving away from oils with high levels of erucic acid and tolerance levels for human exposure to erucic acid have been established based on the animal studies (Food Standards Australia New Zealand, 2003; The Commission of the European Communities, 1980).

The result obtained from this study is higher than the findings of Nathalia *et al*. (2013). Linoleic, linolenic, arachidonic and eicosatrienoic fatty acids are unsaturated fatty acids that have positive health implication over saturated oleic and erucic acids. The levels of the different saturated (*trans)* and unsaturated (cis) fatty acids were determined in this study, with results showing high intake of saturated fats such as oleic and erucic acids which have implications for heart related diseases.

CONCLUSION

Result from the study has shown that cereal bars produced from locally available and cheap cereal like maize, millet or guinea corn and dried nuts/dried fruits were of acceptable quality, without altering the sensory attributes of the bars.

Cereal bars produced possess all advantages of muesli, plus the benefit of sesame seed. The alternative cereal bars are high in unsaturated fatty acids and in protein of high biological value as well as minerals.

From the results obtained in this study, it can be concluded that the use of local raw materials as ingredients for cereal bar production improved the nutritional values of this snack food. The developed cereal bar can be considered a healthier alternative to several high carbohydrates (wheat) based snacks, as it has the potential to supply energy and nutrient in a compact and digestible manner and also useful to prevent heart and artery diseases and invigorate the nervous system due to the unsaturated nature of the lipid in the products

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