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Mineral Bioavailability, Physico-Chemical and Sensory Properties of Granola Produced from Different Cereals and Processing Methods

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Abstract Twelve breakfast cereals were formulated. Eight of them were baked with four samples having sugar and four with date fruit as sugar replacer, while the last four extruded. Yellow maize granola with sugar was used as control. The samples were subjected to sensory, chemical and functional analysis as well as mineral bioavailability. Sensory analysis showed a significant difference ($p \leq 0.05$) in color, taste, flavor, texture and overall acceptability for baked product while for extruded samples; there was a significant difference in color, taste and flavor with no significant difference ($p \geq 0.05$) in texture and overall acceptability. Samples produced with date showed an increase in the ash, fat, protein and energy contents with a decrease in moisture content except the maize products which showed a decrease in their fat contents. The result also showed that the extrusion process increased crude fiber, carbohydrate and starch with very low fat and moisture content, with a reverse in the sugar baked granola. Functional analysis of the samples showed an increase in swelling power and water absorption capacity with the date baked granola, but not statistically different ($p \geq 0.05$). Mineral analysis using Atomic Absorption Spectrophotometer (AAS) investigated calcium, sodium, iron, magnesium and potassium as well as bioavailability of minerals studied using Pepsin and Pancreatin enzymes in an in–vitro digestion method. The products were high in calcium, sodium and potassium and very low in iron. However not all the minerals detected were bioavailable. A mineral range of 87.36 - 91.29% and 87.04 - 88.13% of sodium and potassium were available in soluble forms in sugar baked granola, while 69.93 - 73.38% and 87.04 - 88.13% of sodium and potassium in date containing products and a decrease of 46.85 - 70.50% and 73.02 - 90.25% for sodium and potassium in extruded products. This study showed that the production of granola from locally available cereals and inclusion of date fruit gave a desirable product with improved nutritional values.

Keywords: *granola, cereals, processing method, physico-chemical, mineral bioavailability, sensory*

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1. Introduction

The perception of food has changed tremendously as a result of technological advancement and increased nutritional awareness. There is a demand for convenient and ready to eat foods by most consumers which add bulk and satiety to their appetite [1]. The need for food has transcended to foods enriched with dietary fibre and micronutrients which aid in some physiological reductions such as cholesterol, blood sugar level and improved colonic health [2].

Breakfast cereals are ready to eat foods made from cereal grains like rice, wheat, maize and Oat [1]. Granola a breakfast cereal, is basically known to be made from oats, walnut, peanut and wheat [3] but other locally available materials such as maize, millet and guinea corn have been used in its production and has shown to be rich in carbohydrates, dietary fibre, low fat, protein and varying amounts of minerals such as calcium, magnesium, potassium and iron [2,3].

There is an increased consumer awareness towards less sugar consumption or sugar free foods and as a result some natural alternatives have been made available as sugar replacers in foods namely; raw honey, brown rice syrup, corn syrup, molasses, date palm [4,5].

Date fruit locally known as "Debino" in Hausa language of Nigeria, has been used to replace sugar in so many food products like bread, cake and cookies [5,6]. The wide use of dates in food may be attributed to its richness in carbohydrates in form of sugars, dietary fibre, proteins, vitamins mainly A, B_1 and B_2,, abundant minerals like iron, potassium, calcium, chlorine, magnesium [5] as well as its low glycemic index that reduces carbohydrates digestion and absorption, remedies for hangovers and alcoholic intoxication as well as its benefits during pregnancy and childbirth [7,8].

Granola an unpopular breakfast cereal has been found to contain some minerals namely: calcium, potassium, sodium, magnesium, iron, zinc copper and phosphorus [9]. Its production has seen many declines in consumption over the years but gained popularity since the invention of granola bar due to its increased health benefit, convenience, delicious taste and versatility in various meals [10]. Bioavailability of mineral can be seen as the proportion of mineral intake capable of being absorbed through the intestine and made available either for metabolic use or storage [11]. The mineral bioavailability of some foods has been evaluated using the *In-vitro* digestibility method developed by Elles *et al.*, [12], Kiin-Kabari *et al.* [13].

Processing methods has shown to have an effect on the bioavailability of nutrients in food. The use of high temperature short time extrusion cooking has been used in the production of breakfast cereals and snack foods [1,14] and as such was used in this study in the production of granola and compared with conventional baking method. There is little or no information on the effect of date inclusion, processing and bioavailability of minerals in granola or related products; therefore, the objectives of this work are.

To prepare and evaluate the effect of date meal inclusion as a sugar replacer and processing methods on the chemical and sensory properties of granola

To determine the percentage soluble fraction (bioavailability) of minerals present in granola

2. Materials and Methods

2.1. Materials

Maize (*Zea may)*, Millet (*Peniselum glaucum),* Guinea corn (*Sorghum bicolor*)*,* Peanut (*Arachis hypogaea*)*,* Coconut (*Cocus nucifera),* Wheat (*Triticum spp), Dates* (*Phoenix dactylifera*)*,* Milk, Sugar, Vegetable oil and Vanilla flavor were purchased from Mile 3 Market in Port Harcourt, Rivers State Nigeria.

2.2. Chemicals

All chemicals used for this work were of analytical grade and obtained from the Department of Food Science and Technology Laboratories, Rivers State University, Port Harcourt

2.3. Methods

2.3.1. Preparation of Cereal Whole Meals

Cereal grains such as Maize (yellow and white), Guinea corn and Millet were sorted to remove impurities, cleaned, winnowed and the grains milled using a dry milling machine (M6FFC Grain mill). The meals obtained were then stored in an air-tight container for use in granola production.

2.3.2. Preparation of Date Pulp

The seeds of the date palm fruits were removed and discarded. The pericarp were oven dried at 45°C for 8 hrs and milled using hand milling (M6FFC grain mill) machine [5].

2.4. Composition and Production of Granola

Granola, a cereal based meal were made from 500g each of maize, millet, guinea corn, respectively with coconut (80g), peanut (160g), wheat flour (100g), sugar/date (160g), water (200ml), vegetable oil(16ml) and vanilla flavor (4ml) mixed into dough. Part of the dough was rolled, spread on the tray and baked at 130°C for 50 minutes [9], while the other part was subjected to extrusion cooking [15]. The baked and extruded products (granola) were allowed to cool and stored in an airtight container.

2.5. Enzyme Preparation for In-vitro Digestibility

Pepsin Enzyme Solution: 16mg of pepsin, 3.5ml of 0.06N HCl and 1.0g Sodium Chloride was mixed and made up to 100ml with deionized water.

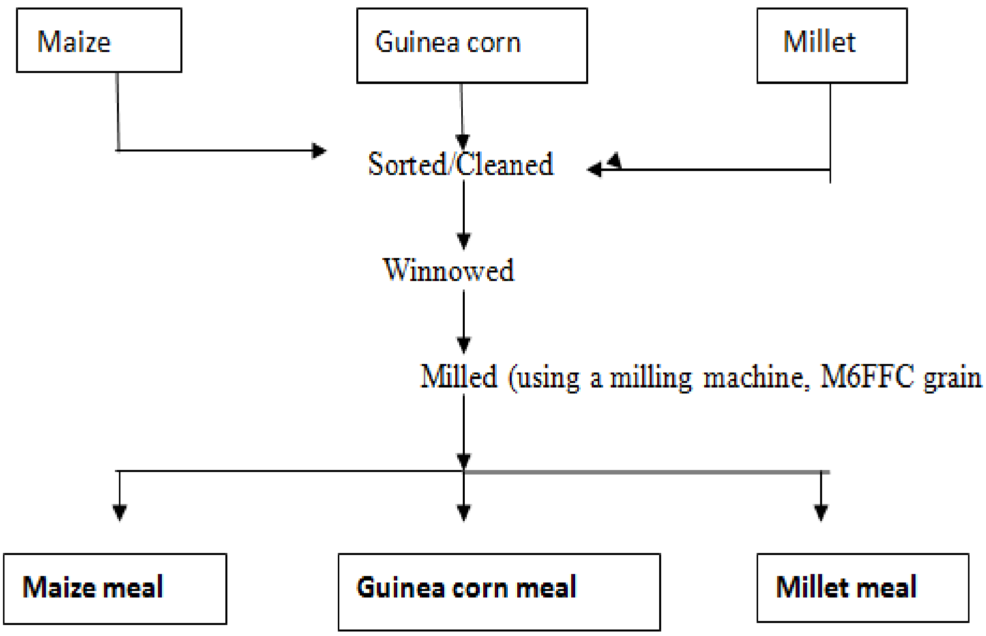

Figure 1. Flowchart for the production of cereal meals (Source: [9])

Pancreatin Enzyme Solution: 1.6g of pancreatin was dissolved in phosphate buffer (P^H 7.5) and made up to 100ml with same buffer solution.

2.6. Sensory Evaluation of Granola

The baked and extruded granola samples were subjected to sensory evaluation. The granola samples were evaluated in milk solution, the form in which it would be consumed and the following parameters assessed for color/appearance, taste, aroma, crispness, texture and overall acceptability, using a 5 point hedonic scale [16]. A total of twenty (20) semi trained panelists drawn from Food Science and technology department who were neither sick nor allergic to any of the raw materials used in the production, were instructed to rinse their mouth with water after tasting each sample.

2.7. Statistical Analysis

Results were statistically analyzed by using analysis of variance technique. Level of significance within means was calculated using the Least Significant Difference and Standard deviation methods.

2.8. Chemical Analysis of Granola Samples

The moisture content of the granola samples was determined using the moisture analyzer (DBS 60-3) at 130^{0}C, while the method described by AOAC [17] was used to determine ash, protein, fat and fibre with carbohydrate calculated by difference. The total energy values of the different samples were determined using the method of Mahgoub [18]. Starch and Sugar was determined by the method of Prapasri *et al*. [19].

2.9. Functional Analysis

Relative bulk density was determined by the method of Narayana and Narasinya [20] while dispersibility was determined by the method of Kulkarni *et al*., [21]. Swelling power and solubility was determined using the method of Takashi and Sieb [22], while water absorption capacity was determined by the method of Sosulski [23].

2.10. Mineral Analysis

2.10.1. Total Mineral

This was done by dry ash method according to AOAC [17] and mineral bioavailability determined using the *in-vitro* enzyme digestion method as described by Ikeda [24].

3. Results and Discussion

3.1. Sensory Evaluation Result of Baked Granola Sample

Table 1 shows the sensory evaluation result of eight baked granola samples produced from two sets of four cereals namely maize(yellow and white), Guinea corn and millet; one set produced with sugar and the other produced with date fruit, all consumed in a given quantity of milk and sugar in the ratio 4:1,weight for weight. Color/Appearance ranged from 2.85 – 6.25 with sample A (yellow maize/sugar) as the highest and sample H (millet/date) as the least. Result of sensory evaluation of baked granola showed that there was significant difference ($p \leq 0.05$) in color between the maize based granola produced with sugar and the non sugar containing samples.

Taste ranged from 2.50 – 4.50 with sample F (white maize/date) as the highest and sample H (millet/date) as the least. Flavor ranged from 2.70 – 4.30 with sample E (yellow maize/date) as the highest and sample H (millet/date) as the least. Texture ranged from 2.45 – 4.30 with sample F (white maize/date) as the highest and sample H (millet/date) as the least. Overall acceptability ranged from 2.70 – 4.45 with samples E and F (yellow and white maize/date) as the highest and sample H (millet/date) as the least.

Taste, Flavor, Texture and Overall acceptability showed significant difference ($p \leq 0.05$) with sample E (yellow maize + date) been the most preferred in taste, flavor and overall acceptability. There was a significant difference ($p \leq 0.05$) in texture between sugar baked products, date baked and extruded samples.

The use of date as sugar replacer showed a decrease in color and texture when compared with the sugar containing samples. This may be due to the brown color, fiber and fat content in the raw date.

Table 1. Sensory Evaluation Result of Baked Granola Samples

Sample	Color	Taste	Flavor	Texture	Overall acceptability
A	6.25^a	3.80^a	3.90^a	5.70^a	3.85^a
B	6.20^a	3.65^a	3.60^a	5.65^a	3.60a
C	6.10^b	4.00^a	3.85^a	5.80^a	3.90a
D	5.75^c	3.35^b	3.35^b	5.50^a	3.35^b
E	4.00^d	3.80^a	4.30^a	4.05^b	4.45^a
F	4.45^d	4.50^a	3.80^a	4.30^b	4.45^a
G	3.15^e	3.00^b	2.85^b	2.85^c	3.05^b
H	2.85^f	2.50^c	2.70^b	2.45^c	2.70^c

Means with the same superscript in the same column are not significantly different ($P \geq 0.05$).

Key: A = Yellow maize / sugar
B = White maize / sugar
C = Guinea corn / sugar
D = Millet / sugar
E = Yellow maize / date
F= White maize / date
G = Guinea corn / date
H = Millet / date.

3.2. Sensory Evaluation Result of Extruded Granola Samples

Table 2 shows the sensory evaluation result of extruded granola samples produced from four different cereals namely; maize(yellow and white), guinea corn and millet with either sugar or date fruit consumed in a given quantity of milk and sugar in the ratio of 4:1,weight for weight. Color/Appearance ranged from 3.35 – 4.05 with sample K (guinea corn/sugar) as the highest and sample I (yellow maize /date) as the least. Taste range Flavor ranged from 3.00 – 4.05 with sample I (yellow maize /date) as the highest and sample L (millet /date) as the least. Texture ranged from 3.00- 3.95 with sample I (yellow maize /date) as the highest and sample L (millet/date) as the least. Overall acceptability ranged from 3.00 -4.15 with sample I (yellow maize/date) as the highest and sample L (millet/date) as the least.

From the sensory evaluation of extruded products, result showed that color, taste, flavor, texture and overall acceptability respectively where significantly different from each other except in texture which showed no significant difference between the samples. In Overall acceptability, samples I, J and K (extruded yellow, white maize and guinea corn) were the most preferred and showed no significant difference ($p \geq 0.05$). Sample I (yellow maize) showed to have the highest value in overall acceptability but least in color. This may be due to Millard reaction (reaction between protein and sugar) or the effect of high temperature on the carotenoid content of yellow maize [25].

3.3. Chemical Composition Result of Granola Samples

Table 3 shows the chemical analysis result of baked and extruded granola samples prepared from four different cereals with either sugar or dates. Moisture content ranged from 2.70 -8.45% with sample F (white maize /date-baked) as the highest and sample J (white maize/sugar-extruded) as the least. Moisture content ranged from 6.65 -7.15%, 4.50 – 8.45% and 2.70 -3.55% for the sugar baked granola, date baked granola and extruded granola, respectively with a significant difference between them ($p \leq 0.05$).The moisture content of sugar baked granola is slightly higher than the finding of Eke-Ejiofor *et al* [9] with values ranging 5.65 – 6.75%. The date baked granola is less than the findings of Agbaje *et al.*, [2] with value of 12.90-18.73% which was produced with puffed glutinous rice and dried Sunnah foods. The substitution of sugar with date in the samples showed lower moisture content when compared with those produced with sugar. This finding disagrees with the finding of Obiegbuna *et al.,* [5] on the moisture content of granulated sugar and date fruit with the value of 3.11 and 6.56%, respectively. Also, the moisture content of the extruded granola is very low due to the little amount of water used in conditioning the feed to about 21-22% moisture content. The low amount of all the granola samples indicates better shelf life as products with less than 12% moisture content have shown to store over a long period without deterioration in color, quality or taste.

Table 2. Sensory Evaluation Result of Extruded Granola Samples

Samples	Color	Taste	Flavor	Texture	Overall acceptability
I	3.35^{c}	4.05^{a}	3.60^{a}	3.95^{a}	4.15^{a}
J	3.90^{a}	3.90^{a}	3.90^{a}	3.90^{a}	3.90^{a}
K	4.05^{a}	3.35^{b}	3.35^{b}	3.55^{a}	3.75^{a}
L	3.60^{b}	3.00^{c}	3.00^{c}	3.00^{a}	3.00^{b}

Means with the same superscript in the same column are not significantly different (P<0.05)
Key: **I** = yellow maize / date extruded
J = white maize / sugar extruded
K = guinea corn /sugar extruded
L= millet / date extruded

Table 3. Chemical Composition (%) Result of Granola Sample

Sample	Moisture	Ash	Fat	Fiber	Protein	CHO	Sugar	Starch(g/100g)	Energy (kcal)
A	7.15^{bc}±0.25	1.07^{d}± 0.21	12.67^{ab}±0.0	7.26^{j} ± 0.00	12.08^{fgh}±0.0	56.4^{h}±30.0	12.45^{i}±0.00	11.20^{j} ±0.00	388.07^{g}±0.00
B	6.90^{bcd}±0.00	1.76 ^{abc}±0.23	10.36^{d} ± 0.13	5.92 ^{k}± 0.01	14.08^{c}±0.02	54.97^{k} ±0.01	13.28 ^{d}±0.00	11.93^{def} ±0.00	369.44^{l}±0.00
C	7.65^{ab}± 0.65	1.44^{bc} ± 0.35	11.80^{b} ±1.03	8.14^{i} ±0.04	12.13^{efg}±0.01	58.81 ^{d}±0.01	12.49^{i} ±0.04	11.25^{i} ±0.01	389.96^{f}±0.00
D	6.65^{cde} ±0.25	1.19^{bc} ± 0.22	10.83^{c} ± 0.32	12.38 ^{c}±0.01	11.7^{i}±0.00	57.15^{e} ± 0.05	14.12 ^{b}±0.00	12.71 ^{b}±0.03	373.07^{k}±0.00
E	6.10^{de} ± 0.40	2.27^{a} ±0.18	12.23^{b} ± 2.64	9.80^{g} ± 0.00	15.17^{b}±0.01	55.51^{j} ±0.00	12.62^{g} ±0.00	11.36^{h} ±0.00	392.79^{e}±0.00
F	8.45^{a} ± 0.25	1.93^{abc}±0.24	13.78^{ab} ± 0.04	11.8 ^{d}± 0.00	13.72^{d}±0.02	56.19 ^{i}±0.01	13.90 ^{f}±0.02	12.51^{c}±0.02	403.66^{d}±0.00
G	4.50^{f} ± 0.00	1.53^{bc} ±0.46	16.36^{a} ± 1.06	8.47^{h} ± 0.00	12.32^{ef}±0.02	56.83 ^{g}±0.00	12.9 ^{ci}±30.00	11.63^{g} ±0.01	423.84^{a}±0.00
H	5.10 ^{f}± 0.30	2.01^{ab}±0.69	15.07^{ab} ± 0.29	10.54^{e} ±0.01	16.66^{a}±0.01	50.64^{l} ±0.00	14.5^{a} ±10.01	13.06 ^{a}±0.01	404.83^{c}±0.00
I	3.20^{g} ±0.10	1.71^{abc} ±0.48	11.42^{b} ± 0.42	14.19^{a}±0.01	12.45^{e}±0.00	57.05^{f} ±0.00	13.18^{e} ±0.01	12.06^{e} ±0.18	380.78^{j}±0.00
J	2.70^{g} ±0.00	1.61^{abc} ±0.38	10.01^{e} ± 0.20	12.74^{b} ±0.01	9.65 ^{j}±0.35	63.66^{a} ±0.00	12.59^{gh} ±0.00	12.59^{bcd}±0.00	383.88^{i}±0.00
K	2.85^{g}±0.15	1.60^{abc} ± 0.36	11.30 ^{b}± 1.20	9.97^{f} ±0.00	11.62^{i}±0.00	59.61^{c} ±0.01	12.0^{j}+0.00	12.04^{ef} ±0.00	386.62^{h}±0.00
L	3.55^{g}±0.05	1.47^{bc} ±0.61	13.56^{ab} ± 3.10	10.00^{f} ±0.00	11.92^{ghi}±0.02	62.48^{b} ±0.00	12.6^{gh}+0.01	12.61^{bc} ±0.01	419.64±^{b}0.00

Means with same superscript in the same column are not significantly different (P<0.05)
Key: A= yellow maize/sugar baked, B= white maize/sugar baked, C= Guinea corn/sugar baked, D = Millet / sugar baked,
E = Yellow maize / date baked, F= White maize / date baked, G = Guinea corn / date baked, H = Millet/date baked,
I= yellow maize/date extruded, J= white maize/sugar extruded, K= Guinea corn/sugar extruded, L = millet/ date extruded
M.C = Moisture content, **CHO** = Carbohydrate.

Ash content ranged from 1.07 – 2.27% with sample A (yellow maize/sugar-baked) as the highest and sample E (yellow maize/date-baked) as the highest. Fat content ranged from 10.01 – 16.36% with sample G (millet/date-baked) as the highest and sample J (white maize / sugar-extruded) as the least. The ash content ranging from 1.07 -1.76% for sugar baked granola samples (samples A –D) is higher than the finding of Eke –Ejiofor and Beleya [9]. The date baked granola had ash content ranging from 1.53 – 2.27% which agrees to the finding of Agbaje *et al.*, [2] with puffed glutinous rice and dried sunnah foods. It also agrees with the ash content of date fruit pulp reported by *Obiegbuna et al.,* [5]. The ash content of the extruded granola ranging from 1.47-1.71% is less than the findings of Sushil *et al.,* (2016) on extruded snacks and the difference may be due to the different recipes used as well as the cereal which is the carbohydrate source in the production. This study showed that the incorporation of date increased the ash content of the granola with significant difference ($p \leq 0.05$) between the samples.

Fat content of granola ranged from 10.36 – 12.67%, 12.23 – 16.36% and 10.01 -13.56% for the sugar baked, date baked and extruded granola, respectively with significant difference between the samples ($p \leq 0.05$). The sugar baked granola had fat content less than the findings of Eke-Ejiofor and Beleya [9] which ranged from 13.45-16.09%, but higher than that reported by Agbaje *et al.,* [2]. This difference may be traced to the vegetable oil, peanut and coconut used in this study. Furthermore, this study showed that the use of date increased the fat content of the granola which has shown to be high in unsaturated fat [5].

Crude fiber ranged from 5.92 – 14.19% with sample I (yellow maize /date-extruded) as the highest and sample B (white maize /sugar-baked) as the least. Crude fibre content ranging from 5.92 -12.38%, 8.47–11.88% and 9.97-14.19% for the sugar baked, date baked and extruded granola, respectively, showed that the use of date increased the fibre content of the samples with the extruded products showing higher values when compared with the baked products. The extruded products values are higher than the findings of Mohammad *et al* [26] with 2.89% which was extruded with cereals and pulses. This difference may be due to the whole grain and coconut used in the present study as against the flour used in previous research. The samples differ significantly ($p \leq 0.05$).

Protein content ranged from 11.62-16.66% with sample H (millet /date-baked) as the highest and sample K (guinea corn /sugar-extruded) as the least. In agreement with the present results, Obilana and Taylor [27] reported that millets has been found to be of more nutritional value than most cereals because of their high level of proteins in terms of amino acids such as methionine, cystine and other vital amino acids necessary for human health. Protein content ranged from 11.75 – 14.08%, 12.32 -16.66% and 9.65 – 12.45% for the sugar baked, date baked and extruded samples, respectively. The samples differ significantly ($p \leq 0.05$). The protein content of the sugar baked granola in the present study is higher than the findings of Eke –Ejiofor and Beleya [9] except for the oat based granola (12.45%) that corresponds to the present study. The date baked samples are in agreement with the findings of Sushil *et al*., [1] with sample H (baked millet + date) as the highest. The protein content of the extruded samples is in agreement with the finding of Mohammad *et al*., [15] with values of 11.00 -15.15%. Sample I (extruded yellow maize) was the most preferred. There was significant difference between the samples. The use of date as sugar replacer increased the protein content of the granola samples with the exception of sample F showing a reverse trend. Also, extrusion process of granola showed a decrease in the protein content of the granola samples except sample L which showed a reverse trend when compared to the sugar baked samples. This decrease in the protein content of the granola samples may be attributed to the denaturation effect of heat on the samples.

Carbohydrate ranged from 54.97-63.66% with sample J (white maize /sugar-extruded) as the highest and B (white maize /sugar-baked) as the least. Carbohydrate content ranged from 54.97 – 58.81%, 50.64 – 56.83% and 57.05 - 63.66% for the sugar baked, date baked and extruded samples, respectively. The result showed a higher carbohydrate content in sugar baked than in date baked granola. This agrees with the finding of Obiegbua *et al*., [5] on the carbohydrate content of granulated sugar (95.88%) being higher than that of date fruit (79.44%). An increase in carbohydrate content was shown with the extruded samples when compared to the sugar baked regardless of date or sugar used. The samples showed a significant difference ($p \leq 0.05$)

Sugar content ranged from 12.04- 14.51% with sample H (millet /date-baked) as the highest and sample K (guinea corn / sugar-extruded) as the least. Total sugar content ranged from 12.45 -13.28%, 12.62 – 14.51% and 12.04-13.18% for the sugar baked, date baked and extruded granola, respectively. The samples showed a significant difference, while starch ranged from 11.20-13.06g/100g with sample A (yellow maize/sugar-baked) as the least and sample H (millet/date-baked) as the highest. Starch content ranged from 11.20-12.71g/100g, 11.36-13.06 g/100g and 12.04 -12.61 g/100g for the sugar baked, date baked and extruded granola, respectively. Date inclusion in the baked samples showed an increase in the dietary starch content. Dietary starch otherwise known as resistant starch in foods helps with appetite suppression and reduces risks associated with diabetes and colon cancer [28].

Energy content ranged from 369.44 – 419.64 kcal with sample G (guinea corn/date-baked) as the least and sample H (millet/date-baked) as the highest. This is less than the finding of Eke –Ejiofor and Beleya [9] with 448 kcal. The energy content of the date baked is less than the findings of Agbaje *et al.,* [2] with 379.80 kcal which may be a reflection of the cereal material used. The energy content increased with the addition of date in baked samples than the sugar baked samples as well as a higher energy value observed in extruded granola when compared with the findings of Mohammad *et al.,* [15] with 347.80 kcal. There was significance difference between the samples ($p \leq 0.05$).

3.4. Functional Analysis Result of Granola Samples

Table 4 shows the functional properties of baked and extruded granola samples produced with sugar and date. Dispersibility ranged from 73.75 -80.25% with sample I (extruded yellow maize) as the highest and sample G and

H (date baked guinea corn and millet, respectively) as the least. There was significant difference ($P \leq 0.05$) between the samples. Dispersibility shows the ease of separation of sample mass which allows particles to sink below the surface and disperse rapidly in liquid [29]. Kulkarni *et al.,* [21] reported that the higher the dispersibility of a starch based product, the better the starch reconstitutes in water.

Solubility ranged from 19.51 – 28.18% with samples A (sugar-baked yellow maize) as the least and J (white maize / sugar-extruded) as the highest. There was significant difference ($P \leq 0.05$) between the samples. Solubility shows the extent of Intermolecular cross bonding within the granules [30].

Swelling power ranged from 4.37 – 5.28g/g with samples K (guinea corn /sugar-extruded) as the highest and L (millet/date-extruded) as the least. Swelling power ranging from 4.37 -5.28 g/g agrees with the finding of Eke –Ejiofor *et al.*, [9] who reported a value of 4.57- 5.89 g/g in an earlier study of granola. Sample K (extruded guinea corn) was the highest. There was significant difference between the samples ($p \leq 0.05$). Swelling capacity is a function of the product to rise when having interaction with water [9].

Water absorption capacity ranged from 0.97 -1.95 g/g with sample A (sugar baked yellow maize) as the least and sample H (date baked millet granola) as the highest. The study showed a significant difference ($p \leq 0.05$) between the samples. The date baked granola had higher water absorption than the sugar baked and extruded granola products. This may be due as a result of the high fiber content of date fruit. Water absorption helps in bulking and consistency of products and an increase in food systems enables end users to manipulate the functional properties of the dough in bakery products [9].

Bulk density ranged from 0.12 - 0.27g/ml with sample K (guinea corn /sugar-extruded) as the least and sample I (yellow maize /date-extruded) as the highest. This result agrees with the work of Mohammad *et al.*, [15]. There was a significant difference ($p \leq 0.05$) between the samples. Bulk density helps in packaging and material handling since a high bulk density gives room for higher amount of material occupying a smaller volume [31].

Table 4. Functional Properties (%) Result of Granola Samples

Samples	Dispersibility (%)	Solubility (%)	Swelling Power(g/g)	Water Absorption (g/g)	Bulk Density (g/ml)
A	$75.75^{d} \pm 0.00$	$19.51^{l} \pm 0.00$	$4.43^{ab} \pm 0.00$	$0.97^{b} \pm 0.00$	$0.21^{e} \pm 0.00$
B	$75.25^{de} \pm 0.25$	$20.42^{k} \pm 1.60$	$4.70^{ab} \pm 0.06$	$1.77^{a} \pm 0.51$	$0.21^{e} \pm 0.00$
C	$77.00^{c} \pm 0.00$	$25.16^{c} \pm 2.41$	$4.49^{ab} \pm 0.16$	$1.66^{ab} \pm 0.59$	$0.19^{f} \pm 0.00$
D	$75.75^{d} \pm 0.25$	$25.33^{b} \pm 1.34$	$4.61^{ab} \pm 0.24$	$1.75^{a} \pm 0.55$	$0.21^{e} \pm 0.00$
E	$74.75^{e} \pm 0.25$	$24.72^{d} \pm 0.43$	$5.02^{ab} \pm 0.25$	$1.89^{a} \pm 0.72$	$0.18^{g} \pm 0.00$
F	$79.75^{abc} \pm 0.25$	$22.73^{h} \pm 0.44$	$4.91^{ab} \pm 0.21$	$1.90^{a} \pm 0.63$	$0.23^{d} \pm 0.00$
G	$73.75^{f} \pm 0.25$	$24.43^{f} \pm 2.86$	$4.75^{ab} \pm 0.37$	$1.94^{a} \pm 0,52$	$0.22^{e} \pm 0.00$
H	$73.75^{f} \pm 0.25$	$21.95^{j} \pm 0.40$	$4.59^{ab} \pm 0.06$	$1.95^{a} \pm 0.57$	$0.26^{b} \pm 0.02$
I	$80.25^{a} \pm 0.25$	$24.69^{e} \pm 1.71$	$4.47^{ab} \pm 0.17$	$1.65^{ab} \pm 0.60$	$0.27^{a} \pm 0.02$
J	$80.00^{b} \pm 0.00$	$28.18^{a} \pm 1.45$	$4.69^{ab} \pm 0.15$	$1.49^{ab} \pm 0.58$	$0.23^{d} \pm 0.00$
K	$75.75^{d} \pm 0.25$	$22.31^{i} \pm 1.38$	$5.28^{a} \pm 0.04$	$1.70^{ab} \pm 0.62$	$0.12^{h} \pm 0.01$
L	$75.75^{d} \pm 0.25$	$24.10^{j} \pm 1.09$	$4.37^{b} \pm 0.83$	$1.70^{ab} \pm 0.69$	$0.25^{c} \pm 0.00$

Means with the same superscript in the same column are not significantly different ($P < 0.05$)

Key**:**

A= yellow maize/sugar baked, B= white maize/sugar baked, C= Guinea corn/sugar baked,
D = Millet / sugar baked, E = Yellow maize / date baked, F= White maize / date baked,
G = Guinea corn / date baked, H = Millet / date baked, I= yellow maize/date extruded,
J= white maize/sugar extruded, K= Guinea corn/sugar extruded, L = millet/ date extruded.

Table 5. Mineral Composition (mg/100g) of Granola Samples

Sample	Calcium (Ca)	Iron (Fe)	Sodium (Na)	Potassium (K)	Magnesium (Mg)
A	$2,273^{a} \pm 0.00$	$7.79^{f} \pm 0.00$	$298.90^{e} \pm 0.00$	$553.00^{e} \pm 0.00$	$257.77^{e} \pm 0.00$
E	$1462^{e} \pm 0.00$	$12.62^{d} \pm 0.00$	$538.73^{b} \pm 0.00$	$701.86^{b} \pm 0.00$	$306.12^{b} \pm 0.00$
I	$1978^{b} \pm 0.00$	$16.50^{c} \pm 0.00$	$540.24^{a} \pm 0.00$	$740.29^{a} \pm 0.00$	$251.74^{f} \pm 0.00$
C	$1528^{d} \pm 0.00$	$12.02^{d} \pm 0.00$	$298.98^{e} \pm 0.00$	$655.74^{c} \pm 0.00$	$308.52^{a} \pm 0.00$
G	$1880^{c} \pm 0.00$	$17.16^{b} \pm 0.00$	$392.44^{c} \pm 0.00$	$664.98^{d} \pm 0.00$	$296.46^{d} \pm 0.00$
K	$505^{f} \pm 0.00$	$21.50^{a} \pm 0.00$	$329.92^{d} \pm 0.00$	$569.48^{f} \pm 0.00$	$301.09^{c} \pm 0.00$

Means with the same superscript in the same are not significantly different ((P<0.05

Key **:** **A** =Baked Yellow maize/sugar, **E** = Baked Yellow maize/date, **I** =Extruded Yellow maize/date, **C** = Baked Guinea corn / sugar, **G** = Baked Guinea corn / date
K = Extruded Guinea corn/sugar.

3.5. Mineral Content (mg/100g) of Granola Samples

Table 5 shows the total mineral composition of six granola samples produced from yellow maize, guinea corn, date or sugar with different processing methods. Calcium (Ca) content ranged from 505 - 2,273 mg/100g with sample K (extruded guinea corn) as the least and sample A (sugar baked yellow maize) as the highest. There was significant difference ($p \leq 0.05$) between the samples. This difference in value may be due to the different cereals and processing methods used in the production. Calcium plays a role in most body metabolic processes and provides rigidity to the skeleton [9]. Maize contain high amount of phosphorus, potassium and magnesium but low in calcium, sodium, zinc etc [32]. This finding corresponds to the work of Matilda *et al*. [33] who proposed that cereals are poor in zinc and calcium. Processing and milling of maize can reduce or remove most of these minerals through the removal of bran.

Iron content (Fe) of samples ranged from 7.79 – 21.50 mg/100g with sample A (Sugar baked yellow maize) as the least and sample K (extruded guinea corn) as the highest. The extruded samples (I and K) had higher iron content than the baked samples. The samples differed significantly ($p \leq 0.05$). Iron is important in haemoglobin formation, oxygen and electron transport in the human body (Kalagbor and Diri, 2014)[34]. The Iron content in this study is less than the maximum limit of iron concentration in food given by FAO/WHO [35] which is 42.5 mg/100g. Also the iron in this study corresponds to the Recommended Daily Allowance (RDA) of iron 15mg/day for females 14-18 years and 11mg/day for males 14-18 years [36].

Sodium (Na) content ranged from 298.90 - 540.24 mg/100g samples A (sugar baked yellow maize) as the least and sample I (extruded yellow maize) as the highest with significant difference between the samples ($p \leq 0.05$). Sodium is the major cation in extracellular fluid in the body and necessary for maintenance of plasma volume, acid-base balance, normal cell function and transmission of nerve impulse [9].

Potassium ranged from 416 – 702mg/100g with sample E (yellow maize / date-baked) as the highest and sample K (guinea corn / sugar-extruded) as the least. Potassium (K) content ranged from 553.00 - 740.29 mg/100g with sample I (extruded yellow maize) as the highest. The was significant difference ($p \leq 0.05$) amongst the samples. Potassium is a major nutrient for the maintenance of total body fluid volume, acid and electrolyte balance [36].

Magnesium (Mg) content ranged from 251.74 – 308.52 mg/100g with sample I (extruded yellow maize) as the least and sample C (Sugar baked guinea corn) as the highest. There was significant difference ($p \leq 0.05$) between the samples.

3.6. Mineral Soluble Fraction (Bioavailability) of Granola Samples

Table 7 shows the percentage soluble fraction of granola. The bioavailability of minerals refers to the proportion of mineral intake capable of being absorbed through the intestine and made available either for metabolic use or storage [11]. Percentage soluble fraction of calcium ranged from 4.70 – 52.76mg/100g with sample A (yellow maize /sugar-baked) as the least and sample K (guinea corn/ sugar-extruded) as the highest. There was significant difference ($p \leq 0.05$) between the samples.

The percentage soluble proportion of iron ranged from 67.63 – 93.09mg/100g with sample C (guinea corn / sugar-baked) as the least and sample I (yellow maize / date-extruded) as the highest. These values represent the proportion of iron released after enzymatic digestion of the samples. An increase in Iron was shown in the extruded products with no significant difference ($p \geq 0.05$) between the samples.

The soluble sodium fraction available for absorption ranged from 46.85 – 91.29mg/100g with sample I (yellow maize/ date-extruded) as the least and sample C (guinea corn / sugar-baked) as the highest. There was significant difference ($p \leq 0.05$) between the samples. Sugar baked granola (A and C) showed to have a higher sodium content than the date baked samples (E and G) with the extruded samples (I and K) having the least.

Potassium soluble fraction ranged from 73.02 -90.25 mg/100g. There was significant difference between the samples ($p \leq 0.05$) with sample K (guinea corn / sugar-extruded) as the least and sample I (extruded yellow maize) as the highest. The study showed a reduction in potassium content with date baked granola (E and G) when compared to the sugar baked samples (A and C).

The percentage soluble fraction and bioavailable magnesium ranged from 10.39 – 30.97mg/100g with sample K (guinea corn / sugar-extruded) as the least and sample G (guinea corn / date-baked) as the highest. The study showed date baked granola (E and G) to have higher magnesium content than the others. The samples were statistically different from each other in term of the mineral content.

Table 6. Digested Fraction (Mineral) (mg/100g) Result after Invitro Digestion

Sample	Calcium	Iron	Sodium	Potassium	Magnesium
A	$106.94^{f} \pm 0.00$	$5.28^{f} \pm 0.00$	$261.13^{d} \pm 0.00$	$481.38^{e} \pm 0.00$	$30.85^{f} \pm 0.00$
E	$284.78^{a} \pm 0.00$	$10.53^{d} \pm 0.00$	$376.75^{a} \pm 0.00$	$594.88^{c} \pm 0.00$	$49.11^{c} \pm 0.00$
I	$274.90^{b} \pm 0.00$	$15.36^{a} \pm 0.00$	$253.12^{e} \pm 0.00$	$668.13^{a} \pm 0.00$	$30.98^{e} \pm 0.00$
C	$269.38^{c} \pm 0.00$	$8.13^{e} \pm 0.00$	$272.95^{c} \pm 0.00$	$577.96^{d} \pm 0.00$	$52.90^{b} \pm 0.00$
G	$229.64^{e} \pm 0.00$	$12.51^{c} \pm 0.00$	$287.98^{b} \pm 0.00$	$507.51^{b} \pm 0.00$	$91.84^{a} \pm 0.00$
K	$267.00^{d} \pm 0.00$	$15.11^{b} \pm 0.00$	$232.61^{f} \pm 0.00$	$415.88^{f} \pm 0.00$	$31.40^{d} \pm 0.00$

Means with the same superscript in the same column are not significantly different.
Key : **A** =Baked Yellow maize /sugar, **E** = Baked Yellow maize / date, **I** =Extruded Yellow maize/date
C =Baked Guinea corn /sugar, G=Baked Guinea corn /date, **K**=Extruded Guinea corn/ sugar.

Table 7. % Soluble Fractions (Mineral) Result of Granola

Sample	Calcium	Iron	Sodium	Potassium	Magnesium
A	$4.70^{f}\pm 0.00$	$3.28^{f}\pm 0.00$	$87.36^{b}\pm 0.00$	$87.04^{c}\pm 0.00$	$11.96^{e}\pm 0.00$
E	19.47 ± 0.00	$5.53^{d}\pm 0.00$	$69.93^{e}\pm 0.00$	$84.75^{d}\pm 0.00$	$16.04^{c}\pm 0.00$
I	$13.8^{d}\pm 0.00$	$6.34^{c}\pm 0.00$	$46.85^{f}\pm 0.00$	$90.25^{a}\pm 0.00$	$12.30^{d}\pm 0.00$
C	$17.62^{c}\pm 0.00$	$4.13^{e}\pm 0.00$	$91.29^{a}\pm 0.00$	$88.13^{b}\pm 0.00$	$17.14^{b}\pm 0.00$
G	$12.21^{e}\pm 0.00$	$7.51^{b}\pm 0.00$	$73.38^{c}\pm 0.00$	$76.31^{e}\pm 0.00$	$30.97^{a}\pm 0.00$
K	$52.76^{a}\pm 0.00$	$8.11^{a}\pm 0.00$	$70.50^{d}\pm 0.00$	$73.02^{f}\pm 0.00$	$10.39^{f}\pm 0.00$

Means with the same superscript in the same column are not significantly different
Key : **A**=Baked Yellow maize /sugar, **E** =Baked Yellow maize / date, **I**=Extruded Yellow maize/ date
C =Baked Guinea corn / sugar, **G**=Baked Guinea corn / date, **K**=Extruded Guinea corn/sugar

4. Conclusion

Result from the study has shown that granola produced with different cereals is of accepted quality in sensory and nutritional evaluation. The study showed an increase in the amount of fat, protein, ash, crude fibre and energy content with a decrease in carbohydrate content in the samples produced with date when compared to those produced with sugar with no sensory differences. The increased fiber content in the date products would be of important health benefit in reducing cholesterol and cardiovascular ailments as well as inhibiting the actions of some food components such as phytic acid which reduces the bioavailability of some minerals during absorption. Furthermore, the low carbohydrate content in date is beneficial for weight loss. The use of date as sugar replacer has also shown an increase in bioavailability of minerals such as magnesium and iron but not all minerals detected in the products were bioavailable when digested enzymatically into soluble forms. This could be due to the presence of minerals having same charges, phytic acid, and type of processing method used and the absence of some vitamins that helps in mineral absorption. Extrusion processing method improved the crude fibre and carbohydrate content of the products with little or no sensory changes when compared to the conventional baking method.

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