European Journal of Food Science and Technology
Vol.4, No.5, pp.18-26, December 2016
Published by European Centre for Research Training and Development UK (www.eajournals.org)

THE COMPOSITIONAL AND MINERAL CONTENT OF GRANOLA (BREAKFAST CEREAL), PRODUCED FROM DIFFERENT LOCALLY AVAILABLE CEREAL GRAINS

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ABSTRACT: *The consumption of ready-to-eat breakfast cereal contributes significantly to the dietary intake of a number of nutrients. However the knowledge of the mineral content of such breakfast cereal is limited. The present study was aimed to evaluate the proximate, mineral and sensory characteristics of the new granola products. Six different ready-to-eat breakfast cereals were produced from different locally available and cheap cereal grains such as maize (white, yellow and popping corn varieties), guinea corn and millet. Oat was used as control and samples were analyzed using standard methods. Sensory analysis showed that there was significant difference in their color, taste, texture and overall acceptability, while flavor showed no significant difference ($p \geq 0.05$) in all the samples. Oat based granola (control) had the highest values for fat, protein and energy which were significantly different from the other samples, but however lower in moisture content, fiber and total available carbohydrate. Yellow maize granola had the lowest protein content as well as the highest value for carbohydrate with the control showing the reverse trend. The result also showed that the control sample A, had the lowest value for fiber and the highest energy while the white maize granola which had the highest fiber had the least energy in kcal/g. A total of eight essential minerals associated with cereal grains were evaluated, namely calcium, magnesium, potassium, sodium, phosphorus, iron copper and zinc. The yellow maize granola (sample C) was significantly high ($p \leq 0.05$) in calcium, iron and copper but low in magnesium, sodium and zinc, while the millet based granola (sample F) was significantly ($p \leq 0.05$) high in potassium and zinc. Magnesium and phosphorus were highest in the guinea corn based granola (sample E). The ready to eat breakfast granola have shown from the study to contribute significant amount per/100g of consumption of the important minerals particularly iron and magnesium. This study also showed that the production of granola from other locally available grains gave acceptable products without altering its properties.*

KEYWORDS: Composition, mineral elements, sensory properties, granola, breakfast, cereals

INTRODUCTION

Dietary guidelines note that the high nutrient density of breakfast cereal especially those that are whole grain or high in cereal fiber make them an important source of key nutrient (NHMRC 2013). In addition to providing an important source of mineral, breakfast cereals are also potentially important

ISSN 2056 - 5798(Print), ISSN 2056 - 5801(online)

sources of antioxidants. Earlier studies by Hills (1995), Ruxton and kirk (1997), Mullan and Singh (2010) are largely in agreement that regular breakfast cereal consumption has the following benefits- higher intake of carbohydrates, lower fat, enhanced micronutrient intake, higher milk intake, improved nutritional status and lower serum cholesterol concentration. Grains and grain foods are staples in the diets of most cultures around the world, and have made an important contribution to daily nutrient requirements since cultivation began. Their consumption is encouraged in dietary guidelines around the world for the significant contribution these foods make to nutrient intakes. Cereal grains are high in carbohydrate, low in fat, good sources of protein and provide varying amounts of fiber, vitamins and minerals. Due to prevalence of micronutrient deficiencies especially iron and zinc in many developing countries, efforts are being made to assess micronutrient content of foods

Oat and walnut are the main raw materials for the production of granola, which is relatively high in cost due to the fact that it is not grown in Nigeria. Granola is unpopular and therefore its consumption is very low and so stands the status of a smuggled product from Ghana where it is more of a staple food (Eke-Ejiofor *et al* 2016). Grain foods, both whole and refined are the leading contributors of seven key nutrients in most cereal based diet – fiber, iron, magnesium, iodine, carbohydrates and B-group vitamins including folate and thiamin (Wieser and Koehler 2008). Corn and millet fall under the "warm season" cereals grown in tropical lowlands throughout the year and in temperate climates during the frost-free, season as against "Cool-season" cereals (wheat, rye, barley, and oats) which grows best in a moderate climate. The benefits of breakfast cereals have not been fully harnessed due to the high cost of the available and processed foreign breakfast cereals. However, there is little or no information on the compositional and mineral content of granola products. Therefore the objectives of this study are; to prepare granola from other locally available and cheap cereal grains and to evaluate the sensory, chemical and mineral composition of these products.

MATERIALS AND METHODS

Materials

Maize (*Zea may*), oat (*Avena sativa*), peanut (*Arachis hypogaea*), coconut (*Cocos nucifera*), wheat (*Triticum spp*), guinea corn (Sorghum bicolor), millet (Pennisetum americanum), milk, sugar, vegetable oil and vanilla flavor were purchased from Mile 3 Market in Port Harcourt, while African Walnut was purchase in "Spar" a supermarket in Port Harcourt, Rivers State. Nigeria

Reagents and Chemicals

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

Preparation of cereal whole Meals

ISSN 2056 - 5798(Print), ISSN 2056 - 5801(online)

Cereal grains such as maize (white, yellow and pop), guinea corn and millet were sorted to remove spoilt grains. They were cleaned and winnowed, and grains milled using a dry milling machine. The meal obtained were then stored in an air-tight container for use in the preparation of granola.

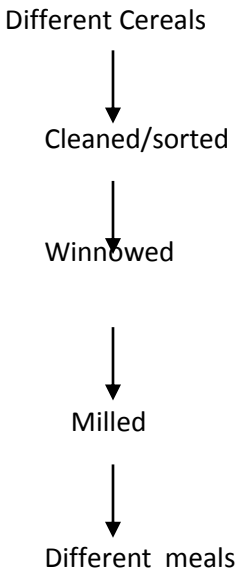

Figure1: Flowchart for production of cereal meal
Source: Adapted from Houssou and Ayemor, (2002)

Preparation of granola (Eke-Ejiofor *et al* 2016)
Different meals (Oat, maize (white, yellow and pop varieties), guinea corn and Millet) were separately mixed with coconut mesh, ground peanut, wheat flour and sugar were weighed differently into bowls and each mixed with water, vegetable oil and vanilla flavor into a dough, kneaded and cut into shape. Each sample was spread on the tray and baked in an oven at 130^{o}C for 50min. The baked products (granola) were allow to cool and was store in an airtight container.

Sensory Evaluation
Granola samples were subjected to sensory evaluation within 24 hours of production. The granola were evaluated using milk solution (the form in which it is to be served), and samples evaluated for color/appearance, taste, texture/mouth feel, flavor and overall acceptability. A questionnaire was used to assess the above mentioned attributes using a 9-point hedonic scale to measure the degree of likeness of samples with 9 = like extremely, 5 = neither like nor dislike 1 = dislike extremely (Anonymous 2008).Twenty (20) semi trained panelists drawn from within and outside the Department of Food Science and Technology, who were regular consumers of cereals and who were neither sick nor allergic to any component of the raw material used for the production of the products were involved

ISSN 2056 - 5798(Print), ISSN 2056 - 5801(online)

in the assessment. The panelists were instructed to rinse their mouth with water after tasting each granola sample.

Chemical Analysis of Granola Samples

The chemical analysis of granola samples was determined using the AOAC (1990) methods for moisture, ash, protein, fat and fiber. Total carbohydrate was calculated by difference of moisture, ash, protein, fat and fiber.

Mineral Analysis of Granola Samples. (Garcia *et al* 2008)

Total mineral determination was done using Atomic Absorption Spectrophotometer (AAS), for the determination of micro and macro elements in food and feed. The dry ashing method was used. 1g of a well-blended sample was pre ashed at 300^0C and further ashed to 600^0Cfor 2hrs in a furnance and cooled. 25ml of 3M HCl was added and filtered into a 100ml volumetric flask and diluted to volume with deionized water. Sample was vortexed and centrifuged at 3000rpm for 10mins

Statistical Analysis

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

RESULTS AND DISCUSSION

Sensory Evaluation of Granola in Milk Solution

Table 1 shows the sensory evaluation result of different granola samples produced from locally available cereals, and consumed in a given quantity of milk and sugar in the ratio 3:1, weight for weight. Color/Appearance ranged from 4.80 – 7.50 with sample C (yellow maize) as the highest and sample F as the least. Samples A, B, C and D did not differ significantly in color, while taste, flavor, texture and overall acceptability ranged from 4.80 – 7.70; 5.40- 6.90, 5.00 - 7.50 and from 5.00 – 8.00 with sample A (control) having the highest values respectively. Flavor showed no significant difference ($p \geq 0.05$) in all the samples, while taste, texture and overall acceptability differed significantly. ($p \leq 0.05$). The sensory result further showed that color and overall acceptability had close pattern where samples A-D behaved alike showing no higher preference amongst each other.

Proximate Composition Result of Granola Samples.

Table 2 shows the proximate composition result of granola samples. Moisture content of the different cereal based granola samples ranged from 4.80% to 7.79% with sample A (control) having the lowest and sample E (guinea corn) as the highest. This is in agreement with the earlier report of Eke-Ejiofor *et al* (2016) on granola, but less than the finding of Annelisse (2009) with the 15.1% with use of resistant starch for production of granola bar. The low moisture content of these products is an indication of adequate drying processing and shows good potential for storability at room temperature. Souci *et al* (2008) and Belitz *et al* (2009) reported that cereal and cereal based products with moisture content of 11-14% is usually characterized by high content of carbohydrate. This report agrees with the present finding as low moisture affected the total available carbohydrate. The ash content of the various granola samples ranged from 0.74% to 1.48% in the present study with sample D (Popcorn granola) having the least value and sample F (millet granola) as the highest. This is less than that

ISSN 2056 - 5798(Print), ISSN 2056 - 5801(online)

reported earlier by Eke-Ejiofor *et al (*2016) on granola samples. The present result also is in agreement with the finding of Jeffrey *et al.,* (2011) who reported that the ash content of corn meal as 1.50%. The differences in ash may be due to the composition of the different cereals.

Fat content of granola samples ranged from 13.12% to 16.09% with sample D (popcorn granola) as the least and Oat (control) granola as the highest. This result is less than that earlier reported by Eke-Ejiofor *et al* (2016) of 18.29% to 22.53% for maize based granola, but agrees with the finding of Annelisse (2009) with a value of 18.60%. The higher fat content of sample A (control) may be as a result of high fat content of Oat and African walnut, which was substituted with coconut in all the other granola samples, thereby giving a product of less fat content. To further support the higher fat content of the Oat based granola (control), Eliasson and Larsson (1993) and Delcour and Hoseney (2010), reported that oats are rich in lipids in contrast with other cereals. The fat content may also be influenced by varietal difference. (Eke-Ejiofor *et al* 2016)

Protein content of the various granola samples ranged from 10.31% to 12.45% with sample C (yellow maize granola) as the lowest and the sample A (control) as the highest. The present finding is higher than that reported by Eke Ejiofor *et al* (2016) with a value of 6.65% to 10.92% for granola and Muhammad *et al* (2012) with a value of 9.00% of corn grit. Sample A (oat granola) has the highest protein content. The protein result of sample A (control) with a higher protein content is expected because of the presence of wheat which is known for its high protein, in relation to other cereal grains.

Crude fiber ranged from 1.92% to 4.81% with the control (sample A-Oat granola) having the lowest and sample B (Yellow maize granola) having the highest. This result is higher than the findings of Muhammad *et al*., (2012) with a value of 3.91% for granola bar substituted with native syrup. The result indicates that maize is a richer source of fiber. However the coconut residue added to samples B-F may have contributed to the fiber content of the samples. This also agrees with the report of Trimidad *et al* (2001) which states that coconut residue made into flour contains dietary fiber. Dietary fiber has an important health implication in the prevention of risk of chronic disease such as cancer, cardiovascular disease and diabetes (Trimidad *et al* 2001). Arancon, 1999 reported that coconut flour is used as composite in the baking of some product to improve the nutritional composition.

Carbohydrate content ranged from 63.59% to 69.16% with sample a (control) having the lowest and sample C (yellow maize granola) as the highest. The result of the present study is higher than that reported by Annelisse (2009) and Eke-Ejiofor *et al* 2016. Energy values ranged from 419.02kcal/100g – 448.97kcal/100g with sample B (white maize granola) as the least and sample A (control) as the highest. This result also is in agreement with the findings of Annelisse (2012) with a value of 450kcal/100g. The result shows that despite the change in the composition of the original ingredients, it did not adversely affect the derivable energy in the new product. Eke-Ejiofor *et al* (2016) had reported higher energy values for maize based granola. There was significant difference ($P \leq 0.05$) in all the proximate parameter analyzed.

Mineral Content of Granola Samples

ISSN 2056 - 5798(Print), ISSN 2056 - 5801(online)

Table 3 shows the mineral composition of granola produced from locally available cereal grains. Calcium content of the granola samples ranged from 169mg/100g -268mg/100g with sample A (control) having the lowest and sample C the highest. The yellow based maize granola was seen to contain the highest amount of calcium as compared to the other samples. The variability in calcium content may be as a result of the different cereals used for the production of granola. Calcium provides rigidity to the skeleton and plays a role in most metabolic processes. The magnesium content of the granola samples ranged from 11071mg/100g to 12551mg/100g as shown in the table. The yellow maize granola (sample C) had the highest quantity when compared to the others.
Potassium is an essential nutrient needed for maintenance of total body fluid volume, acid and electrolyte balance and normal cell function (Yung 2001). Potassium (k) of the various granola samples ranged from 36809mg/100g to 38794mg/100g with the popcorn granola as highest and millet as the lowest.

Sodium is the principal cation in extracellular fluid in the body, and is an essential nutrient necessary for maintenance of plasma volume, acid-base balance, transmission of nerve impulse and normal cell function. The level of sodium (Na) in the samples ranged from 12953mg/100g to 16213mg/100g with sample C (yellow maize granola) ranking the highest, while Phosphorous (P) content of granola samples ranged from 21118mg/100g to 23120mg/100g. The control sample containing oat and wheat was seen to have the highest level of phosphorous.

Iron and copper content of samples ranged from 549mg/100g to737mg/100g and from 21.7 to 47.3mg/100g respectively with the popcorn and millet based granola as highest respectively and the yellow maize granola as lowest in both cease. Foods are fortified with iron because it is considered an essential ingredient of the daily diet which must be present for the body to function properly. Iron (Fe) plays an important role in the formation of haemoglobin, oxygen and electron transport in human body (Kalagbor and Diri, 2014). The recommended daily allowance (RDAs) of iron depends on the age and sex of an individual. The RDA for iron is 15mg/day for females age 14-18 and 11mg/day for males age 14-18. The daily value for iron is 18mg/day (FS 2002.) The FAO/WHO (2001) maximum limit for Fe concentration in food is 425mg/kg^{-}1 or 42.5mg/100g. The result obtained in the study is higher than the recommended allowance.

Zinc is essential to all organisms and has an important role in metabolism, growth, development and general well-being. It is an essential co-factor for large number of enzymes in the body. Zinc deficiency leads to coronary heart diseases and various metabolic disorders (Saraf and Samant, 2013). The zinc content of samples ranged from 153 to 227mg/100g with the yellow maize granola (sample C) as the lowest and millet granola as the highest. The content of zinc reported in the present study is generally higher than the permissible levels of 99.4mg/kg (9.94mg/100g) set by FAO/WHO (2001). Zinc is essential for protein and nucleic acid synthesis as well as carbohydrate metabolism.

CONCLUSION

ISSN 2056 - 5798(Print), ISSN 2056 - 5801(online)

Result from the study has shown that granola is a breakfast cereal that is inexpensive due to the availability of the raw material used, nutrient dense and convenient food which can be recommended to form part of a healthy balanced diet. The regular consumption of a given quantity of granola can help ensure an adequate intake of the minerals under review, which would assist in reducing the risk of being overweight or of developing cardiovascular diseases. The study has also shown that any of the locally available cereal grains could be used to produce granola of acceptable quality without altering the flavor, texture and taste

Table 1 Sensory Evaluation Result of Granola in Milk Solution

Samples	Color	Taste	Flavor/ aroma	Texture	Overall acceptability
A	6.90^{a}	7.70^{a}	6.90^{a}	7.50^{a}	8.00^{a}
B	7.30^{a}	6.30^{b}	6.80^{a}	6.90^{a}	7.40^{a}
C	7.50^{a}	6.60^{ab}	6.90^{a}	6.80^{a}	6.90^{a}
D	7.40^{a}	6.50^{b}	6.40^{a}	6.50^{ab}	7.10^{a}
E	5.50^{b}	5.50^{bc}	6.20^{a}	4.90^{b}	5.80^{b}
F	4.10^{c}	4.80^{c}	5.40^{a}	5.00^{b}	5.00^{b}

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

Key: A= Oat granola (control)
B= white maize granola
C= yellow maize granola
D= popcorn granola
E=Guinea corn granola
F= Millet granola

Table 2: Proximate Composition (%) Result of Granola Samples

Sample	MC	Ash	Fiber	Fat	Protein	CHO	Energy (kcal)
A	4.80^{b}	1.14^{ab}	1.92^{bc}	16.09^{a}	12.45^{a}	63.59^{b}	448.97^{a}
B	6.13^{ab}	1.03^{ab}	4.81^{a}	13.46^{b}	10.70^{b}	63.77^{b}	419.02^{b}
C	5.46^{b}	0.79^{b}	4.56^{a}	13.71^{b}	10.31^{b}	69.16^{a}	441.27^{a}
D	5.48^{b}	0.74^{b}	3.33^{ab}	13.12^{b}	11.56^{ab}	65.75^{b}	427.32^{b}
E	7.79^{ab}	0.79^{b}	3.31^{ab}	13.15^{b}	10.90^{ab}	66.05^{b}	426.15^{b}
F	6.95^{a}	1.48^{a}	2.58^{b}	13.45^{b}	10.87^{ab}	64.65^{b}	423.13^{b}

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

Key: A= Oat granola (control)
B= white maize granola
C= yellow maize granola
D= popcorn granola
E=Guinea corn granola
F= Millet granola

ISSN 2056 - 5798(Print), ISSN 2056 - 5801(online)

MC= Moisture content
CHO= Carbohydrate

Table 3: Mineral Content (mg/100g) of Granola Samples

Sample	Ca	Mg	K	Na	P	Fe	Cu	Zn
A	169^{e}	11514^{c}	37689^{c}	13600^{cd}	21118^{e}	588^{c}	40^{b}	187^{c}
B	250^{b}	12204^{b}	37989^{b}	16213^{a}	21947^{b}	610^{bc}	32^{c}	203^{b}
C	268^{a}	11071^{d}	37580^{c}	12953^{e}	22342^{b}	737^{a}	47^{a}	153^{d}
D	218^{c}	11203^{d}	36809^{e}	15725^{b}	21800^{d}	549^{d}	39^{b}	201^{b}
E	228^{c}	12551^{a}	37295^{d}	13712^{c}	23120^{a}	628^{bc}	32^{c}	222^{a}
F	199^{d}	12002^{b}	38794^{a}	15725^{b}	21226^{e}	669^{b}	21^{d}	227^{a}

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

Key: A= Oat granola (control)
B= White maize granola
C= Yellow maize granola
D= Popcorn granola
E= Guinea corn granola
F=Milletgranola

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