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ENERGY OPTIMIZATION, PROXIMATE COMPOSITION, MINERALS CONTENT AND SENSORY EVALUATION OF COOKIES: A COMPLEMENTARY SNACK PRODUCED FROM DEFFATED CRICKET AND SORGHUM FLOUR BLENDS

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Abstract

In this study, energy optimization, proximate composition, mineral content and sensory evaluation of cookies produced from malted sorghum and defatted cricket flour blend were study. A preliminary study was carried out to ascertain the optimum acceptable limit of cricket flour in sorghum cookies production, cricket flour yielded the most acceptable cookies at 30% w/w, hence in the main study the level of cricket flour was varied to 30% w/w, while sorghum flour was varied in

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the ration 100:0, 95:5, 90:10, 85:15, 80:20, 75:25 and 70:30 giving a total of seven samples. Proximate composition, selected mineral composition and sensory evaluation of the cookies were done using standard analytical methods. Energy optimization was also done using standard methods. The protein content of the cookies increased from 7.99% to 17.55% as the percentage of cricket flour increased from 0 to 30%. Calcium, Zinc and Fe content ranged from 11 mg/100g to 60 mg/100g, 2 mg/100g to 19 mg/100g, 0.6 mg/100g to 9 mg/100g, respectively. Consuming 1.78 packet will provide 79.17 kcal which is about 40% of the kcal required to be supplied by complementary foods considering the energy needs from complementary foods for infants with "average" breast milk intake in developing countries which are approximately 200 kcal per day at 6-8 months of age, 300 kcal per day at 9-11 months of age, and 550 kcal per day at 12-23 months of age. Sample A was the most accepted. This study hence provides a way improving the nutritional content of cookies by addition of defatted cricket to malted sorghum flour.

Introduction

Complementary foods are any food other than breast milk given in the complementary feeding period (WHO/UNICEF [14]). These foods range from the commercial foods to the locally prepared ones and the feeding process varies widely among different culture in terms of variety, quality, and quantity of foods which are used (Johnson [9]). In the developing countries, there is higher cost of fortified nutritious complementary foods which make younger children to depend on poorly processed traditional foods. In other to reduce malnutrition, high proteinous foods are needed to increase the growth of the child (Okoronkwo et al. [10]).

Complementary snacks also referred to as finger foods, are usually soft enough to chew, easy to pick, grasp, cut and are mostly cereal based (USDA [12]). They are given to children alongside complementary foods other than breast milk given in the complementary feeding period. They contribute to the daily energy and other nutrient requirements of the infant (PAHO/WHO [11]).

An infant's need for energy and nutrients starts to exceed what is provided by breast milk from the age of 6 months, and complementary feeding becomes necessary to fill the energy and nutrient gap (Dewey and Brown [5]). Dewey and Adu-Afarwuah [23] reported that complementary foods are often of inadequate nutritional quality, or they are given too early or too late, in too small amounts, or not frequently enough. In many countries, the period of complementary feeding from 6-23 months is the time of peak incidence of growth faltering, micronutrient deficiencies and infectious illnesses (Dewey and Adu-Afarwuah [23]). Therefore, in order to meet the recommended nutrient intake, finger foods also known as snacks are recommended to be given to infants beyond 6 months of age, once or twice per day based on the child's appetite (WHO [13]).

Crickets essentially viewed as an animal source of food can contribute valuable protein, fat and important micronutrients to humans as a part of a varied diet. Crickets generally consist of about 41 percent protein, 38 percent fat and rich in iron, calcium and amino acids such as tryptophan. They have the potential to provide bioactive compounds that have health benefits addressing global health challenges beyond simple nutritional values, as is the case for other food groups such as fruits and vegetables (Ekpo [15]). However, any identified health benefits need to be confirmed in human studies or in standardized assays accepted in health research prior to making health claims (Mital et al. [18]). Crickets, because of their high contents of fat are sometimes defatted either wholly or partially by hexane in order to reduce the level of fat for further food values.

Sorghum (Sorghum bicolor) grain contains high carbohydrate which in turn provides the energy and calorie requirement of people consuming it. Sorghum is the fifth most important cereal in the world (Salim et al. [16]), it is grown in all ecological zones in Nigeria. In Nigeria sorghum food dishes are numerous. These include *mumu*, *pap*, *tuwo*, *waina*, *ibier*, *choko* and *gwae* (Igbian and Akpappunan [25]). Apart from food, sorghum is also used for medicinal purposes and as a raw material for the industries (Abdulrahaman [24]). Sorghum protein in common varieties varies from about 7 to 10% of the kernel weight (FAO [22]). The protein has moderate amounts of sulphur containing amino acids, methionine and cystine but is low in lysine and very low in tryptophan (FAO [22]). It is therefore thought wise to supplement sorghum flour with defatted cricket flour, which are high in protein, macro nutrients, micro-nutrients and high health promoting properties. Crickets are rich in lysine and tryptophan (FAO [22]). Hence, it could form a good supplement to sorghum which is low in tryptophan and lysine.

Although the Unites States Department of Agriculture [12] has recommended the consumption of non-adult foods by infants, studies have shown that most finger foods given to children of complementary feeding age are not appropriate for their age group. These finger foods have high sugar and high fibre content which poses a lot of risk such as dental crises to their health (USDA [11]). Unfortified complementary foods that are predominantly plant-based generally provide insufficient amounts of certain key nutrients (particularly iron, zinc and calcium) to meet the recommended nutrient intakes during the age range of 6-24 months (WHO/UNICEF [14]; Gibson et al. [7], and Dewey and Brown [5]).

Hence, this study seeks to formulate and determine the nutrient composition of a cricket – sorghum based complementary snack, as well as to evaluate its acceptability for children of complementary feeding age.

Materials and Methods

Sample collection

Sorghum was purchased in Makurdi Modern Market, Benue State while cricket was gotten from an open market at Agasha, Benue State.

Sample preparation

Preparation of malted sorghum flour

The sorghum was sorted out to remove dirt, stones and other extraneous materials. It was then washed thoroughly with clean water. The sorghum grains were soaked separately in water (1:2 w/v) for 6 hours with the water being change at 2 hours interval. After 6 hours, the water was drained and the grains were kept in a dark cupboard to germinate. The grains were watered 2 times a day at regular intervals. After germination for 2 days (48 hours), the grains were dried in a hot air oven dryer at 60°C overnight. The vegetative parts were removed by rubbing between palms and then winnowing. The dried malted grains were dry milled in a laboratory Kenwood blender and sieved with a 500μm screen sieve to obtain fine flour. This was kept in a Ziploc bag for analysis.

Preparation of defatted cricket flour

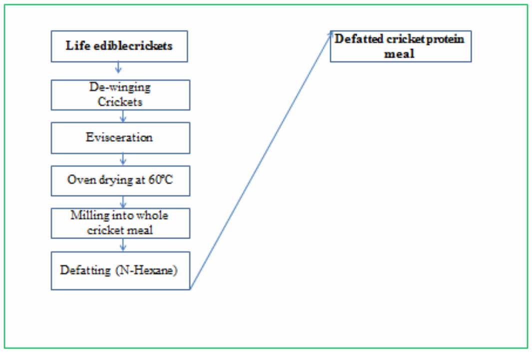

Figure 1. Preparation of deffated cricket flour source: Aluko [3].

Production of cookies

Cookies were produced using the conventional creaming method (Figure 2). Fat and sugar were creamed together till the mixture was fluffy. After creaming, flour, baking powder and milk with egg yolk as well as a pinch of salt were added and mixed until batter was uniformly mixed. The batter was manually kneaded to ensure uniformity. It was then transferred to a clean tray and gently rolled into a sheath using a roller. The batter sheath was cut into shapes using cookie cutter and placed into a greased pan. This was then baked in the oven at 200°C for 15min. The baked cookies were left to cool before packaging in Ziploc bags for analysis.

Mixing of fat and sugar
↓
Addition of egg yolk
↓
Addition of dry ingredients
(malted sorghum flour, cricket bean flour, milk, baking powder)
↓
Thorough mixing
↓
Kneading
↓
Rolling into flat sheaths
↓
Cutting into shapes
↓
Placing on greased oven tray
↓
Baking at 200°C for 15 min
↓
Cooling
↓
Packaging

Figure 2. Flow chart for the production of malted sorghum-deffated cricket cookies.

Energy optimization by linear programming

Nutrient optimization by linear programming using graphical representation in Microsoft Excel was carried out in order to identify the combination of Sorghum and Defatted cricket meal that meet two nutritional constraints at the lowest possible cost. 746 kcal of energy at 9 months was used as WHO/UNICEF [14] estimate of nutritional requirements during complementary feeding period.

To determine the combination of sorghum and cricket meal that will provide the required amount of energy, i.e., 746 Kcal, the following equation was used

$$E_{mf} \cdot X_{mf}/100 + E_{sf} \cdot X_{sf}/100 = 746,$$

where $X_{mf} \cdot X_{sf}$, E_{mf} and E_{sf} represent the weight (grams) and the energy content (kcal/100g) of sorghum flour and cricket flour, respectively. These combinations were represented graphically and all combinations below the line provide less than the required energy.

The combinations obtained were used for cookies production.

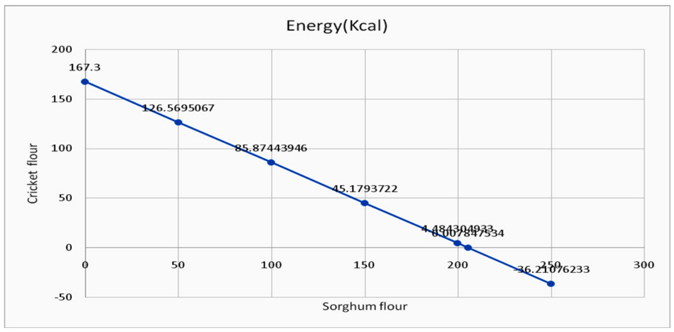

Figure 3. Graph showing the combinations of sorghum and cricket meal for energy constraints.

Table 1. Combinations of sorghum and cricket derived from the graphical illustration

Sorghum	0	50	100	150	200	205.5	250
Cricket flour	167.3	126.5695	85.87444	45.17937	4.484305	0.007848	36.2108

Two combinations of sorghum and cricket flour were picked from the graphical illustration (samples A and E), one from optimization using Microsoft excel (sample D), another two from the traditional trial and error method (samples B and C) and then a reference sample.

Table 2. Formulation of cookies

Flour ratio	Fat (g)	Sugar (g)	Salt (g)	Bi-carbonate (g)	Milk (g)	Egg yolk (g)	Water (ml)
	48.4	36	0.8	1	20	20	40

Table 3. Flour blends formulation

	SAMPLES						
	A (Control)	B	C	D	E	F	G
Sorghum flour	100	95	90	85	80	75	70
Defatted Cricket flour	0	5	10	15	20	25	30
Reference (Wheat)							

Analytical methods

The proximate composition, vitamin A and D analysis and mineral elements (Ca, Zn and Fe) to determine how much of major or macro components were determined according to standard methods as described by AOAC [2] with some little modification. The carbohydrates was determined by difference using the formula: % carbohydrate = 100 -% protein + % ash + % crude fiber + % crude fat + % moisture (Ihekeronye and Ngoddy [19]).

Sensory evaluation

The sensory evaluation was done using 12 panellists comprising of nursing mothers who are experienced in complementary feeding. The samples were kept in Ziploc bags at room temperature. Panellists rated the biscuit samples for colour (very dark brown to very light brown), texture – hand feel (softness to hardness), smoothness - mouth feel (smooth or gritty), aroma, taste and overall acceptability using 1-5 hedonic scale where 1 represents dislike extremely, 2 – dislike, 3 like moderately, 4 – like and 5 like extremely.

Statistical analysis

The data generated were analyzed using analysis of variance (ANOVA), and means were separated using Duncan's multiple range test (DMRT) at 5% level of probability $(p \leq 0.05)$. The statistical package for social scientist (SPSS) software, version 20.0 was used for the analysis.

Results and Discussion

Proximate composition of cookies produced from sorghum and cricket flour blends

The result of the proximate analysis on cookies samples shows that there was no significant difference at $p \leq 0.05$ in the moisture content and dry matter of all the sorghum-cricket samples as compared to the reference sample, wheat cookies. The optimized samples had the lowest moisture content, which indicates better stability in the storage shelf life than the mean of the moisture content of the samples from the traditional trial and error method.

The protein content of the samples is higher than the WHO/UNICEF [14] estimated nutritional requirement, 9.1g/d for 6-8 months, 9.6g/d for 9-11 months and 10.9g/d for 12-23 months child. Protein content of the samples was significantly different as the cricket flour contributed greatly to the cookies formulation. The protein mean values of sorghum – cricket samples indicate that they can be used in eradicating protein energy malnutrition, poor nutrition and growth faltering which is often associated with the complementary feeding period.

The fat content of the sorghum – cricket cookies samples are higher than that of the reference sample which had the lowest mean. This may allow for the absorption of fat-soluble vitamins, provide essential fatty acids that are required for normal brain development, healthy skin, resistance to infection and disease etc. There was significant difference at $p \leq 0.05$ in the mean of the samples. The optimized samples had low fat content as compared to those from the trial and error method though they all are within the percentage suggested by Dewey and Brown [5] and Bier et al. [20] who suggested that the optimal amount of fat in the diets of infants and young children should be between the range of 30-45% of total energy. This is considering the fact that fat is important in the diets of infants and young children because it provides essential fatty acids, facilitates absorption of fat soluble vitamins, and enhances dietary energy density and sensory qualities; and also been reasonable to compromise between the risks of too little intake (such as inadequate essential fatty acids and low energy density) and excessive intake (thought to potentially increase the likelihood of childhood obesity and future cardiovascular disease).

There was significant difference at $p \leq 0.05$ in the mean of the energy values of the biscuit samples. The energy values were higher in the sorghum – cricket samples than the reference sample, sample F, which had the lowest. Energy intake helps in carrying out physical activities, growth and normal development. This will contribute to the estimated energy requirement by WHO/UNICEF [14] for infant and young children who are required to have 682 kcal/day, 830 kcal/day and 1,092 kcal/day for 6-8 months, 9-11 months and 12-23 months child, respectively which is needed for optimum growth and development of the child.

The reference sample (sample F) had the lowest mean value for fibre. There was significant difference in the fibre, ash and carbohydrate content of the sample with the range for ash and carbohydrate.

Energy optimization for the sorghum-cricket biscuit

An infant of 6-8 months for instance is required to have an estimated protein requirement of 9.1g/day and energy of 682 kcal/day according to WHO/UNICEF [14]. Taking sorghum-cricket cookie, sample A, the most preferred optimized cookies sample, as an example,

$$20.39\text{g protein} = 100\text{g biscuit}$$

$$1\text{g} = 100/20.39 = 4.90,$$

$$9.1\text{g protein} = 9.1 \times 4.90 = 44.59\text{g},$$

i.e., 44.59g of the biscuit will meet the required protein intake.

Assuming a pack of biscuit is 25g, the number of packet to be consumed will be $44.59/25 = 1.78 \sim 2$ packets.

Also, sample A optimized sorghum-cricket biscuit contains 44.48g carbohydrate in 100g. However, 1g of carbohydrate gives 4 kcal of energy, i.e.,

$$1\text{g} = 4\text{kcal}.$$

Hence, 44.48g will provide

$$44.48 \times 4 = 177.92\text{ kcal}.$$

If 100g biscuit gives 177.92 kcal,

$$1\text{g} = 1.7792\text{ kcal}.$$

Hence, 25g packet of biscuit will give

$$25 \times 1.7792 = 44.48\text{ kcal}.$$

Consuming 1.78 packet will provide 79.17 kcal which is about 40% of the kcal required to be supplied by complementary foods considering the energy needs from complementary foods for infants with “average” breast milk intake in developing countries (WHO/UNICEF [14]) which are approximately 200 kcal per day at 6-8 months of age, 300 kcal per day at 9-11 months of age, and 550 kcal per day at 12-23 months of age.

Selected mineral content of cookies produced from sorghum and defatted cricket flour blends

The Iron content of the cookies samples shows the reference sample having the least. The optimized samples had a relatively higher Iron content than those from the trial and error method. Iron is a vital component as it aids proper growth and formation of healthy blood cells.

The Zinc content of the optimized samples had relatively high mean values than the biscuit samples from the trial and error combination. The high value in the Zn and Fe content of the optimized samples could be due to the higher content of sorghum in the biscuit composition. Zinc contributes to a healthy immune system and general growth and maintenance of all tissues.

This may contribute to the proportion of the recommended nutrient intake that needs to be supplied by complementary foods which is 97% for iron, 86% for zinc, 81% for phosphorus, 76% for magnesium, 73% for sodium and 72% for calcium (Dewey [21]) that is needed for optimal growth and development.

Sensory evaluation

The organoleptic property of a product determines its level of consumption and acceptability by the consumer. The sensorial quality of the cookies samples made from sorghum and cricket evaluated shows significant difference at $p \leq 0.05$ in the quality attributes. Samples D and C were rated brown in colour, while E, A and B were rated light brown as against the very light brown colour of the reference sample. All the optimized samples were rated slightly hard except for sample D which was moderately soft and sample E which was hard in texture (hand feel). The smoothness (mouth feel) attribute of both the optimized and trial and error composed samples were rated slightly gritty except for sample D which was rated gritty as compared to the smooth mouth feel of the reference sample. This implies that the sorghum-cricket samples can easily be broken and soft enough to give a child of complementary feeding age.

The aroma of samples A and E was ranked high respectively next to that of the reference sample by the panellists. There was no difference in the ranking of the cookies samples composition of the traditional trial and error method. In terms of taste, sample A was more preferred out of the sorghum-cricket cookies and ranked high next to the reference sample. Sample D was the least preferred in taste of all the samples.

Generally, sample A, out of the optimized samples was rated higher and most accepted by the panelists and more preferred along with the reference sample followed by samples E and B.

Conclusion

The study revealed that acceptable complementary snack with improved nutrient content can be produced from sorghum and defatted cricket flour. Sample A was the most accepted. Protein, Ash, fibre and fat were increased in biscuit samples, selected minerals analyzed increased likewise, anti nutrient content was within the range of acceptable limit for tannin, trypsin inhibitor and phytate. Hence, the snacks revealed that snacks can be produced and tailored towards infants of complementary age using the local food available, sorghum and defatted cricket flour in order to meet their recommended dietary intake and ensure adequate nutrition of infant and young child for adequate physical and cognitive development and safeguard a healthy start to life.

References

[1] E. A. Amankwah, J. Barimah, R. Acheampong, L. O. Addai and C. O. Nnaji, Effect of fermentation and malting on the viscosity of maize-cricket abean weaning blends, Pakistan Journal of Nutrition 8 (2009), 1671-1675.

[2] AOAC, Official Methods of Analysis, 15th ed., Association of Official Analytical Chemist., Washington, D.C., 1990.

[3] J. M. Aluko, A laboratory procedure for the preparation of hydrolysate, Journal of Food Science 46 (2008), 1523.

[4] A. Briend, N. Darmon, E. Ferguson and J. G. Erhardt, Linear programming: A mathematical tool for analyzing and optimizing children’s diets during the complementary feeding period, Journal of Pediatric Gastroenterology and Nutrition 36 (2003), 12-22.

[5] K. Dewey and K. Brown, Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs, Food and Nutrition Bulletin 24(1) (2003), 5-28.

[6] FMOH, Facilitators Guide book on the Community Infant and Young Child Feeding Counselling Package, Nigeria: Federal Ministry of Health (2012), 64.

[7] R. S. Gibson, E. L. Ferguson and J. Lehrfeld, Complementary foods for infant feeding in developing countries: their nutrient adequacy and improvement, European Journal of Clinical Nutrition 52 (1998), 764-770.

[8] C. Hotz and R. S. Gibson, Traditional food-processing and preparation practices to enhance the bioavailability of micronutrients in plant-based diets, Journal of Nutrition 37 (2007), 1097-1100.

[9] D. Johnson, Nutrition in infancy: physiology, development and nutritional recommendations, Draft, 2003. http://course:washington,edu./nutria526/resources/intphys/ht

[10] C. U. Okoronkwo, E. A. Udensi, H. C. Okereke and N. O. Ndubuisi, Amino Acid Profile and Growth Promoting Response of Fermented and Germinated Complementary Foods Based on Maize and Pigeon Pea Flour, International Journal of Innovative Research and Development 5(10) (2016), 192-196.

[11] PAHO/WHO, Guiding principles for complementary feeding of the breastfed child, Washington DC, Pan American Health Organization/World Health Organization, 2002.

[12] USDA, Infant Nutrition and Feeding, A Guide for Use in the WIC and CSF Programs, Unites States Department of Agriculture, Washington, D.C., 2009, pp. 105-127.

[13] WHO, Infant and young child feeding, Model chapter for textbooks for medical students and allied health professionals, Geneva: World Health Organization, 2009.

[14] WHO/UNICEF, Complementary feeding of young children in developing countries: a review of current scientific knowledge, (WHO/NUT/98.1) Geneva: World Health Organization, 1998.

[15] K. P. Ekpo, The bioavailability and Post prandial utilisation of sweet lupin (*Lupinus albus*)-flour protein is similar to that of purified soy bean protein in human subjects: a study using intrinsically N-15-labelled proteins, British Journal of Nutrition 87 (2010), 315-323.

[16] J. Salim, F. Kida and S. Fagbemi, Production and quality assessment of enriched cookies from whole wheat and full fat peanut, European Journal of Food Science and Technology 2(1) (2017), 19-28.

[17] G. I. Onwuka, Food analysis and instrumentation: theory and practice, Surulere: Naphthali Prints, 2005, PP. 89-97; 133-139.

[18] J. A. Mital, D. S. Ikuomola, T. A. Sanni, Y. O. Esson, V. A. Ayo and A. Ajayi, Evaluation of the nutritional quality of soy-acha composite biscuits, Nigeria Food Journal 2(2) (2011), 371-385.

[19] A. I. Ihekeronye and P. O. Ngoddy, Integrated Food Science and Technology for the Tropics, Macmillan Education Limited, London, 1985, pp. 139-193.

[20] E. Bier, E. A. Tydeman, H. B. Lewis, R. Phalora, J. Rosborough, D. R. Picout and P. R. Ellis, Manipulation of lipid bio accessibility of almond seeds influences postprandial lipemia in healthy human subjects, American Journal 23(7) (2008), 2-24.

[21] J. U. Dewey, Nutrient, Antinutrient composition and health benefits of cocoa (Threobroma cacao), peanut and crayfish (Astacusfluriatilis) Flours, Pakistan Journal of Nutrition 11(9) (2011), 743-746.

[22] FAO, African experience in the improvement of post-harvest techniques, synthesis based on the workshop held in Accra, Ghana, (1992), 4.

[23] J. U. Dewey and J. Adu-Ajarwuah, Effect on bodyweight of a free 76 kilo joule (320 calorie) daily supplement of almonds for six months, Journal of the American College of Nutrition 21 (2008), 275-283.

[24] M. A. Abdulrahaman, A possible protective effect of nut consumption on risk of coronary heart disease, Archives of Internal Medicine 152 (1997), 1416-1424.

[25] J. H. Igbian and R. D. Akpapunan, Effects of appetite, BMI, food form and flavour on mastication: almonds as a test food, European Journal of Clinical Nutrition 62 (2005), 1231-1238.