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RESEARCH PAPER

Processing and Assessment of Quality Characteristics of Corn-peanut Flakes

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Abstract

Proximate composition, anti-nutritional compounds and sensory quality attributes of flakes based on corn and peanut for possible use as ready to eat food. The product takes were prepared as per the standard protocol from corn - peanut blends in the ratios of 100:0, 90:10, 80:20 and 70:30. The analysis of flakes revealed significant differences among different blends. On basis of sensory evaluation the flakes prepared from germinated corn flour: roasted peanut flour of (80: 20) attained highest overall acceptability score (8.57±0.01) and it contained 9. 94 ±0.04 % crude fat, 16.24 ±0.04 % crude protein, 2.56 ±0.01% crude fibre, 3.12±0.02% ash, 64.27±0.07% carbohydrate content and 2.92±0.01 mg/100g β-carotene. The results obtained in this study also showed that flakes prepared from germinated corn flour: roasted peanut flour of 80: 20 contained 14.60±0.01 mg/100g calcium, 0.86±0.01 mg/100g zinc and 0.73±0.01 mg/100g iron.

Keywords: corn, peanut, germination, fermentation, roasting, flakes.

Breakfast cereals have become firmly established on breakfast tables almost all over the world. In addition to a wide variety of forms, tastes and colours, they are expected today to also meet stringent nutritional quality requirements. Cereals and legumes provide the major caloric and protein source for humanity and therefore are the mainstay of agriculture. There protein complementation has long been recommended as a suitable strategy for augmenting the protein quality of cereal and legume based foods. Corn and peanut have promising nutritional attributes where one complements the other with the deficient amino acid creating mutual balance. Corn (*Zea mays* L.) constitutes an important source of carbohydrates, proteins, vitamin B, and minerals (Latham, 1997). As a result of this maize has acquired a well deserved reputation as a poor man's nutricereal. Nutritionally, maize is a relatively poor cereal when it comes to the quality of its protein, because it has limiting amounts of two essential amino acids, lysine and tryptophan (Azevedo *et al.* 1997). Peanut or groundnut (*Arachis hypogaea* L.) is rich in protein (25.6%) and fat (46.1%) (Bender *et al.* 1998). The protein contains moderate quantities of tryptophan and threonine and could form a good supplement to maize protein which is low in tryptophan (Elegbede *et al.* 1997).

Traditional methods employing roasting, germination and fermentation of grains are often used separately or in combination during food preparation (Griffith *et al.* 1998a). Germination improves digestibility, bioavailability of vitamins, minerals, amino acids, proteins and photochemical, and decreases anti-nutrients and starch of some cereals and legumes (Egli *et al.* 2004). Fermentation modifies some physical characteristics of cereals and legumes, increases the level of some nutrients, digestibility and bioavailability, decreases levels of anti nutrients, increases nutrient density and imparts some antimicrobial property (Onweluzo *et al.* 2009). Roasting on the other hand is described as a method that uses dry heat for short periods of time. Traditional roasting of grains is used primarily to enhance flavour, but other benefits include reduction of anti-nutritional factors and extension of storage life (Griffith *et al.* 1998b). The objective of the present study was to assess proximate, mineral and anti-nutritional composition of corn flakes blended with peanut flour with a view to provide preliminary information towards utilization of this legume in various food applications.

MATERIALS AND METHODS

Germination, fermentation and roasting of raw materials

Corn and peanut grains were obtained from a local market and cleaned manually. The corn was germinated as described by Griffith *et al.* (1998b). Seeds were rinsed and then soaked in water (1:3, w/v) for 9 hr at ambient temperature (23– 25°C). The water was drained and seeds were placed on perforated aluminium pans lined with filter paper, and kept at room temperature (28 ± 2°C) for germination. Germinating seeds were sprinkled with water to maintain adequate hydration. The corn germinated in 48 hr. and then sprouted seeds were dried in a hot-air oven at 60°C for 12–20 hr to a moisture content of 10% (wb). Dried sprouts were milled to flour. Another lot of corn was kept for fermentation for 3 days as described by Mbata *et al.* (2009) and Steve *et al.* (2011). The corn grains were soaked in water (2: 3, w/v) and left for 24 hr to ferment at room temperature (28 ± 2°C). The steep water was discarded by decantation and the steeped grains were spreaded on a clean tray pan and thereafter oven dried at 60° C for 20 hrs. Dried sprouts were milled to flour. A lot of peanut was roasted at 120° C for 10 min. On cooling, the hulls of the nuts were manually rubbed off and winnowed followed by milling to flour (Emmanuel and Okorie, 2002). The roasted peanut flour was added to germinated and fermented flour at substitution levels of 0, 10, 20 and 30%, respectively.

Product development

The preparation of Ready To Eat (RTE) flakes using cereal flour was standardized following the method of Leusner (1999). The process is shown in Fig. 1.

Mixing of corn and peanut flour
↓
Mix flour with water
↓
Dough formation (moisture content 22 to 35%)
↓
Sheeting using roller (thickness 0.38-0.63 mm)
↓
Cutting into flakes (0.35-0.65 g)
↓
Baking (210° C for 2-3 min)
↓
Flakes

Fig. 1: Flow chart for preparation of corn-peanut flakes

Physico- Chemical and Sensory analysis

The flakes made from corn and peanut were packed in aluminium laminated pouches.

Proximate Analysis: The moisture, ash, crude fat, crude fibre, crude protein (N x 6.25) and carbohydrate (by difference) were determined in accordance with AOAC methods (1995). β-carotene was determined by the method of Srivastava and Kumar, (1996).

Anti-nutritional factors: Tannin content was determined by the Folin-Denis method and Phytic acid were determined as described by Wheeler and Ferrel (1971).

Minerals: Calcium was estimated by titration method (Jaiswal, 2003) while, zinc and iron was determined by Atomic absorption spectrophotometer. The minerals were expressed in mg/100g sample.

Colour: The colour was evaluated by measuring L, a*, b* parameters by means of Hunterlab colorimeter. Colour was expressed in CIE-Lab parameters as L (whiteness/ darkness), a* (redness/greenness), and b*(yellowness/blueness) (Akesowan, 2010).

Sensory evaluation: The samples were evaluated on the basis of texture, appearance, taste and overall acceptability using 9 point hedonic scale assigning scores 9- like extremely to 1- dislike extremely. A score of 5.5 and above was considered acceptable (Amerine *et al.* 1965).

Statistical analysis: The results obtained were statistically analyzed using completely randomized design (CRD) for interpretation of results through analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Proximate composition: Increased peanut flour substitution gave progressively higher protein, fat, crude fibre and ash contents of the product with lower carbohydrate content (Table 1). The moisture content of the flakes ranged from 2.16±0.05% to 3.23±0.03 %. There was a progressive decrease in moisture content of the blended product which could mean a reduction in pre-disposition to shelf spoilage (Aremu, 2006). Ijarotimi (2012) have also reported that the variation in the moisture content is due to drying level and the ability of the dehydrated samples to absorb moisture in the environment of high range of relative humidity of 80.4%-85.6%. The fat content ranged between 3.77±0.20 and 14.12±0.02 %. Highest crude fat content was recorded in T_4. Increasing the peanut flour proportion in the blend significantly increased the fat content of the flakes as the peanut is known to be a rich source of fat. This is in agreement with the findings of Anjanaku *et al.* (2012) who found that increase in the proportion of peanut flour increased the fat content of the sorghum ogi. Flakes made using fermented corn showed less fat content than germinated ones. It could be attributed to the activities of micro-organisms on these nutrients in utilizing them to synthesize protein for their growth (Steve and Olufunmiayo, 2011). The addition of peanut improved the protein level in corn flakes which may help in reducing malnutrition by consuming such products. The crude

Table 1: Proximate composition (%) of corn-peanut blended flakes

Treatment	Moisture content	Crude fat	Crude protein	Crude fibre	Ash	Carbo-hydrate	β-carotene (mg/100g)	Rehydration ratio
T_1 (100:0:: GCF: RPF)	3.03 ± 0.05	3.91 ± 0.32	11.09 ± 0.02	1.96 ± 0.01	2.01 ± 0.01	77.99 ± 0.35	1.04 ± 0.01	3.70 ± 0.06
T_2 (90: 10:: GCF: RPF)	2.86 ± 0.04	8.08 ± 0.28	14.73 ± 0.09	2.08 ± 0.01	2.71 ± 0.01	69.14 ± 0.24	2.49 ± 0.01	2.90 ± 0.11
T_3 (80: 20:: GCF:RPF)	2.57 ± 0.06	9.94 ± 0.04	16.24 ± 0.04	2.56 ± 0.01	3.12 ± 0.02	64.27 ± 0.07	2.92 ± 0.01	2.77 ± 0.04
T_4 (70: 30:: GCF:RPF)	2.16 ± 0.05	14.12 ± 0.02	17.19 ± 0.09	2.73 ± 0.01	4.43 ± 0.06	58.71 ± 0.13	4.18 ± 0.01	2.75 ± 0.06
T_5 (100:0:: FCF: RPF)	3.23 ± 0.03	3.77 ± 0.20	11.05 ± 0.02	1.80 ± 0.01	1.97 ± 0.01	78.18 ± 0.15	1.09 ± 0.01	3.76 ± 0.05
T_6 (90:10:: FCF: RPF)	2.91 ± 0.08	8.05 ± 0.27	14.32 ± 0.13	1.97 ± 0.01	2.51 ± 0.01	69.82 ± 0.24	2.66 ± 0.01	3.08 ± 0.01
T_7 (80:20:: FCF: RPF)	2.79 ± 0.06	9.89 ± 0.06	16.15 ± 0.23	2.33 ± 0.02	2.93 ± 0.01	64.56 ± 0.34	2.97 ± 0.01	2.98 ± 0.01
T_8 (70:30:: FCF: RPF)	2.39 ± 0.16	13.16 ± 0.01	16.80 ± 0.16	2.65 ± 0.02	4.29 ± 0.02	60.04 ± 0.20	4.21 ± 0.01	2.96 ± 0.04
C.D. (p=0.05)	0.23	0.58	0.36	0.04	0.07	0.71	0.04	0.17

protein in various products content ranged between 11.05±0.02 % and 17.19±0.09 % and highest protein content was present in T_4. The increase in protein content during germination and fermentation may be due to synthesis of proteins/enzymes or a compositional change following the degradation of other constituents (Steve and Olufunmiayo, 2011).

The increase in protein could also be attributed to a net synthesis of enzymic protein (e.g. proteases) by germinating seeds (Nzeribe and Nwasike, 1995). Highest crude fibre of 2.73±0.01 % was obtained in $T_{4.}$ while the lowest crude fibre was recorded 1.80±0.01 % in T_5. Lorri and Svanberg (1991) observed that fermentation decreased starch content and long chain fatty acids along with non-digestible plant components (fibre), thus improving food utilization efficiency and nutritional quality. Ademulegun and Koleosho (2008) have found utilization of carbohydrates in the seed during sprouting leaves a high fibrous seed. There was a significant improvement in the ash content of the blends as substitution of peanut increased and the ash content ranged between 1.97±0.01 to 4.43±0.06 % and highest crude fibre was recorded in T_4.

Similar results were reported by Gernah *et al.* (2011) in case of maize. Carbohydrate of various blends ranged from 58.71±0.13 to 78.18±0.15 % and the lowest carbohydrate 58.71±0.13 % was recorded in $T_{4.}$ The decreased carbohydrate levels of the germinated seeds might be due to increase in α- amylase activity (Lasekan, 1996). β-carotene increased from 1.04±0.01 mg/100g in T_1 to 4.21±0.01 mg/100g in T_8 at 30% peanut substitution. Similar results had also been reported by Takyi (1999) in stew (Cereal/yams + leafy vegetable + 1 dry roasted fish + fat i.e shea butter) in which it was found that sample with high content of fat reported high β-carotene. of Our results are in agreement with that of Jalal *et al.* (1998) who found that increasing dietary fat concentrations should be considered along with increasing the consumption of **β-**carotene-rich foods. Inactivation of certain oxidative enzymes takes place during fermentation which results in the breakdown of some structures leading to a higher bioavailability of β-carotene (Guerra–Vargas *et al.* 2001). Rehydration ratio showed decreasing trend with increase in peanut content, maximum rehydration ratio was 3.76±0.05 in T_5. Increases in protein content with relative decrease in starch content may influence the extent of starch gelatinization during extrusion processing leading to a decrease in relative water absorption (Yagci and Gogus, 2008). This phenomenon may cause a decrease of rehydration rate of flakes with the increase in peanut flour content in blends. Similar behaviour of rehydration ratio was shown by Sirawdink and Ramaswamy (2011) in protein rich extruded products from tef, corn and soy protein isolate blends.

Anti-nutritional factors: The phytic acid content of corn-peanut flakes varied significantly as peanut substitution level increased (Table 2). The lowest phytic acid of 0.051±0.001 g/100g was recorded in T_5 and highest of 0.094±0.001 g/100g was recorded in T_4. It has been reported that an appreciably high amount of protein was observed to be associated with phytic content and it was found that as the protein content increased, phytate levels also increased (Reddy and Pierson, 1994). Coulibay *et al.* (2011) reported that excess of 800 mg phytic acid per day is probably not good. Scientific studies have established that processing methods such as cooking, dehulling, soaking, fermentation and germination improve the nutritional quality of food products by reducing or eliminating the anti-nutrient composition of the food products (Anju and Khetarpaul, 2008; Syed *et al.* 2011). The tannin content ranged between 0.084±0.001 g/100g and 0.122±0.001 g/100g and treatment T_8 recorded the lowest tannin. The reduction in tannins during fermentation can be attributed to the microbial degradation compounds or due to less extractable tannin-protein complex (Emmambux and Taylor, 2003).

Mineral composition: Table 2 presents the minerals content of flakes which increased with increased peanut flour content in the flakes. The highest calcium, zinc and iron was 17.39±0.02, 0.98±0.01 and 0.86±0.01 mg/100g in T_4 respectively. This observation is similar to other investigators who have reported that germination increases retention

Table 2: Mineral and anti-nutritional compounds (mg/100g) in corn-peanut blended flakes

Treatment	Calcium	Zinc	Iron	Phytic acid (g/100g)	Tannins (g/100g)
T_1 (100:0:: GCF: RPF)	7.15±0.01	0.42±0.06	0.38±0.01	0.074±0.001	0.122±0.001
T_2 (90: 10:: GCF: RPF)	10.94±0.01	0.62±0.01	0.51±0.01	0.077±0.001	0.111±0.001
T_3 (80: 20:: GCF:RPF)	14.60±0.01	0.86±0.01	0.73±0.01	0.083±0.001	0.095±0.001
T_4 (70: 30:: GCF:RPF)	17.39±0.02	0.98±0.01	0.86±0.01	0.094±0.001	0.087±0.001
T_5 (100:0:: FCF: RPF)	7.06±0.01	0.45±0.10	0.36±0.01	0.051±0.001	0.115±0.001
T_6 (90:10:: FCF: RPF)	10.86±0.01	0.60±0.03	0.49±0.01	0.055±0.001	0.102±0.001
T_7 (80:20:: FCF: RPF)	14.41±0.01	0.84±0.02	0.69±0.01	0.068±0.001	0.088±0.001
T_8 (70:30:: FCF: RPF)	17.29±0.02	0.94±0.01	0.83±0.01	0.073±0.001	0.084±0.001
C.D. (p=0.05)	0.03	0.11	0.01	0.002	0.002

Table 3: Colour value in corn-peanut blended flakes

Treatment	L	a*	b*
T_1 (100:0:: GCF: RPF)	65.89±0.27	18.73±0.01	21.53±0.01
T_2 (90: 10:: GCF: RPF)	64.43±0.50	21.43±0.01	23.43±0.01
T_3 (80: 20:: GCF:RPF)	62.03±0.81	23.73±0.01	24.83±0.01
T_4 (70: 30:: GCF:RPF)	60.13±0.61	24.63±0.01	25.23±0.01
T_5 (100:0:: FCF: RPF)	65.59±0.83	21.83±0.01	26.93±0.01
T_6 (90:10:: FCF: RPF)	64.09±1.32	22.93±0.01	26.53±0.01
T_7 (80:20:: FCF: RPF)	62.63±0.99	22.23±0.01	26.53±0.01
T_8 (70:30:: FCF: RPF)	60.29±1.03	23.83±0.01	25.83±0.01
C.D. (p=0.05)	2.58	0.03	0.02

of all minerals and B-complex vitamins compared to other processing methods (Egli, 2001; Helland *et al.* 2002; El-Adawy 2002).

Colour: It is an important quality parameter of flakes. When considering colour evaluation it was evident that addition of peanut decreased L-value whereas increased a* value of corn peanut blended flakes. In Table 3 it could easily be seen that highest value of L (65.89±0.27) and a* (18.73±0.01) was recorded in T_1, while the highest value of b* (26.93±0.01) was recorded in T_5. Similar results have been reported in chiffon cake with addition of konjac flour and SPI by Akesowan (2010). Longer period of germination (36 and 48 h) resulted in lower L of flour. This is probably due to enzymatic browning that occurs during germination (Borijindakul and Phimolsiripol, 2013). The millards reaction involves the reaction between aldehydes and amines, resulting in the formation of dark pigments (melanoidins), (Alais and Linden, 1991) which affect the colour of flakes.

Sensory evaluation: Taste scores were significantly different for product containing 10%, 20% and 30% peanut substitution level, the taste significantly improved among the blends with increased amount of peanut (Table 4). Flakes containing peanut upto 30 % was rated the best i.e T_3. The addition of peanut at different levels however altered textural properties of different treatments. The maximum score of 8.95±0.01 was recorded in T_2 and the minimum score of 8.14±0.01 in T_8. Appearance of corn-peanut blended flakes was significantly influenced by different treatments. Maximum score of 8.20±0.01 was recorded for T_7 and the minimum score of 7.87±0.01 in T_1. Data (Table 4) regarding overall acceptability

Table 4: Sensory evaluation of corn-peanut blended flakes

Treatment	Taste	Texture	Appearance	Overall acceptability
T_1 (100:0:: GCF: RPF)	7.55±0.02	8.87±0.01	7.87±0.01	8.10±0.01
T_2 (90: 10:: GCF: RPF)	8.65±0.01	8.95±0.01	8.03±0.01	8.54±0.01
T_3 (80: 20:: GCF:RPF)	8.95±0.01	8.64±0.02	8.13±0.01	8.57±0.01
T_4 (70: 30:: GCF:RPF)	8.26±0.01	8.32±0.01	8.02±0.02	8.20±0.01
T_5 (100:0:: FCF: RPF)	7.48±0.01	8.81±0.01	7.91±0.01	8.07±0.01
T_6 (90:10:: FCF: RPF)	8.56±0.01	8.93±0.01	8.07±0.01	8.52±0.01
T_7 (80:20:: FCF: RPF)	8.84±0.01	8.56±0.01	8.20±0.01	8.53±0.01
T_8 (70:30:: FCF: RPF)	8.02±0.00	8.14±0.01	8.04±0.02	8.06±0.01
C.D. (p=0.05)	0.04	0.03	0.04	0.02

GCF- Germinated corn flour; RPF- Roasted peanut flour; FCF- Fermented corn flour.

of corn-peanut flakes showed that the highest score of 8.57±0.01 was recorded in T_3 followed by 8.54±0.01 in T_2 and the minimum score of 8.06±0.01 in T_8. The flavour, taste and texture were improved with greater proportions of germinated ingredient over fermented ingredient. Subsequently, the germinated-mixtures had higher scores for overall acceptability. This implies that the raw flavour, that has always been a hindrance in acceptability, was suppressed by the malted flavour. Mtebe *et al.* (1993) have previously observed an improvement in flavour and level of consumer preference when malted finger millet was mixed with un-germinated flours from other cereals.

CONCLUSION

The flakes prepared in treatment T_3 (80: 20:: GCF:RPF) had desirable nutritional quality, as well as anti-nutrient composition and sensory properties. Hence, it can be recommended that roasted peanut upto 20% can be used in combination with germinated corn for producing of flakes which will prove to be of immense benefit for population of all age groups in developing countries, because of their low cost and ease of preparation.

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