INCORPORATION OF PEANUT PASTE AS SMOTHERING IN POPCORN PRODUCTION.

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ABSTRACT
Thisstudy investigated the impact of incorporating peanut paste as smothering in popcorn production. The popcorn samples were respectively produced by substituting butter with peanut paste in the ratio 100:0, 60:40, 50:50, 40:60 and 30:70. Proximate analysis of the samples showed moisture(8.48% to 9.50%), fat(5.10% - 7.43%), ash(3.73% - 3.97%), fiber(4.58% - 4.76%), protein(7.77% – 9.10%)and carbohydrate(68.01% to 67.55%). Results revealed that the protein, fiber and ash contents increased significantly ($p<0.05$) as the incorporation of peanut paste increased. The addition of peanut paste also led to significant ($p < 0.05$) increase in phosphorus(299.68mg/100g – 304mg/100g), calcium(48.33mg/100g –50.66mg/100g), iron(4.86mg/100g -5.19mg/100g), potassium(324.89mg/100g – 327.31mg/100g) and magnesium(107.92mg/100g – 112.39mg/100g). Enhancement of vitamin A(2.76µg – 3.06µg), vitamin C(0.37mg/100g – 0.69mg/100g), vitamin E(20.33 mg/100g–20.69mg/100g), thiamine(4.04mg/100g – 4.33mg/100g), vitamin B2(5.66mg/100g – 6.26mg/100g) and vitamin B3(1.69mg/100g – 5.50mg/100g) were respectively observed.Organoleptic assessment of the products proved that samples with 30%, 50% and 60% substitution of butter with peanut paste were all rated higher in taste, appearance, aroma and general acceptability than the sample with 70% peanut substitution. The findings of this study concisely proved the dual suitability of peanut paste in popcorn production in terms of nutrient enhancement and consumer acceptability.

Keywords: Popcorn, Peanut paste, Butter, Nutrient composition, Organoleptic attributes.

INTRODUCTION

Popcorn, also known as popping corn, is a special variety of corn (Zea mays,everta) first found in Mexico about 10,000 years ago. Its starchy endosperm contains 14 -20% moisture, which turns to steam and expands when heated, thereby causing the kernel to explode and flip inside out. This distinguishes it from other varieties and makesit suitable for the production of "popcorn", a whole grain food consumed largely as a snack (Sweley, 2011). It contains some nutrients considered very important for human health. It yields significant amounts of fiber and polyphenols that support blood circulation, digestion and reduction of the incidence of prostate and breast cancer (Susan *et al*., 2013; Jinchen*get al*., 2015). Consumption of whole grains has been proved to reduce inflammation and risk of heart disease. But popcorn is less known and valued for these benefits by majority of the consumers who merely appreciate its sweetness and convenience.It is mixed with toasted peanut and hawked as a delicacy along some streets in Nigeria thus providing a casual job for some teenagers.

Toasted peanut is ground to produce the peanut paste whichis rich in protein, carbohydrate, unsaturated fatty acids, folate, niacin, pantothenic acid, pyridoxine, riboflavin, thiamin, manganese, phosphorus, selenium, copper, iron and zinc.As a legume product, it can improve thenutritional composition of most cereal foods which are lower in essential amino acids and some minerals such as calcium, potassium, iron and zinc if blended or included in the formulation (Shalini*et al*., 2016).Peanut paste is a great source of resveratrol, phenolic acids, flavonoids, and phytosterols that constantly stop the absorption of cholesterol from the foodwhereascholesterol in the butter commonly used for the production of popcorn can accumulate and cause heart attack.Also the B-sitosterol contained in peanut paste helps in fighting against cancer (Beesabathuni and Natchu, 2010) and could therefore make a healthy food by being consumed or included in composite (Griel*et al*., 2004).

Regrettably, popcorn is very often produced with high quantities of butter or margarine (including artificial butter) most of which are hydrogenated or partially-hydrogenated. Trans fats contained in such butter increase the risk of heart diseases and other health complications, whereas peanut consumption improves indices of cardiovascular diseases (Alper and Mattes, 2003). Also, in-order to reduce cost and maximize profit, some unscrupulous producers of popcorn apply artificial butter flavoring. Thiscontains diacetyl implicated with lung diseases and offers no nutritional value (Daniel *et al*., 2008; Zaccone*et al*., 2013). Thus the supposed healthy food(popcorn) turns unhealthy.On this, Shalini*et al*. (2016) suggested that organizational initiatives and greater commercialization of peanut products can be taken as a dual approach to build a healthy population; via production and consumption of healthy foods. This could be achieved by total elimination or reduction of unhealthy food constituents and incorporation of healthy materials. Therefore the main objective of this study is to evaluate the quality of popcorn produced with peanut

paste as substitute to the widely used commercial butter.

Materials and Method

The popcorn samples were produced with corn (1.5kg), sugar(75g), butter/peanut paste(100g), and milk(100g).The samples were each analyzed for vitamins and proximate compositions using the method of AOAC (2010). The carbohydrate was derived by subtracting the sum of other proximate components,protein, fat, ash and fibre on dry weight basis from 100. Mineral analysis was done using flame spectrophotometer, model AA 7000 while the organoleptic attributes were evaluated using a hedonic scale as described by Ihekoronye and Ngoddy (1985). The results were analyzed with the Statistical Package for Social Science (SSPS) Window 17.0. One-way analysis of variance (ANOVA) was employed to determine the means and standard deviations. Determination of least significant differences (LSD) and separation of means were carried out as described by Ihekoronye and Ngoddy (1985).

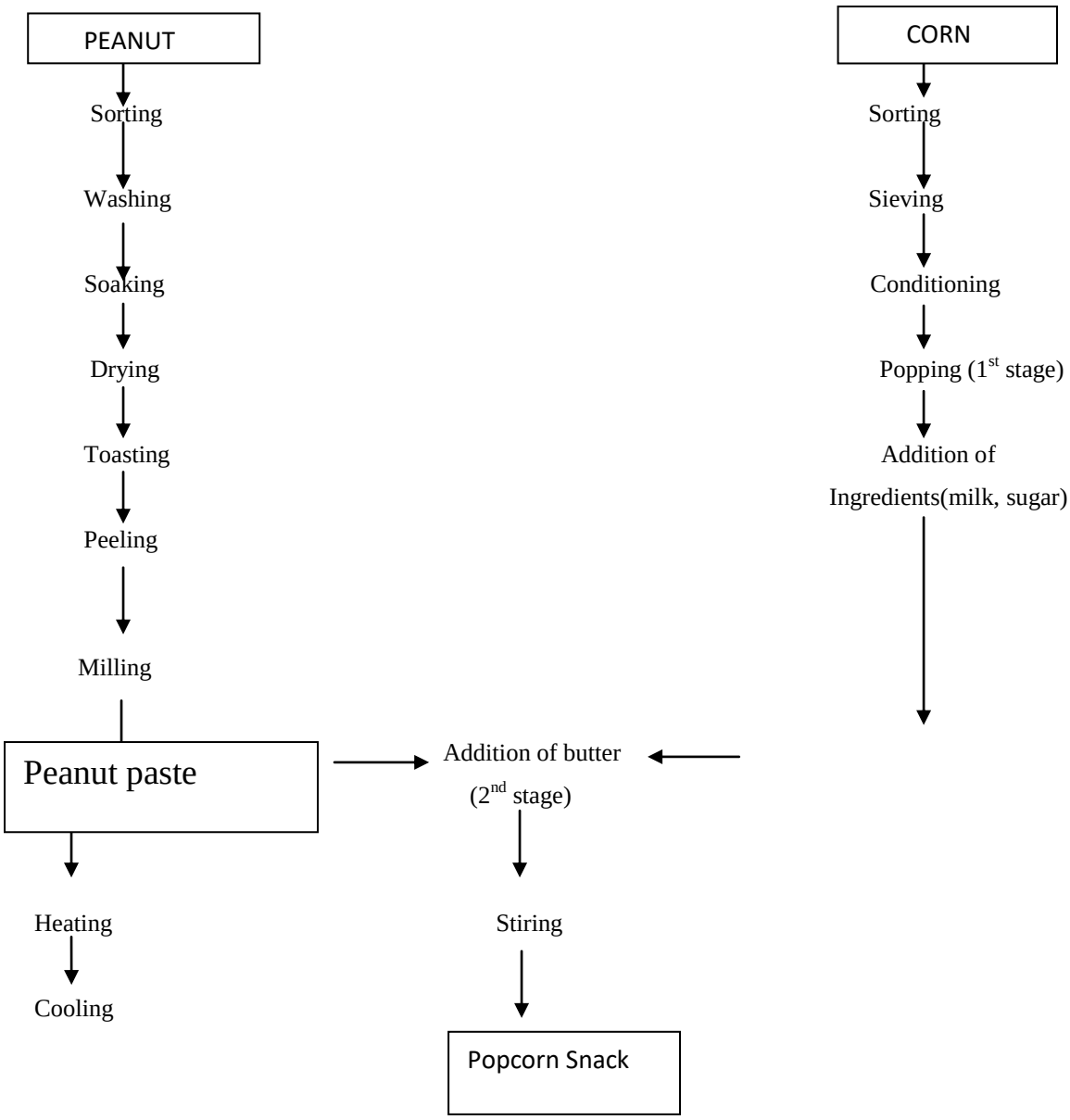

Fig. 1: Production of popcorn

RESULTS AND DISCUSSION

Proximate composition of popcorn samples

Moisture content of the popcorn samples was within 8.48% to 9.50%. Products with higher quantity of peanut paste had more moisture content. Similar trend of result was reported by Sudha*et al*. (2007) where peanut butter was used to substitute margarine in biscuit production. This increase in moisture content was attributed to higher amount of fibre in peanut butter because fibre has strong affinity for water and products containing fibre. Moisture level of popcorn should be regulated to avoid stickiness and loss of crispiness or poor texture.

The protein content of the popcorn samples ranged from 7.77%-9.11% (Table 1). The result shows that the addition of peanut pastesignificantly ($P < 0.05$) improved the protein content of the popcorn. This justifies the assertion of Asibuo*et al.* (2008) that groundnut provides an inexpensive source of high quality dietary protein. Therefore food preparations incorporating groundnut could improve the protein level and help in reducing malnutrition.Also incorporation of peanut paste significantly($P < 0.05$) enhanced the fibre content of the popcorn samples.The fibre increased proportionally as peanut addition increased. This suggests that peanut paste containshigher fiber than butter. The fiber levels varied from 4.58% to 4.76%.The result agrees with the fact that popcorn as a whole grain is high in fibre (4.58%). Fibre in foods aids digestion and helps to fight against cancer.Significant ($P < 0.05$) decrease from 7.73% to 5.10% in fat content was observed as the substitution of butter with the peanut paste increased. Fat in popcorn is a smothering agent. It aids palatability and flavor. Ash content of the popcorn samples ranged from 3.73% to 3.97%. The ash content of the popcorn samples increased with the addition of higher quantities of peanut paste. The result corresponds with the work of Olawuni*et al*. (2019). This also justifies the report of Alabi and Anuonye (2007) that legumes are good sources of ash. Ash level of foods may be an index of mineral concentration. This therefore suggests that inclusion of peanut paste could improve the mineral concentration of the popcorn samples.The carbohydrate content of the popcorn samples decreased as addition of peanut paste increased. But the values (68.01% to 67.55%) proved that the popcorn samples could still serve as good sources of energy to its consumers.This finding corresponds with the work of Olawuni*et al*. (2019) in which peanut butter was incorporated as shortening for biscuit production.

Table 1: Proximate composition of popcorn sample

SAMPLE	MOISTURE CONTENT (%)	PROTEIN (%)	FAT (%)	FIBRE (%)	ASH (%)	CHO (%)
A	**$8.48^{d}\pm0.06$**	**$7.77^{d}\pm0.02$**	**$7.43^{a}\pm0.01$**	**$4.58^{c}\pm0.06$**	**$3.73^{d}\pm0.02$**	**$68.01^{a}\pm0.15$**
B	**$8.88^{c}\pm0.01$**	**$8.37^{c}\pm0.08$**	**$6.69^{b}\pm0.04$**	**$4.60^{bc}\pm0.04$**	**$3.80^{c}\pm0.03$**	**$67.66^{ab}\pm0.20$**
C	**$9.05^{c}\pm0.04$**	**$8.57^{b}\pm0.04$**	**$6.10^{c}\pm0.03$**	**$4.68^{ab}\pm0.07$**	**$3.89^{b}\pm0.01$**	**$67.60^{b}\pm0.16$**
D	**$9.24^{b}\pm0.05$**	**$9.06^{a}\pm0.06$**	**$5.50^{d}\pm0.06$**	**$4.72^{a}\pm0.03$**	**$3.91^{ab}\pm0.03$**	**$67.57^{b}\pm0.06$**
E	**$9.50^{a}\pm0.06$**	**$9.12^{a}\pm0.05$**	**$5.10^{e}\pm0.04$**	**$4.76^{a}\pm0.02$**	**$3.97^{a}\pm0.02$**	**$67.55^{b}\pm0.08$**
LSD	**0.18**	**0.08**	**0.14**	**0.10**	**0.07**	**0.39**

Values are means of triplicate analysis and standard deviation. Means on the same column with the same superscript are not significantly ($p>0.05$)different.

WHERE

A =Popcorn produced with 0% peanut paste
B =Popcorn produced with 40% peanut paste
C =Popcorn produced with 50% peanut paste
D =Popcorn produced with 60% peanut paste
E =Popcorn produced with 70% peanut paste

Vitamin composition of popcorn samples.

The vitamin A content of the popcorn samples significantly ($p < 0.05$) differ due to the inclusion of peanut paste. Samples with higher quantity of peanut paste have higher vitamin A levels. The result showed increase from 2.76µg – 3.06µg. A similar trend of result was observed for vitamin C which ranged from 0.37mg/100g to 0.67mg/100g.The products may not be considered good sources of vitamin C because the values are too low compared to 60mg and 100mg of vitamin C recommended daily for non-smoking adults and smokers respectively (Tamborlane*et al.*, 1997). Vitamin E content of the popcorn samples also increased significantly ($p<0.05$) as the substitution of butter with peanut paste increased. Vitamin E increased from 20.33mg/100g to 21.10mg/100g. This increase couldimply that peanut paste is richer in vitamin E than butter (Geulein, 2010). Vitamin E is an important antioxidant considered as anti-aging. It

also aids the vitality of reproductive organs and is also involved in immune function and regulation of certain metabolic processes (Gao*et al*., 2006).Fair concentrations (4.04mg/100g – 4.43mg/100g) of thiamine were found in the respective samples. Significant ($p < 0.05$) differences were observed across the samples as the incorporation of peanut paste increases. Thiamine is required for metabolism of glucose, amino acid and lipid (Leblanc *et al.*, 2011).

The least amount of vitamin B2 (5.66mg/100g) was found in sample Acontaining 0% peanut paste while the highest value (6.26mg/100g) was recorded for the popcorn with the highest quantity (50%) of peanut paste. Incorporation of peanut paste also caused enhancement of niacin from 0.74mg/100g to 1.25mg/100g. Niacin is a micronutrient that the body uses for proper metabolism, nervous system function and protection of antioxidants. Recommended dietary allowance for the vitamin is 0.9 – 1.6 on daily basis (USDA, 2002). The popcorn samples could therefore be recommended for any population where niacin deficiency is worrisome.

Table 2: **Vitamin composition of popcorn samples**

Samples	Vit. A (mg/100g)	Vit. C (mg/100g)	Vit. E (mg/100g)	Vit. B1 (mg/100g)	Vit B2 (mg/100g)	Niacin (mg/100g)
A	**$2.76^{c}\pm0.02$**	**$0.37^{d}\pm0.04$**	**$20.33^{d}\pm0.02$**	**$4.04^{e}\pm0.06$**	**$5.66^{e}\pm0.03$**	**$0.74^{e}\pm0.03$**
B	**$2.85^{bc}\pm0.04$**	**$0.48^{c}\pm0.01$**	**$20.67^{c}\pm0.02$**	**$4.15^{d}\pm0.04$**	**$6.09^{d}\pm0.04$**	**$0.82^{d}\pm0.04$**
C	**$2.93^{b}\pm0.02$**	**$0.57^{b}\pm0.05$**	**$20.75^{bc}\pm0.07$**	**$4.25^{c}\pm0.06$**	**$6.14^{c}\pm0.02$**	**$0.91^{c}\pm0.04$**
D	**$2.99^{b}\pm0.08$**	**$0.60^{b}\pm0.03$**	**$20.80^{b}\pm0.04$**	**$4.32^{b}\pm0.05$**	**$6.19^{b}\pm0.04$**	**$1.11^{b}\pm0.05$**
E	**$3.06^{a}\pm0.05$**	**$0.67^{a}\pm0.02$**	**$21.10^{a}\pm0.06$**	**$4.43^{a}\pm0.01$**	**$6.26^{a}\pm0.03$**	**$1.25^{a}\pm0.03$**
LSD	**0.10**	**0.05**	**0.08**	**0.06**	**0.05**	**0.01**

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly ($P < 0.05$) different.

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E =Popcorn produced with 70% peanut paste

Mineral composition of popcorn samples

The iron content of the popcorn samples fell within 4.86mg/100g- 5.19mg/100g. Sample E had the highest value (5.19mg/100g) while sample A had the least (4.86mg/100g). The result suggests that peanut paste is richer in iron content than butter. Also the products may serve well for both children and adults considering the assertion that the maximum tolerable iron intake for adults and children are respectively 9-17mg/day and 1-5mg/day.Iron is involved in oxygen transport and helps regulate cell growth and differentiation (Beard, 2001).High value of potassium was recorded for each of the samples. Sample E had the highest value, 325.31mg/100g followed by sample D(325.18mg/100g), sample C(325.07mg/100g), sample B (324.93mg/100g) and sample A(324.89mg/100g). There was significant ($p < 0.05$) increase in the calcium content of the popcorn samples due to the addition of peanut paste**.** The values ranged from 48.33mg/100g to 50.66mg/100g. Calcium is necessary for healthy bones and teeth, muscles relaxation and contraction, nerve functioning, blood clotting and blood pressure regulation (Brotto, 2011).Similar trends of increase from 107.92mg/100g – 108.39mg/100g and 299.68mg/100g – 300.10mg/100g were each observed for magnesium and phosphorus. This implies that the inclusion of peanut paste in popcorn production improves its magnesium and phosphorus contents. Magnesium helps to keep the heart rhythm steady and promotes normal blood pressure. A number of studies have shown that magnesium intake is associated with reduced inflammation and a decreased risk of metabolic syndrome and type 2 diabetes(Lopez-Ridaura *et al*., 2004).Phosphorus is essential to life in several different ways. It primarily aids formation of bones and teeth, synthesis of protein for the growth, maintenance, and repair of cells and tissues. Phosphorus is the second most abundant mineral in human bodies, representing about 1% of the total body weight (Calvo and Lamberg-Allardt, 2015).

Table 3: **Mineral composition of popcorn samples**

Samples	Phosphorous (mg/100g)	Calcium (mg/100g)	Iron (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)
A	**299.68^{e}±0.04**	**48.33^{d}±0.05**	**4.86^{c}±0.02**	**324.89^{c}±0.05**	**107.92^{e}±0.04**
B	**299.79^{d}±0.04**	**49.40^{c}±0.06**	**4.91^{c}±0.04**	**324.93^{c}±0.07**	**109.11^{d}±0.09**
C	**301.80^{c}±0.06**	**49.49^{bc}±0.13**	**5.01^{b}±0.05**	**325.07^{c}±0.04**	**110.18^{c}±0.03**
D	**302.99^{b}±0.05**	**50.55^{ab}±0.08**	**5.08^{b}±0.03**	**326.18^{b}±0.09**	**111.26^{b}±0.02**
E	**304.00^{a}±0.08**	**50.66^{a}±0.01**	**5.19^{a}±0.10**	**327.31^{a}±0.15**	**112.39^{a}±0.03**
LSD	**0.06**	**0.14**	**0.09**	**0.22**	**0.12**

A =Popcorn produced with 0% peanut paste
B =Popcorn produced with 40% peanut paste
C =Popcorn produced with 50% peanut paste
D =Popcorn produced with 60% peanut paste
E =Popcorn produced with 70% peanut paste

Sensory qualities of popcorn samples

The sensory characteristics of the popcorn samples which includes appearance, texture, aroma, taste and overall acceptability was each assessed by 30panelists with the use of a hedonic scale. Sensory scores for appearance of the popcorn samples ranged from 5.17 to 7.10. The statistical analysis revealed that there was no significant difference ($p > 0.05$) among samples A, B, C and D.The panelist showed preference for the appearance of sample B (40% peanut paste). Lightbrownish colour of the popcorn sample could be due to the addition of peanut paste. Sample with the highest quantity (70%) of peanut paste was least scored for colour. The sample was too brownish and appeared falsely burnt. The scores for aroma of the popcorn samples were within 5.77 to 7.43 with sample B having the highest score (7.43) while sample E had the lowest score (5.77).Substitution of butter with peanut paste also led to significant ($p < 0.05$) variation in the mouthfeel of the samples. Sample with 40% substitution was preferred to all others. The least appreciated was the popcorn produced with 70% level of substitution. It was also observed that addition of peanut paste significantly ($p < 0.05$) enhanced the taste of the samples. Sample B which contains the least quantity (40%) of peanut paste had the highest score (7.60), followed by sample C (7.5) produced with 50% peanut paste. Sample B had the highest overall acceptability score of 8.70 and was significantly ($p < 0.05$) appreciated more than other samples. The overall acceptability has to do with the consumer's acceptance of the product.

Table 4: Sensory qualities of popcorn samples

SAMPLE	APPEAR-ANCE	AROMA	TASTE	MOUTH-FEEL	OVERALL ACCEPTABILITY
A	**6.87^{a}**	**6.50^{bc}**	**6.23^{b}**	**6.40^{bc}**	**6.37^{d}**
B	**7.10^{a}**	**7.43^{a}**	**7.60^{a}**	**6.87^{ab}**	**8.70^{a}**
C	**7.03^{a}**	**7.27^{a}**	**7.50^{a}**	**7.33^{a}**	**8.53^{b}**
D	**6.93^{a}**	**6.87^{ab}**	**7.17^{a}**	**7.40^{a}**	**8.20^{c}**
E	**5.17^{b}**	**5.77^{c}**	**6.00^{b}**	**6.00^{c}**	**5.90^{e}**
LSD	**0.61**	**0.74**	**0.74**	**0.57**	**0.15**

A =Popcorn produced with 0% peanut paste
B =Popcorn produced with 40% peanut paste
C =Popcorn produced with 50% peanut paste
D =Popcorn produced with 60% peanut paste
E =Popcorn produced with 70% peanut paste

CONCLUSION

The result of this work showed that production of popcorn with peanut paste increased most of the nutrients in the popcorn samples such as protein, ash,fibre, vitamins and minerals. This proved that the nutritional value of popcorn can be enhanced through the incorporation of peanut paste. The observed nutrient enhancement suggests that consumption of the product may prevent or ameliorate both macro and micro nutrient deficiencies. Organoleptic assessmentof the samples revealed their wide

acceptability especially samples produced with less than 60% substitution of butter with peanut paste. Therefore the use of peanut paste in the production of popcorn is recommended as well as its inclusion in the formulation of other foods.

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