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PieCrust Developed from Lemon Peel Fat Replacer

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Abstract: *The aim of this research was to analyse the chemical, colorimetric and sensory properties of pie crust incorporated with lemon-derived fat replacer. Results showed that the fat replacer had dietary fibre content of 14 % and ahigh water holding capacity, (86 %). The pectin content of the lemon peel was found to be 21.26 % which is very high. Sensory evaluation of pie crusts consisting of different proportions of lemon peel as a substitute for fat revealed that pie crusts prepared with 0 and 5 % fat replacer had the highest level of acceptance for all sensory attributes.*
Keywords: *Lemon peel, pectin, dietary fibre, fat replacer,pie crust.*

I. Introduction

Citrus is one of the most important fruit crops and is consumed as fresh fruit or in the form of juice because of the nutritional value it adds to food(Dugo and Giacomo, 2002).Many biologically active substances can be found in citrus fruits and they include folic acid, carotenoids, vitamin C, dietary fibre, potassium and other phytochemicals (WHO, 2003).

Dietary fibre plays an important role in human health due to their role in the prevention, reduction and treatment of diseases such as diabetes and heart diseases (Anderson et al., 1994).This has led to an increase in the daily level (25-30 g/day) of dietary fibre in the diet. The addition of fibre in foods that are mostly consumed could help overcome the fibre deficit (Fernandez- Gineset al., 2003).One of the major causes of obesity is the intake of fatty and high-calorie foods. Other causes include physical inactivity, genetics and socio-cultural factors. Obesity is becoming a major problem in some regions and among certain group of people in Ghana. Amoah (2003) conducted a research in some urban and rural areas in Accra and found that the rate at which overweight and obesity occur was 23.4 % and 14.1 % respectively among adults aged 35 years and above. He also found that, obesity increased with age up to 64 years and that there were more people who were overweight and obese in the urban high-class residents compared with the low-class residents. People with tertiary education had the highest prevalence of obesity compared with less literate and the illiterate.

This study was designed to evaluate the proximate, water holding capacity and pectin content of lemon peel flour and the effect of their incorporation at different levels (0-40 %) on the sensory attributes and the calorimetric properties of pie crusts.

II. Materials And Methods

Lemon fruits (rough lemons) used in this study were obtained from a local farm in Ghana..

Preparation of fat replacers

Matured, green lemon fruits were harvested and washed with water to remove dirt. They were then sorted to remove undesirable ones and peeled with clean knife. The peels (albedo) were dried using solar dryer until constant moisture content was attained and the dried sample milled into a smooth powder. The fat replacer (powder) was packaged in high density polyethylene bags and stored.

Preparation of pie crusts

The dry ingredients were measured into a mixing bowl and the fat was rubbed onto the soft wheat flour. Salt solution was measured and added to the mixture to obtain the required dough. The dough was rolled on a board and cut into shapes and one-half of the cut dough folded on the other and sealed with a fork. They were arranged on a prepared baking sheet and baked in a preheated oven for 40 min and cooled. Subsequent pie crusts prepared had some of the fat substituted with fat replacer.

Analytical Methods

Proximate composition was estimated using AOAC (1990) and method proposed by Kirk and Sawyer (1991).The water-holding capacity was determined according to a method by Anderson et al. (1969). One gram of lemon peel flour was weighed into a 50 mL centrifuge tube and 25 mL of water added and stirred for 30

minutes. The mixture was then centrifuged at 2500 rpm for 10 minutes and the supernatant removed. The weight of the pulp was recorded and water-holding capacity calculated.

Sensory analyses on reduced fat pie crusts

Fifty untrained panellists participated in the sensory evaluation and consisted of twenty-eighty (28) women and twenty-two (22) men. The ages of the panellists ranged between 20 – 50 years. The selection criteria were based on good health, availability, interest and no likeness for the products. All panellists used a numerical intensity scale (1 = dislike extremely 9 = like extremely) to rate each attribute across the 6 samples. Each sample was given a three (3) digit code and presented in white polystyrene plates. The order of presentation was randomized to reduce position effects. Rinse water presented in transparent cups and unsalted crackers presented in white polystyrene plates were given to the panellists for cleansing of the palate between samples. All evaluations were conducted in isolated sensory booths illuminated with white incandescent lighting. Panellists were provided with questionnaires on which they ticked in the 9 point scale to show the intensity of the rating for each sample attribute. All statistical analyses were performed with the MS Excel and Minitab software. Individual ANOVAs were conducted on each attribute rated by panellists to determine the difference among treatments. Fisher's least significant difference (LSD) at $p \leq 0.05$ was used to compare sample means.

Colour measurements

Surface colour of the baked lemon pie crust samples were measured using the CIE colour scale. The CIE colour scale measured the degree of lightness L* (black [0] to light [100]), a* (red [60] to green [-60]), b* (yellow [60] to blue [-60]) using a Chroma Meter CR- 310 (Minolta Co. Ltd., Osaka, Japan). The Chroma Meter was standardized using a white (Y= 93.7, x= 0.3138 and y= 0.3194) standard plate. Three samples were used per experiment.

III. Results And Discussion

Chemicalanalyses on the lemon peel-derived fat replacer yielded 21.26 % pectin as shown in Table1, showing the fat replacing potential of lemon peels. A research conducted by Lerotholi (2009) reported pectin content of 22.22 % from dried lemon peels. The lemon peels also contained high amount of dietary fibre, (14%) and carbohydrate, (71.50 %), while it had low contents of fat,(0.05 %), protein, (1.50 %) as well as ash content of (2.13 %). Marin et al. (2007) reported high amount of dietary fibre from the solid residue of citrus× limon. The water holding capacity of lemon peels was 86 %, an indication that the fibre in the lemon peels interacted and held water strongly to form gel and so this lemon peels could potentially be used as a functional ingredient to modify the texture of formulated foods.

With respect to colorimetric evaluation, for the L*values, no significant difference ($P \geq 0.05$)was observed when product A (0 %) was compared with all the other products (Fig.1). However, pie crust with 5% fat replacement had the highest L*value whilepie crust with 40% fat replacement recorded the least L* value of64.48. Yi et al. (2009) stated that the most desirable crust colour of pastry (bread) should be golden brown. The mean L* values were found to range from 70.99-64.48. Generally, the pie crusts containing more fat were found to be lighter than those with less fat. Wafaa et al. (2011) reported that cakes and cookies prepared with pectin fat replacer decreased in L* value with increasing levels of fat replacement. It was however reported that, L* values for 25, 50 and 75% substitution were higher than that of the control.

Yellowness, b*, values decreased with increasing levels of lemon peel fat replacerand significant differences ($p \leq 0.05$) were observed among the six products. b*values of the crust were in the order: B > C> A > D > E > F (Fig.2). Wafaa et al. (2011) reported that cakes and cookies prepared with pectin fat replacer decreased in b* value with increasing levels of fat replacement, however, b* values for 25, 50 and 75% substitution were higher than that of the control. This affirms to the trend observed in the current study.

Sensory Evaluation

According to Bennion (1995), the food choices consumers make are affected by many factors such as income, culture, religion and health. Yet, for most people and more importantly, foods must be palatable if they are to be eaten. Palatability of foods is determined by different sensory attributes such as odours, appearance, taste and mouthfeel.

In the current study, there was no significant ($p \geq 0.05$) difference in the appearancerating for pie crusts between 5 % and 10 % and the control(Fig.3). A report by Wang and Sullivan (2010)showed lower ratings by panellists for appearance of brownies substituted with pumpkin puree as a fat replacer. The trend observed confirm how easily fat could affect the appearance of products.

With respect to colour, no significant differences ($p \geq 0.05$) were observed among control pie crust, 5 % and 10%fat-replaced samples whereas pie crusts with 20 %, 30 % and 40 % were significantly different

($p \leq 0.05$) from each other as shown in Fig. 4. The general decline in colour rating from panellists could be due to the reduction in fat content since fat incorporates a uniform golden colour to baked products by interfering with the gluten formed when flour proteins are hydrated. Masoodi and Bashir (2012) reported a decrease in colour rating in a study on the quality of biscuits when fortified with flaxseed.

Aroma is one of the sensory attributes which helps to advertise food commodities. Significant differences ($p \leq 0.05$) were observed in aroma for most of the products in the current study (Fig.5)Panellists rating of 5.9 for pie crust with 40 % fat-replacement, which corresponded with like slightly on the hedonic scale, whereas the control, had the highest rating of 8.33 which indicated that they liked the aroma very much (Fig. 5). Masoodi and Bashir (2012) also reported a decrease in aroma during studies on the quality of biscuits fortified with flaxseed.

Generally for taste, there was a decrease in panellists rating as the level of fat replacement was increased. The control (0 %) had the highest rating for taste with a value of 8.41; an indication that panellists liked the taste very much as compared with all the other products but no significant difference ($p \geq 0.05$) was observed between 0 % and 5 % fat replacementproducts (Fig.6). Furthermore, there was no significant difference ($p \geq 0.05$) between 5 % and 10 % fat replaced products with values of 7.5 and 6.9 respectively. Pie crusts with 30 % and 40 % fat replacement had the least rating for taste and this could be due to the bitter principle (limonin) associated with the lemon peel. Panellists commented that if consumers are educated on the health benefits of limonin they might prefer the reduced fat products to the control.

Statistical analysis showed that for chewiness significant differences occurred among most of the products. Although no significant difference ($p \geq 0.05$) was observed between 0 % and 5 % fat replaced products, pie crust with 20 %, 30 % and 40 % fat replacement were found to be significantly different ($p \leq 0.05$) from each other (Fig. 7).Panellists preferred the chewiness of the control which had a rating value of 8.41 to the chewiness of the other products and this could be due to the formation of gel in the reduced fat products as a result of the presence of pectin in the lemon peel which interacted with water in the presence of less fat. The results are in agreement with research conducted by Akesowan, (2007) in which was reported lower ratings from panellists for chewiness of water chiffon cakes when konjac flour and soy protein isolate mixture was added to replace fat in the cakes.

Gumminess is defined as the energy needed to disintegrate a semisolid food until it can easily be swallowed (Szczesniak, 1963). Sensory rating for gumminess was in the order A > B > C > D >E > F (Fig. 8). From the statistical data obtained for gumminess, no significant difference ($p \geq 0.05$) was observed between products with 0 % and 5 % fat replacement but there were significant differences ($p \leq 0.05$) when the control, 0 % was compared with the rest of the products. Awadet al. (2005) also showed that the reduction of fat content in cheese significantly increased gumminess in the products.

No significant difference ($p \leq 0.05$) in mouthfeel was observed between pie crusts with 0 % and 5 % fat replacement, as well as between 5 % and 10 % reduced fat pie crust. Decreasing fat content affected the mouthfeel of the products in that, pie crust with 0 % replacement had the highest rating followed by 5 %, 10 %, 20 %, 30 % and 40 % respectively. The trend could be due to the fact that increasing the fat replacer increased the formation of gel as a result of the interaction between the flour and water in the presence of small amount of fat. This created an undesirable mouthfeel in the products.

In generally, panellists preferred the control and 5% fat replaced product in that, no significant difference ($p \geq 0.05$) was observed between them and they had the highest ratings for overall acceptability (8.40 and 8.36 respectively). From fig. 10, pie crust with 10% replacement had overall acceptability of 7.22 and could also be recommended. However, 20 %, 30 % and40 % fat replaced products had lesser ratings of 7.06, 5.06 and 2.62 respectively and most of the panellists rated acceptance based on the presence of Limonin which added some bitterness to the products. Panellists commented that if they were educated on the health benefits of limonin they would prefer the fat-replaced products.Often times, substituting fat in a recipe decreases the acceptability of the final product as shown by Swanson and Munsayae (2003), in a study that examined the effects of partially substituting fat in different types of cookies with applesauce and prune puree. The research found that substituting fat in the cookies affected the consumer preference, in that, cookies made with fruit substitute tend to be less liked by panellists. Similar results were found by work done by Wiese and Duffrin (2003), in which pawpaw fruit was used as fat replacer in plain shortened cake. As the fat replacer was increased, preference also decreased.

IV. Conclusion

A novel pie crust product, fortified with lemon peel was successfully produced.On the basis of sensory evaluation, pie crusts fortified with0 % and 5 % lemon peel fat replacer had the highest level of acceptance with no significant difference ($p \geq 0.05$)between them. In particular, pie crust made with high levels of lemon peel fat replacer turned out dark in color while those with less fat replacer were lighter. The fat mimetic made from

lemon peel could be used as an excellent replacement for fat if the bitterness is reduced. The nutrient composition of lemon peel gives it a high potential for use as a fat replacer.

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Table 1- Proximate, pectin and water holding capacity of lemon peel-derived fat replacer

Nutrient	Amount (%)
Pectin	21.26 ± 1.70
Crude fibre	20.19 ± 0.01
Moisture	4.59 ± 0.042
Fat	0.08 ± 0.014
Protein	1.50 ± 0.041
Ash	2.13 ± 0.014
Carbohydrate	71.50 ± 0.12
Dietary fibre	14.0 ± 0.03
Water holding capacity	86.0 ± 0.12

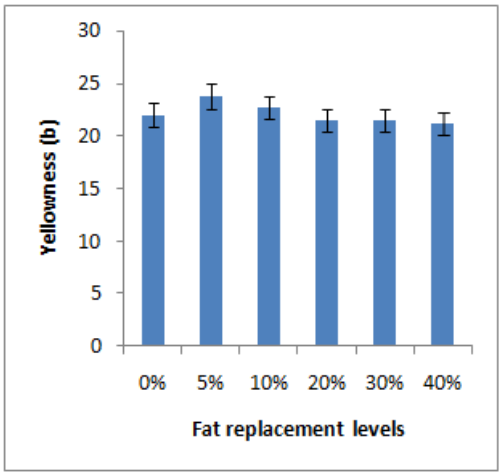


Fig. 1- b* values of pie crusts

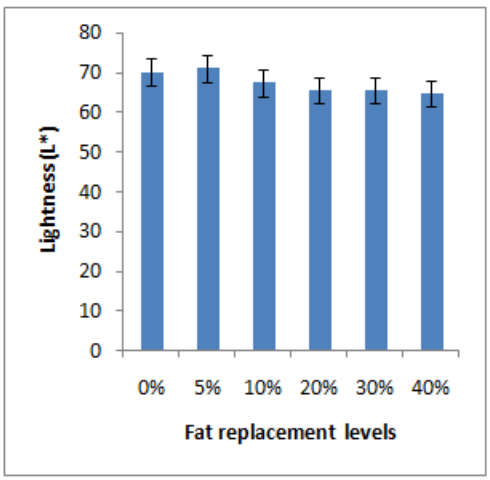


Fig. 2- L* values of pie crusts

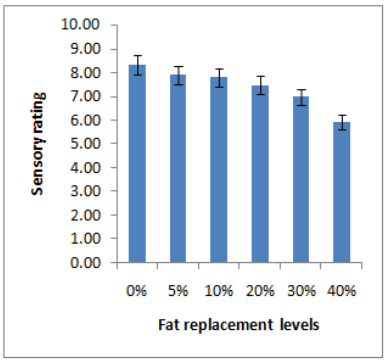


Fig 3- Appearance of the pie crusts

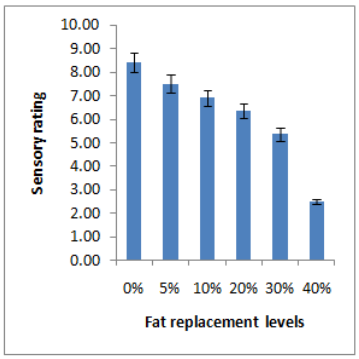


Fig 4- Colour of the pie crust

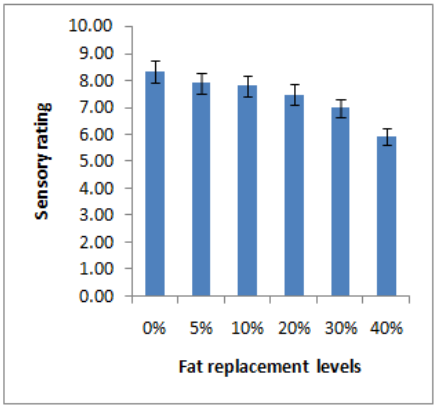


Fig 5- Aroma of the pie crusts

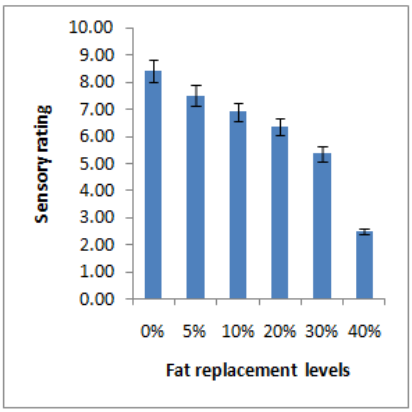


Fig 6- Taste of the pie crusts

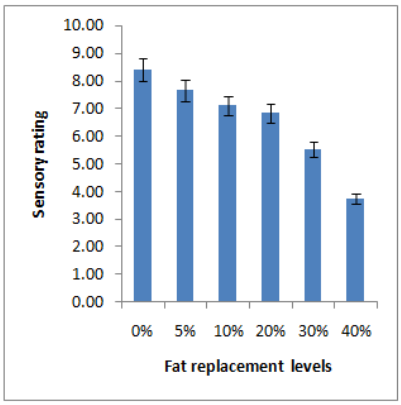


Fig 7- Chewiness of the pie crust

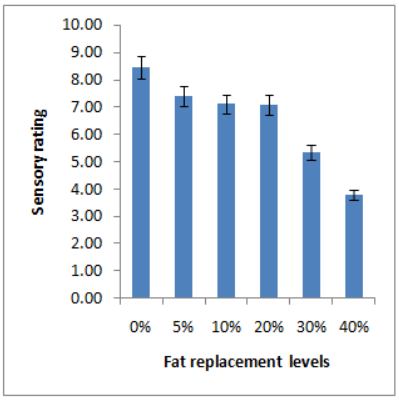
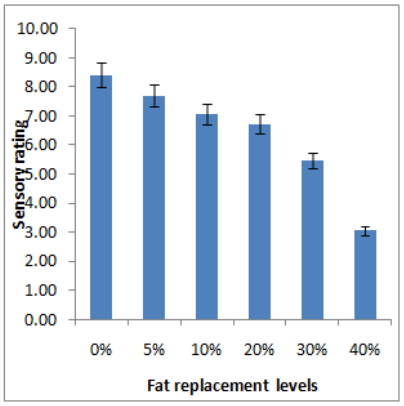


Fig 8- Gumminess of the pie crust



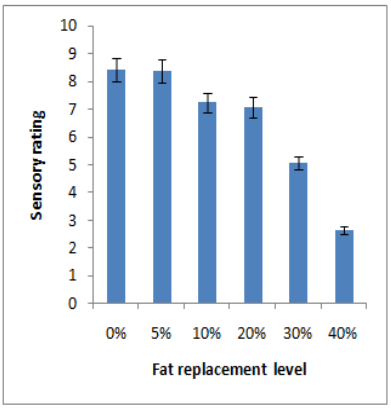


Fig 9- Mouthfeel of the pie crustFig. 10- Overall acceptability of the pie crust