ISSN: 0975 -8542

Journal of Global Pharma Technology

Available Online at: www.jgpt.co.in

RESEARCH ARTICLE

# Investigation of Macadamia Flour Fortified to Wheat Flour in Bread Making

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## Abstract

Bread is one of the most important staple foods in the world. Macadamia nut contains bioactive components and high levels of monounsaturated fatty acids that are beneficial to human health. It would be of therapeutic advantage if wheat flour could be replaced with phytochemical functional nuts other than wheat flour such as macadamia in bread-making. This research has been tried in the application of composite flour through the incorporation of macadamia flour into wheat flour to improve nutritional quality of bread. In this study, macadamia flours were used to substitute refined wheat flour in bread-making doughs at 2%, 4%, 6%, 8%, 10% substitution levels. Significant variations in physicochemical, biological and organoleptic attributes were thoroughly noticed. The substituted bread-making with 8% macadamia flour had enhanced firmness, rich in total phenolics, flavonoids but low in peroxide value. During 8 days of preservation in paper- aluminum foil polyethylene laminate pouch at ambient temperature, the physico-chemical, microbial and sensory characteristics of bread still conformed to overall acceptability.

**Keywords:** *Bread, Macadamia, Firmness, Phenolic, Flavonoid, Peroxide value.*

## Introduction

Macadamia flour is rich in monounsaturated fatty acids (α-tocopherol, sterol), proteins, dietary fiber, phenolics, with outstanding functional properties and antioxidant capacities [1, 3]. Bread is one kind food widely consumed around the word. It is made from wheat flour, yeast, sugar, fat, salt, water in a series of manupulations such as mixing, kneading, fermentation, proofing and baking [4]. Wheat contains huge amount of gluten making raised loaves so it's an ideal choice in bread-making [5]. Legumes have gained special attentions in preparation of bread [6].

There were several studies mentioned to the fortification of substituted flours into bread-making dough. Supplementation of teff grain flour to wheat flour on organoleptic and nutritional evaluation of the supplemented bread was evaluated [7]. Coconut flour was used as a source of protein and dietary fibre in wheat bread [8]. Wheat flour can be replaced partially by cassava flour in the composite bread preparation [9]. The use of whole wheat and soybean flour blends in the production of functional breads was studied [10]. Pita bread fortified with defatted flaxseed flour was evaluated [11]. Nutritional properties and volatile profile of brewer's spent grain supplemented bread were identified [12]. Effects of defatted soy-fortified wheat bread on the organoleptic properties were examined [13]. Utilization of pomegranate peel powder to produce value add bakery product was studied [14]. High dietary fiber bread fortified with quinoa flour was produced [15].

Bread samples were produced from the substitution of wheat flour with cassava flour using malted soybean flour as an improver [16]. Bread was formulated by orghum, buckwheat, chickpea, sprouted wheat and sprouted barley in its nutritive, phytochemical and functional properties [17]. Bread-making potentials of composite flours containing 90% wheat and 10% acha enriched with 0-15% cowpea flour were investigated [18]. High quality vegetable powder enriched bread was produced [19].

The nutritional quality and palatability of bread after partially substituting wheat flour with sweet potato and tiger nut flours were assessed [20]. Fortification of bread with different proportions of rice and sorghum flour was found to improve sensory attributes of the bread [21]. A functional durum wheat bread enriched with bran at high concentration has been developed [22].

Raw mango peel powder was added to fortify whole wheat bread [23]. Nutritional and sensory quality of wheat bread supplemented with cassava and soybean flours were investigated [24]. Substitution of cassava flour with mushroom addition would be a good substitute for wheat flour in bread-making to enhance product quality [25]. Effect of soy enrichment on bread quality was evaluated (Otegbayo, B. O. et al., 2018).

The effect of the fortification of bread with natural sources of calcium such as skim milk powder, egg shell powder, and oyster shell powder at levels of 10%, 2%, and 2%, respectively, on the rheological, nutritional, and sensory properties was determined [26].

Chinese steamed bread fortified with green banana flour was evaluated [27]. Breads made from wheat flour partially substituted with soybean, navy bean, and lupin flours at 10%, 20%, and 30% levels were examined [28]. The effect of *Moringa oleifera* leaf powder addition on physical, sensorial, and antioxidant properties of gluten-free bread was evaluated [29].

The moringa fortified bread samples were evaluated at 5% fortification level [30]. Inclusion of mealworm (*Tenebrio molitor* L.) powder into bread doughs at 5 and 10% substitution level of soft wheat (*Triticum aestivum* L.) flour were tested to produce protein fortified breads [31]. The effect of various bran sources, including wheat, barley, and rice, on the quality and volatile compounds of bread as evaluated [32].

There was not any research mentioned to the application of macadamia flour as a substitution to wheat flour in bread making. Therefore, objective of this our study focused on the possibility of macadamia flour fortified to wheat flour in the physico-chemical, microbial and sensory characteristics of bread.

## Material and Method

### Material

Macadamia nuts were come from Central-Highland, Vietnam. These nuts were dried, roasted and milled into flour. Wheat flour was purchased from Dai Phong Co. Ltd. Other ingredients such as casava starch, shortening, refined sugar, sodium chloride, lecithin, butter etc were purchased from commercial supermarket.

### Researching Procedure

Macadamia flour was fortified by different substitution ratio (2.0%, 4.0%, 6.0%, 8.0%, 10.0%) to wheat flour. Bread-making was prepared by mixing wheat flour with other ingredients and then kneaded using dough mixer for 20 minutes to get dough. The dough was fermented for 45 minutes at ambient temperature. After fermentation, it was baked at 250$^{o}$C for 25 minutes. Loaves were taken out, cooled and packed in paper-aluminum foil polyethylene laminate pouch ready for preservation in 8 days.

### Physico-chemical, Sensory and Statistical Analysis

Texture firmness (g) was evaluated by texture analyzer. Specific loaf volume (cm$^3$/g) was calculated by dividing the loaf volume by loaf weight. Water activity ($a_w$) was measured by a water activity meter. Total phenolic (mg GAE/ 100g) was estimated spectrophotometrically using Folin-Ciocalteu reagent [33]. Total flavonoid (mg GE/ 100g) was estimated spectrophotometrically [34].

Peroxide value (meq O2/kg fat) was determined by mixing sample with a diluted acidic potassium iodide solution and titrating against a 0.1 M sodium thiosulfate using starch indicator. Total plate count (cfu/g) was quantified by 3M-Petrifilm. Sensory score was evaluated by a group of panelist using 9 point-Hedonic scale. The experiments were run in triplicate with three different lots of samples. Statistical analysis was performed by the Stat graphics Centurion XVI.

## Result & Discussion

### Physico-chemical, Microbial and Organoleptic Characteristics of Bread Fortified by Macadamia Flour

In our research, different substituted ratios

 

of macadamia flour (2.0%, 4.0%, 6.0%, 8.0%, 10.0%) to bread-making dough were demonstrated. A significant increase in texture hardness and decrease in specific loaf volume were observed with increased incorporation of macadamia flour.

It might be due to a decrease in the proportion of the gluten content which is an important protein responsible for maintaining the viscoelastic property of bread dough which ensures the increased volume of bread [35].It could be explained via less retention of carbon dioxide gas in the blended dough resulting in dense bread texture.

Gluten is responsible for the elasticity and framework of the loaf during baking. A decreasing trend in specific loaf volume with a progressive increase in the proportion of non-gluten flour was also mentioned [36, 38]. In our research, it's obviously seen that 8.0% macadamia flour was appropriate to substitute wheat flour during bread-making.

**Table 1: Effect of fortified macadamia flour on the physico-chemical, microbial and sensory characteristics of bread after baking**

| Fortified macadamia (%) | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 |
|---|---|---|---|---|---|
| Texture hardness (g) | 121.35±0.04$^{c}$ | 127.46±0.01$^{bc}$ | 129.35±0.02$^{b}$ | 132.27±0.04$^{ab}$ | 134.02±0.03$^{a}$ |
| Specific loaf volume ($cm^3$/g) | 2.65±0.03$^{a}$ | 2.41±0.02$^{ab}$ | 2.34±0.03$^{b}$ | 2.26±0.00$^{bc}$ | 2.15±0.02$^{c}$ |
| Water activity (aw) | 0.42±0.00$^{b}$ | 0.42±0.00$^{b}$ | 0.43±0.02$^{ab}$ | 0.44±0.01$^{a}$ | 0.44±0.02$^{a}$ |
| Total phenolic (mg GAE/ 100g) | 6.35±0.02$^{c}$ | 7.14±0.02$^{bc}$ | 7.85±0.00$^{b}$ | 8.32±0.02$^{ab}$ | 8.48±0.04$^{a}$ |
| Total flavonoid (mg GE/ 100g) | 2.14±0.00$^{c}$ | 2.71±0.01$^{bc}$ | 3.22±0.00$^{b}$ | 3.57±0.01$^{ab}$ | 3.86±0.02$^{a}$ |
| Peroxide value (meq $O_2$/kg fat) | 0.53±0.01$^{b}$ | 0.54±0.02$^{ab}$ | 0.54±0.02$^{ab}$ | 0.54±0.02$^{ab}$ | 0.55±0.00$^{a}$ |
| Total plate count ($10^1$ cfu/g) | 2.15±0.02$^{a}$ | 2.15±0.02$^{a}$ | 2.15±0.02$^{a}$ | 2.15±0.02$^{a}$ | 2.15±0.02$^{a}$ |
| Sensory score | 6.25±0.01$^{c}$ | 7.79±0.04$^{b}$ | 7.92±0.01$^{ab}$ | 8.16±0.01$^{a}$ | 8.19±0.02$^{a}$ |

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Breads supplemented with teff flour, up to a 5% level, are organoleptically and nutritionally acceptable [7]. 20% substitution of coconut flour was possible to produce bread with acceptable qualities [8]. 30% cassava flour fortified with soy protein was possible which improved baking properties of bread [9]. A substitution of 10% soy flour into wheat flour gave the bread with the best overall quality acceptability [10]. Substitution of flaxseed cake flour for wheat flour increased the protein, fat, fibers, ash and mineral contents and remarkably improved the protein quality of the composite flours [11]. Bread loaves from enriched composite flour with up to 10% cowpea flour were acceptable [18].

Fortification of wheat bread with 3-7% defatted soy flour could improves formulation, organoleptic characteristics [13]. Pan bread fortified with 2.5% and 5% pomegranate peel powder had higher score in overall acceptability and physical properties when compared to control pan bread and other various concentration (7.5%) of pomegranate peel powder [14].

The bread formulations with up to 10% added brewer's spent grain flour had good organoleptic attributes and overall acceptability [12]. Cassava flour should be substituted for wheat flour up to 30% using malted soybean flour as improved in making breads [16]. White bread was fortified with 20% finger millet flour receiving acceptable physical and rheological property [35].

There was potential health and sensory benefits of 20% substitution of sweet potato and tiger nut to wheat flour in bread making improved fibre content, improved taste and to promote sweet potato and tiger nut utilization [20].

Incorporation of raw mango peel powder increased the intensity of descriptors like hardness, rubbery texture, fruity aroma, after taste and decreased porosity and traditional bread aroma [23]. The optimum blending ratio for both nutritional and sensory acceptability of bread was in the range of 49.0-71.0% wheat, 10.6-29.0% cassava and 18.2-22.0% soybean flours [24].

 

A substitution of wheat flour with 5% soy flour gave the bread with the best overall acceptability (Otegbayo, B. O. et al., 2018). Blended cassava-mushroom (75:25%) bread was the most acceptable sensory [25]. The addition of natural sources of calcium to bread could positively impact its technological and nutritional properties [26]. The addition of extra water improved the textural properties and appearance of banana flour- steamed bread [27]. Addition more than 2.5% *Moringa oleifera* leaf powder decreased the specific volume of bread [29].

The 5% moringa fortified bread was not significantly different from the bread produced from 100% wheat flour in terms of most of the quality attributes [30]. Breads containing 5% mealworm (*Tenebrio molitor* L.) powder showed the highest specific volume and the lowest firmness [31]. The substitution of wheat flour with 10%, 20%, and 30% of different brans resulted in decreased loaf volume and specifc volume, and increased loaf weight [32].

### Stability of Bread in Paper- aluminum Foil Polyethylene Laminate Pouch during 8 days of Storage

In packed products, the rate of auto oxidation is mainly governed by the oxygen retention in the pack, which in turn is related to the headspace and oxygen permeability of the packaging material [39].

Water activity plays a key role in bread preservation. Nature of packaging material and its porosity plays important role in deciding moisture uptake [40]. Moisture promotes hydrolytic rancidity development [41]. Bread packed in laminate pouches absorbed lesser moisture during storage which might have been due to the impervious nature of aluminium foil in the laminate to air and water vapour. The similar results were mentioned cereal bran incorporated biscuits [42]. The similar results were also noticed for change of peroxide value in preservation of buckwheat-chia flour biscuits [43]. Rancidity inhibited in bread during storage could be explained by antioxidant rich macadamia supplementation.

**Table 2: Stability of bread in paper- aluminum foil polyethylene laminate pouch during 8 days of storage**

| Days of storage | 0 | 2 | 4 | 6 | 8 |
|---|---|---|---|---|---|
| Texture hardness (g) | 132.27±0.04$^{c}$ | 133.04±0.01$^{bc}$ | 133.39±0.03$^{b}$ | 133.75±0.03$^{ab}$ | 133.83±0.00$^{a}$ |
| Specific loaf volume ($cm^3$/g) | 2.26±0.00$^{a}$ | 2.19±0.03$^{ab}$ | 2.14±0.01$^{b}$ | 2.05±0.01$^{bc}$ | 2.01±0.04$^{c}$ |
| Water activity (aw) | 0.44±0.01$^{b}$ | 0.45±0.02$^{b}$ | 0.47±0.00$^{ab}$ | 0.48±0.02$^{ab}$ | 0.52±0.01$^{a}$ |
| Total phenolic (mg GAE/ 100g) | 8.32±0.02$^{a}$ | 8.29±0.01$^{ab}$ | 8.25±0.02$^{b}$ | 8.17±0.01$^{bc}$ | 8.12±0.02$^{c}$ |
| Total flavonoid (mg GE/ 100g) | 3.57±0.01$^{a}$ | 3.53±0.00$^{ab}$ | 3.47±0.04$^{b}$ | 3.42±0.00$^{bc}$ | 3.37±0.03$^{c}$ |
| Peroxide value (meq $O_2$/kg fat) | 0.54±0.02$^{c}$ | 0.61±0.03$^{bc}$ | 0.67±0.03$^{b}$ | 0.73±0.00$^{ab}$ | 0.75±0.01$^{a}$ |
| Total plate count ($10^1$ cfu/g) | 2.15±0.02$^{c}$ | 3.74±0.00$^{bc}$ | 4.25±0.00$^{b}$ | 5.16±0.03$^{ab}$ | 6.23±0.03$^{a}$ |
| Sensory score | 8.16±0.01$^{a}$ | 8.11±0.02$^{ab}$ | 7.95±0.03$^{b}$ | 7.84±0.02$^{bc}$ | 7.63±0.00$^{c}$ |

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

## Conclusion

There has a trend towards the consumption of functional foods beneficial for human health. Macadamia flour with inherent compositional characteristics was successfully fortified in bread-making by partially replacing wheat flour. Substitution of 8% macadamia flour resulted in the best quality attributes of bread. It could be stored in paper- aluminum foil polyethylene laminate pouch for 6 days at ambient condition without any remarkable deterioration in structure and hygenic safety. Macadamia flours may be supplemented to bakery to fortify proteins, monounsaturated fatty acids and dietary fiber, as well as to improve the texture and flavor of the final products. Macadamia flour would be an alternative in bread making with improved nutritional value and prolonged self-life.

 

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