SCAP
SOCIEDADE DE CIÊNCIAS AGRÁRIAS DE PORTUGAL

Effect of the addition of peach palm (*Bactris gasipaes*) peel flour on the color and sensory properties of wheat bread

Efeito da adição de farinha de casca de pêssego (*Bactris gasipaes*) na cor e nas propriedades sensoriais do pão de trigo

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ABSTRACT

The aim of this study was to evaluate the color and sensory characteristics of bread made with different levels of peach palm peel flour (PPPF). This flour was added into breads with a proportion of 2.5-10% (w/w), and studied its effect on total carotenoids, CIELab parameters, and sensory characteristics of bread. Results showed that PPPF supplementation increased the carotenoid content of bread. The color test showed that high levels of PPPF were associated with a decreased L* and H°, while, browning index (BI), increases. Sensory evaluation ratings indicated that bread with acceptable quality attributes can be prepared from wheat flour fortified with PPPF up to 5% level. Thus, peach palm peel, a by-product from the peach palm processing, could be utilized for the preparation of wheat breads.

Keywords: Peach palm peel flour, bread, Total carotenoids, color analysis, sensorial analysis.

RESUMO

O objetivo deste estudo foi avaliar a cor e as características sensoriais dos pães feitos com diferentes teores de farinha de casca de pêssego (PPPF). Esta farinha foi adicionada aos pães em concentrações de 2,5-10% (m / m), sendo estudado o seu efeito sobre os carotenóides totais, parâmetros de cor CIELab, bem como as suas características sensoriais. Os resultados mostraram que a adição de PPPF aumentou o teor de carotenóides de pão. O teste de cores mostraram os níveis elevados de PPPF estão associados com a diminuição do L * e do H °, enquanto que o IB aumenta. A avaliação sensorial indicou poder ser preparado pão com atributos de qualidade aceitáveis, a partir de farinha de trigo fortificada com PPPF até um teor de 5% (m/m). Assim, a pele do pêssego, um subproduto do processamento de pêssego palma, poderia ser utilizada para a preparação de pães.

Palavras-chave: farinha de casca de pêssego, pão, carotenóides totais, análise da cor, análise sensorial.

INTRODUCTION

The color parameter in food is one of the most important quality attributes, and plays an important role in its appearance, processing and acceptability (Demırhan & Özbek, 2011). The color of bread depends on various factors such as the type of flour, type and quantity of additives used, baking temperature and time (Bchir *et al*., 2014). Among the most common additives used in the food industry, synthetic and natural colorants are used to intensify, compensate or add color to a manufactured product, thereby maintaining a pleasant and attractive appearance that resembles the natural product (Santos *et al*., 2014). However, consumption of synthetic colorants in food may present a risk to health. Studies report the development of allergies in children (McCann *et al*., 2007) and the increased risk of cancer associated with the consumption of artificial colorants (Mpountoukas *et al*., 2010). However, the demand for natural colorants, such as ß-carotene, annatto, lycopene, paprika extract, and ß-Apor-8'-carotenal, has increased due to the global trend of maintaining good health and reducing the risk of disease.

Peach palm, pejibaye or chontaduro (*Bactris gasipaes*) is an important fruit in the feeding of native populations since pre-Colombian time. This fruit is source of carotenoids in the diet of the rural and urban population of tropical America, and is also exported to ethnic markets in USA (Rojas-Garbanzo *et al*., 2011). The yellow orange color of the peach palm pulp is due to the presence of carotenoids (1.1 mg/100g – 22.3 mg/100g), being β-carotene (26.2% to 47.9%), *Z*-γ-carotene (18.2% to 34.3%) and *Z*-lycopene (10.2% to 26.8%) the predominant ones (Jatunov *et al*., 2010). The peach palm fruit processing allows to obtain products such as flour, canned fruit, jam, chips and fermented alcoholic beverage (Graefe *et al*., 2013). The fruit processing generates large volumes of solid waste in the form of peels, kernels, and pulp following the industrial processing of fruit juices. One of the most effective options for management of fruit residues is the recovery of phytochemicals/bioactive compounds from the fruit residues, which could be used in food, cosmetic, and pharmaceutical industries (Babbar *et al*., 2015).

Several studies have reported the effect of fruit by-products on baked food color. Ajila *et al*. (2008) and Ajila *et al*. (2010) used mango peel powder in dough biscuits and macaroni preparations. Salgado *et al*. (2011) used cupuassu peel in breads, and Mildner-Szkudlarz *et al*. (2013) used grape pomace in wheat biscuits. Pear, apple and date by-products were used by Bchir *et al*. (2014) in breads. However, these types of investigations are still scarce, especially studies to evaluate natural colorants which can be an alternative to synthetic colorants in bakery products. The aim of this study was to evaluate the color and sensory characteristics of wheat bread made with different levels of peach palm peel flour (PPPF).

MATERIAL AND METHODS

Peach palm peel flour (PPPF) preparation

Cooked peach palm fruit (*Bactris gasipaes*) were acquired in the municipal market in Palmira (Colombia), and then the epicarp (peels) was removed and cut. Peels was oven-dried at 60 °C until the moisture level was constant (11% w/w). Dried peel was ground to a powdered form using an electrical grinder and passed through a 0.25 mm sieve, and refrigerated to 4°C in a refrigeration unit until its later use.

Bread Preparation Procedures

The standard wheat bread or control was prepared by mixing 300 g wheat flour, 93 g water, 6 g yeast, 30 g sugar, 6 g salt, 30 g egg, 75 g margarine and 0.03 g tartrazine, the dye to buy Fleischmann Colombia (E102 or FD&C Yellow 5). The other bread samples were developed by replacing conventional wheat flour with 2.5, 5.0, 7.5 and 10% PPPF, and the tartrazine was not included in the formulation. The bread ingredients used in this study were obtained from a local market. The formulation of bread is prepared considering the specifications described by NTC 1363. The ingredients were kneaded by hand for 10 minutes, 40 g dough pieces were fermented for 35 min at 35 ± 2°C and 90% relative humidity, and baked for 25 min at 180 °C (Oven bakery, Essen).

Physicochemical analysis

For the determination of the pH of bread, the sample of 5 g was placed into a 250 ml beaker and 50 ml distilled water was added. To determine the pH a digital pH metre (pH-metre Metrohm ® 744 pH Meter) was used. Before using, the pH metre was calibrated with commercial buffer solutions of pH 7.0 and pH 4.0. Dry matter of samples (%) was obtained by drying them in an oven at 105 °C until reaching constant dry weight, and dry matter was performed according to Association of Official Analytical Chemists (1998).

Total carotenoids were extracted and quantified according Barrett & Anthon (2001), Fish *et al.* (2002), Nagal *et al.* (2012) and Ordóñez-Santos *et al*. (2014). Briefly, 0.1 g of the sample was weighed in a tube, and then 7 mL of 4:3 ethanol/hexane was added, the tube was capped, covered with aluminum foil, and the flask was then placed in crushed ice and shaken for 1 h, after which 1 mL of distilled water was added and shaking was continued for a further 5 min. A 3 mL sample was taken from the organic (hexane) phase using a Pasteur pipette and absorbance of the extract was measured at 450 nm against hexane in a Spectrophotometer Jenway 6320D (Staffordshire, ST15 OSA, UK). The carotenoid concentration (mg/100 g) is calculated using the equation.

$$\text{Carotenoid as b-carotene (mg/ 100 g)} = \frac{A*V*P}{E*W}*100 \quad (1)$$

where, A = absorbance at 453 nm, V = volume of organic phase, P = molecular weight in g/mole, E = molar extinction coefficient of 13.9 x 10^4 $M^{-1}cm^{-1}$, and W= weight of sample in grams. A Minolta CR-400 color colorimeter was used for this study. The instrument was standardized each time with a black and a white (Y=89.5; x=0.3176; y=0.3347) tile using illuminant D65, and a 2° observer. The parameter L* were determined by reflectance. In addition, the Chroma, hue angle, browning index (BI), and total color change (ΔE), were calculated by the equations

$$C = (a^{*2} + b^{*2})^{1/2} \quad (2)$$

$$h = \tan^{-1} (b^*/a^*) \quad (3)$$

$$\Delta E = (\Delta a^{*2} + \Delta b^{*2} + \Delta L^{*2})^{1/2} \quad (4)$$

$$BI = 100 \times (X - 0.31/0.17) \quad (5)$$

Where

$$X = (a^* + 1.75L^*)/(5.645L^* + a^* - 3.012b^*) \quad (6)$$

Sensory evaluation

The sensory characteristics of standard bread, and incorporated with PPPF were conducted to determine the acceptability of the product according to method described by Ocen & Xu (2013) with a slight modification. An untrained panel of 80 members (males and females) performed the sensory evaluation of breads, which have been freshly prepared and cooled to 30 ° C. Breads were evaluated on the basis of acceptance of their texture, color, taste, odor, and overall acceptability on a nine-point hedonic scale. The values ranged from "like extremely" to "dislike extremely" corresponding to the highest and lowest scores of "9" and "1", respectively. Immediately before sensory testing, the breads were sliced into 30 mm thick slice.

Statistical analyses

The experimental design was a randomized blocks, the treatments were control, 2.5, 5.0, 7.5 and 10% PPPF, with five replicates per treatment. Data was analyzed with a one-way ANOVA and treatments means were compared using Tukey's test ($p \leq 0.05$). All statistical calculations were performed using SPSS 18 for Windows.

RESULTS AND DISCUSSION

Physicochemical properties of peach palm peel flour and of breads

The physicochemical properties analyzed PPPF listed in Table 1. The pH of the flour, are close to those recorded in twenty races chontaduro evaluated by Vargas & Arguelles (2000) (5.43-6.31). The mean dry matter flour chontaduro reported by De Oliveira *et al*. (2006) (92.91%), are close to those obtained in the present study. The carotenoid content in PPPF exceed those reported by Rojas-Garbanzo *et al*. (2011) (23.77 mg/100 g flour) flour peach palm fruit. Probably these differences in carotenoid concentrations are related to genetic differences, degree of fertilization, and drying temperature in the case of Rojas-Garbanzo *et al.* (2011) was 72 ° C and in the present study samples dried at 60 ° C. Low values of L *, C * and high IB, H°, respectively, indicating the presence of a dark yellow color in the PPPF, the flour color is mainly due to the high content of carotenoids (59.31 mg / 100 g flour) (Table 1) and the existence of brown pigments generated during the process of dehydration of the sample.

Table 2 shows the physicochemical properties of the formulations evaluated in this study. In all cases, the measured variables are affected statistically ($p < 0.001$) with the addition of PPPF. The pH, dry matter and total carotenoid concentration in bread significantly increased with the increase of PPPF vs. control (Table 2). The increase in these properties on bread clearly is a result of high dry matter and concentration of carotenoids in the PPPF (Table 1). Moreover, comparing the concentration of total

Table 1 - Mean and standard deviation of physicochemical properties of peach palm peel flour

Variable	Peach palm peel flour
pH	5.20±0.19
Dry matter (%)	89.35±0.68
Total carotenoids (mg/ 100 g)	59.31±1.61
L*	28.16±0.55
C*	14.20±0.72
H°	70.93±0.43
IB	75.10±3.17

Table 2 - Mean and standard deviation of physicochemical properties of breads with different concentrations of peach palm peel flour

PPPF incorporated breads	pH	Dry matter (%)	Total carotenoids (mg/ 100 g)
Control	5.18±0.05^{e}	70.88±0.52^{e}	0.04±0.007^{e}
2.5%	5.30±0.03^{d}	72.48±0.38 ^{d}	0.95±0.09^{d}
5.0%	5.40±0.01^{c}	73.43±0.28^{c}	2.32±0.14^{c}
7.5%	5.50±0.06^{b}	74.46±0.23^{b}	3.01±0.13^{b}
10 %	5.61±0.07^{a}	75.98±0.42^{a}	3.77±0.10^{a}
ANOVA	***	***	***

Averages on the same column followed by different letters vary significantly from each other (P < 0.05) according to Tukey's test.

carotenoids in the PPPF, and breads, significantly reduced carotenoid pigments (Table 1 and 2) are observed. This loss may be associated with the processes of kneading and baking bread, in the case to the incorporation of water, and oxygen in the dough allow activation of lipoxygenase (LOX), responsible for the oxidation of enzyme polyunsaturated fatty acids, which in turn starts the oxidation of carotenoids, and during baking temperatures between 98.40 to 98.80 ° C, which can starts oxidation and isomerization processes in carotenoids (Hidalgo *et al*., 2010). Carotenoids losses during the baked food production have been previously reported by Ajila *et al.* (2008), Ajila *et al.* (2010), and Azizi *et al*. (2012).

Color measurement parameters of breads

The effects of PPPF addition on the crust and crumb color of bread are summarized in Table 3. Adding flour surface color significantly affects crust and crumb bread (Table 3). The PPPF increased in the formulation of bread, decreases statistically the values of L*, C*, H°, and **Δ**E, however, the browning index (IB) significantly increases the brown color of bread crust (Table 3). Compared with the control, high contents of PPPF increase values C *, H ° and IB, while reducing L* (Table 3). In terms of crumb color, the L * and H ° values decrease significantly, while C*, IB and **Δ**E, increase with increasing flour in the formulation (Table 3). Compared with the control, high levels of PPPF reduced to L * and H °, however, increase C *, IB and ΔE (Table 3). These results indicate that the replacement of tartrazine by PPPF in the formulation of the bread product are obtained with dark and yellowish both crumb and crust. Studies by Ma *et al*. (2009), Siddiq *et al*. (2009) and Ocen & Xu (2013) also reported L* and H° reduction in bread samples prepared with wheat germ, maize germ flour and dried by-product of orange, respectively. The lower L*, and H° values, and high IB values observed in their study were possibly due to Maillard browning and caramelization, which are influenced by the distribution of water and the reaction between reducing sugars and amino acids (Siddiq *et al*., 2009). Therefore, due to the Maillard browning, brightness and yellowness of the breads may be decreased. These color changes can also be associated with the content of carotenoids in the PPPF.

Sensory parameters of breads

The effect of incorporation of PPPF on the sensory properties and overall acceptability score is shown in Table 4. In all cases, the sensory attributes are significantly affected by the addition of flour, and the sensory properties decreased significantly with flour bread addition 7.5 and 10% (w/w). The color of the bread containing PPPF was as acceptable as those of control breads up to 5% level of PPPF incorporation. Breads with 5.0% of flour obtained statistically higher qualifications in the descriptors evaluated; this result indicates that this level of substitution had the highest degree of acceptance by consumers (Table 4). Therefore, breads of acceptable overall quality can be prepared using 5% (w/w) PPPF formulations.

Table 3 - Mean and standard deviation of color measurement parameters of breads with different concentrations of peach palm peel flour

PPPF incorporated breads	Crust color				
	L*	C*	H°	IB	ΔE
Control	56.97±0.17^{c}	34.78±0.27^{e}	63.10±0.46^{e}	96.05±0.97^{d}	---
2.5%	60.07±0.24^{a}	41.63±0.40^{c}	67.38±0.27^{b}	115.32±1.27^{c}	8.04±0.45^{b}
5.0%	57.99±0.29^{b}	42.77±0.28^{a}	67.96±0.16^{a}	126.32±1.14^{a}	8.70±0.28^{a}
7.5%	56.54±0.13^{d}	42.03±0.12^{b}	65.50±0.33^{c}	126.81±0.70^{a}	7.44±0.08^{c}
10%	54.78±0.13^{e}	40.55±0.25^{d}	61.44±0.26^{d}	123.28±1.21^{b}	6.27±0.20^{d}
ANOVA	***	***	***	***	***
	Crumb color				
	L*	C*	H°	IB	ΔE
Control	73.30±1.97^{a}	38.85±0.59^{d}	85.42±0.19^{a}	75.18±3.85^{e}	---
2.5	71.88±0.14^{b}	37.75±0.11^{e}	83.74±0.09^{b}	75.07±0.52^{d}	2.12±0.07^{d}
5.0	69.91±0.12^{c}	42.87±0.11^{c}	82.20±0.11^{c}	94.28±0.47^{c}	5.74±0.11^{c}
7.5	69.36±0.10^{d}	45.54±0.16^{b}	81.00±0.23^{d}	104.86±0.55^{b}	8.41±0.13^{b}
10	66.86±0.24^{e}	50.56±0.09^{a}	78.77±0.21^{e}	131.28±0.72^{a}	14.31±0.10^{a}
ANOVA	***	***	***	***	***

Averages on the same column followed by different letters vary significantly from each other ($P < 0.05$) according to Tukey's test.

Table 4 - Mean and standard deviation of sensory parameters of breads with different concentrations of peach palm peel flour

PPPF incorporated breads	Texture	Color	Taste	Odor	Overal Quality
Control	6.40±1.26^{c}	4.73±1.46^{c}	6.57±1.25^{c}	6.42±1.41^{b}	5.95±1.46^{c}
2.5%	7.16±1.20^{b}	7.13±1.17^{b}	7.04±1.37^{b}	6.64±1.50^{b}	6.66±1.42^{b}
5.0%	7.90±0.95^{a}	8.18±1.08^{a}	7.62±0.92^{a}	7.65±1.11^{a}	8.00±0.94^{a}
7.5%	5.44±1.50^{d}	4.00±1.40^{d}	4.34±1.34^{e}	4.12±1.27^{c}	3.32±1.30^{d}
10%	3.32±1.21^{e}	2.92±1.24^{e}	5.34±1.49^{d}	3.77±1.40^{d}	3.23±1.37^{e}
ANOVA	***	***	***	***	***

Averages on the same column followed by different letters vary significantly from each other ($P < 0.05$) according to Tukey's test.

CONCLUSIONS

Peach palm peel flour (PPPF) is an important source of carotenoids. Addition of PPPF increased carotenoid concentration in bread, and can be an alternative replacement tartrazine in the formulation of this product. The studies on sensory evaluations showed that the breads incorporated with PPPF up to 5% (w/w) level resulted in products with good acceptability. Thus, peach palm peel, a by-product from the peach palm processing, could be utilized for the preparation of breads and other food products free synthetic colorants

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