Evaluation of bread made with sweetpotato flour

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Abstract

Wheat and wheat flour to make bread is expensive and must be imported in most tropical countries. The objective of this study was to determine the nutritional value of bread made from wheat (WF) and sweetpotato flour (SF). Four different treatments were evaluated according to the level of replacement of wheat flour with sweetpotato flour [(1) 100% WF : 0% SF; (2) 90% WF : 10% SF; (3) 80% WF : 20% SF; (4) 70%WF : 30% SF). The parameters determined in treatments were: moisture, protein, fat, fiber, ash, carbohydrates and β-carotene, and the sensorial parameters: color and crust of bread, crumb structure, texture, aroma and flavor. The analysis of variance (ANOVA) showed significant differences between treatments for the variables moisture, protein, fat, fiber, ash, carbohydrates and b-carotene and the DUNCAN test revealed that the bread with the highest substitution of wheat flour (70%WF : 30% SF) has the highest percentage of humidity, fiber, fat, ash and beta carotene. For the qualitative variables, the samples were analyzed by the Kruskal Wallis test. The analysis showed a relationship of intrinsic flavor and aroma to treatment 70%: 30% (WF : SF). However, the best relate to all the sensory attributes was observed for treatment 80%: 20% (WF: SF), which obtained the highest acceptance.

Introduction

The food supply has been, throughout history, a constant in the fundamental preoccupations of the man (Cheftel and Cheftel, 1992), being well-known the lack of an adapted nutritional contribution in the vulnerable population of our country, like are the pre-schoolers and suckling babies, due to joint of socioeconomic factors that derive in deficiency states. (FAO, 2004).

At the moment, deficiency of micro-nutrients has been recognized in diverse countries, especially in developing countries and it is known that it has seriously effects the health of children, between which they emphasize the undernourishment by protein and deficiency of vitamin A and iron. (Mendez, 2001). Peru is also facing these problems as it reports the rehearse on Nutrition made by the Bottom of the United Nations for the Childhood. The report reveals that the rate of mortality of the minors of five years in Peru is of 58/1000 born alive ones, which is the third highest one of Latin America, after Haiti and Bolivia (UNICEF, 1998).

Many developing countries and several international organizations (OAA/FAO, the WHO, FDA, CIP among others) are establishing strategies to eradicate these nutritional deficiencies. One of them consists on the enrichment and food fortification of massive consumption, to improve the vitamin A ingestion, and another one stimulating the food consumption of vegetal origin, so it is the case of the sweet potato, which is rich in B-carotene, precursor of this vitamin (Mendez, 2001).

Sweet potato has a large potential to be used as a food in developing nations with limited resources because of its short maturity time and ability to grow under diverse climatic condition and on less fertile soil (Collins, 1989). Sweet potato flour can serve as a source of energy and nutrients [carbohydrates, beta-carotene (provitamin A), minerals (Ca, P, K, Fe, and Zn)], and can add natural sweetness, color, flavor and dietary fiber to processed food products (Woolfe, 1992; Ulm, 1988). Addition of various proportion of sweetpotato flour in wheat flour can increase the nutritive values in terms of fibre and carotenoids. This also helps in lowering the gluten level and prevent from coeliac disease (Tilman et al., 2003).

The aim of this study was to determine the effects of adding different levels of SF on the physico-chemical and the sensory properties of bread. The task of improving the acceptance level falls mainly to the consumers, some of the ways to evaluate the quality of a product are: subjective or sensorially and another one using instruments and chemicals to quantify the nutritional composition.

Materials and methods

The genotype of sweet potato 440442 pertaining to the Bank of Germplasm of CIP-Lima. was seeded in the Experimental Station of La Molina. After harvest, the roots were cured by 2-3 days to room temperature, after that they were washed by immersion and agitation in cold potable water, then with a brush to eliminate the soil adhered to the peel.

Flour preparation

The clean roots were taken to the stage of boiling given by water immersion to 100ºC by 25 min. The elimination of the peel was realised in manual form, soon the roots were pressed, obtaining a uniform mass, later it was placed in later polythene bags for its freeze-dried, where the product was dried to 37ºC ± 2ºC with a residual humidity between 5 - 8%, all the process delayed of 19 to 21hr. The milling was realised with an electrical mill allowing addition their sieving (60mesh= 256um). The final product was packaging in polythene bags and sealed hermetically.

Bread making

Previously to the elaboration of breads, tests preliminary on small scale were realised with the purpose of establishing the optimal percentage from wheat flour (WF) and sweetpotato flour (SF), obtaining a product of good sensorial characteristics. From these tests we obtained the following treatments expressed in percentage proportion in mass (m/m) of WF and SF: (1) 100% WF: 0% SF; (2) 90% WF: 10% SF; (3) 80% WF: 20% SF; (4) 70%WF: 30% SF (Table 1).

Table 1. Quantities of wheat flour (WF) and sweet potato flour (SF) as a mixture of ingredients used for making sweet potato bread according to the treatments proposed

Treatments	WF (g)	SF (g)
100% WF : 0% SF	750	0
90% WF : 10% SF	675	75
80% WF : 20% SF	600	150
70% WF : 30% SF	525	225

Nutritional evaluation

Determination of the proximal composition of sweet potato breads: for these chemical analyses we applied the recommended methods by A.O.A.C. 1990: (humidity % Part 950.46 pp. 931; Total protein % (N x 6.25) Part 984.13 pp. 74: fat extract %, Part 948.16 pp. 871; Crude fiber %, Part 962.09 pp. 80; Ash %, Part 942.05 pp.70, and carbohydrates by difference).

The determination of the β-carotene content occurred by high performance liquid chromatography (HPLC). Monomeric column C18: with a movil phase: methanol: ter-butil metil ether, with isocratic elusion: 80:20, with a flux time of 0.8ml/min, both methods proposed by Rodriguez, B.D - Kimura, M. (2004). The method is based on the extraction, in organic phase of carotenoids with acetone, later the carotenes were separated by means of the HPLC.

Sensory evaluation

A not trained panel was used, integrated by 50 members, to establish what of the treatments has major acceptability (color of the crumb, color of the crust, structures of the crumb, texture, aroma and flavor), evaluated through a preferential test of hedonic scale, where the four treatments were evaluated (Mahecha 1985).

Physical analysis

We realised a uniaxial compression test, analyzing the texture properties of the sweet potato bread, using a Textometer QTS-25 with software Texture Pro v 2.1, at a speed of 15mm/s with a distance of compression of 50%, calibrated with a cell of load of 5 kg, as shown in figure 1.

Figure 1. Texture analizer

Statistical experimental design

A complete randomized design was carried out with four treatments ((1) 100% WF: 0% SF; (2) 90% WF: 10% SF; (3) 80% WF: 20% SF; (4) 70% WF: 30% SF). The studied parametric variables (proximal Composition and β-carotene content) were analyzed by an analysis of variance (ANOVA, SAS, 1998). As a multiple comparison procedure the DUNCAN test was used for those results, where the F-test of the ANOVA was significant. The investigated qualitative variables in the sensorial evaluation were analyzed by the nonparametric Kruskall - Wallis test.(Chacín, 2000).

Results and discussion

The results of the proximal composition of the bread treatments of study are given in table 2. For treatments a similar response was observed regarding to the contents of fat, fiber and ash; the magnitude of these traits increased with the replacement WF by SF.

The ANOVA shows no significant differences between treatments with respect to moisture content. The crude protein content presents a slight diminution when increasing the substitution of WF with SF, as case of the treatment: 70% WF: 30% SF. The results are slightly higher that those reported by Cardenas (1991) who reports 10.6% in dry matter for a bread made from yellow sweet potato. It is important to note that the type of commercial flour contains more protein than the flours to make bread.

Table 2. Averages for the proximate composition of breads made under the treatments in study

Treatments	Moisture%	Protein %	Fat %	Fiber %	Ash%	CHOs
90% WF: 10% SF	$20.60^{a} \pm 0.12$	$11.55^{a} \pm 0.07$	$10.21^{a} \pm 0.01$	$0.34^{c} \pm 0.00$	$1.05^{c} \pm 0.01$	$55.95^{a} \pm 0.07$
80% WF: 20% SF	$20.82^{a} \pm 0.34$	$11.09^{b} \pm 0.05$	$10.39^{a} \pm 0.05$	$0.67^{b} \pm 0.03$	$1.17^{b} \pm 0.01$	$55.85^{b} \pm 0.36$
70%WF: 30% SF	$20.88^{a} \pm 0.01$	$10.40^{c} \pm 0.11$	$11.38^{b} \pm 0.04$	$0.91^{a} \pm 0.01$	$1.33^{a} \pm 0.03$	$55.09^{c} \pm 0.0$

Average of three reading

$^{a, b, c}$ The values denoted different letters in the same column are significantly different ($P < 0.05$).

The fat content, measured as fat extract, increases as the proportion of SF increases (70% WF: 30% SF; 90% WF: 10% SF; 80% WF: 20% SF). The observed increase could be attributed to the carotenoid contribution of the sweet potato, since these pigments are soluble in fats and they are quantified with the fat extract. (Béliz and Grosch, 1997).

The crude fiber content, in dry matter increased from 0.34 to 0.91%, due to the rise of the proportion of flour of sweet potato in the treatments. The fiber is an indicative of the cellulose content, hemicellulose and lignin. The ash content increases from 1.05 to 1.33% as sweet potato flour is added to the treatment. This increase can be attributed to the mineral contribution of sweetpotato.

A slight increase of carbohydrates is observed (table 2) with the change from 90% WF: 10% SF to 80% WF: 20% SF, which could be attributed to the humidity diminution in these two treatments. It should be noted that the sweet potato flour causes an increase of the humidity, because the proteins and the starch of the sweet potato retains major amount of water (Bennion, 1970).

β-carotene content

The **β-**carotene content of bread from sweet potato in the different treatments appears is given in Table 3. The results obtained by ANOVA and the Duncan test, shows significant differences between treatments (P<0.05).

With increasing percentage of substitution of WF the β-carotene content increases significantly. The treatment 70% WF: 30% SF results in a contribution of 44.43 µg/g of β-carotene in dry matter, which implies an additional contribution to the nutritious value of the wheat: sweetpotato bread, with a value of 372.75µg/100g of (RAE) in dry matter. The need of retinol in infants is of 300 µg per day and the amount of β-carotene to cover this need is of 1800µg per day (Woolfe, 1999). The treatment 80% WF: 20% SF, covers 65% with the daily requirements of this vitamin consuming 100g of wheat: sweet potato bread, which is equivalent to 3 bread units of 34 g.

Table 3. -carotene content in the different treatments

Treatments	β -carotene content (µg/g)	Vitamin A value (µg RAE/100g)
90% WF: 10% SF	5.34[a]	44.5
80% WF: 20% SF	23.42[b]	195.16
70%WF: 30% SF	44.43[c]	372.75

The values denoted different letters in the same column are significantly different (P < 0.05).

RAE (Retinol activity equivalents): 12µ -carotene = 1µg retinol = 1 µg RAE (Trumbo et al., 2001)

Sensory evaluation

The Kruskal Wallis test shows highly significant differences for the treatments in accordance to the variables color of crust and crumb of bread, crumb structure, texture, flavor and aroma (Table 4).

Table 4. Average value of sensory variables evaluated for sweet potato bread

Treatments	CB	CC	CS	T	A	F
100% WF: 0% SF	3.42[b]	3.10[b]	3.36[b]	3.38[b]	2.92[c]	2.86[b]
90% WF: 10% SF	4.08[a]	3.94[a]	3.90[a]	3.94[a]	3.52[b]	3.64[a]
80% WF: 20% SF	4.02[a]	3.88[a]	3.72[ab]	3.98[a]	3.86[a]	3.92[a]
70%WF: 30% SF	4.00[a]	3.54[b]	3.74[a]	3.70[ab]	3.72[ab]	3.72[a]

CB: color of bread crust; CC: crumb color of bread; CS: crumb structure; T: texture; A: aroma; F: flavor.

[a, b, c] The values denoted different letters in the same column are significantly different (P < 0.05)

The color of bread crumb (CB) is one of the most important visual characteristics of the product bread. The control (100% WF: 0% SF) is significantly less accepted than the other three treatments.

From left to right: (1) 70%WF: 30% SF; (2) 80% WF: 20% SF; (3) 90% WF: 10% SF y (4) 100% WF: 0% SF

Figure 2. Sweet potato bread with different substitution treatment

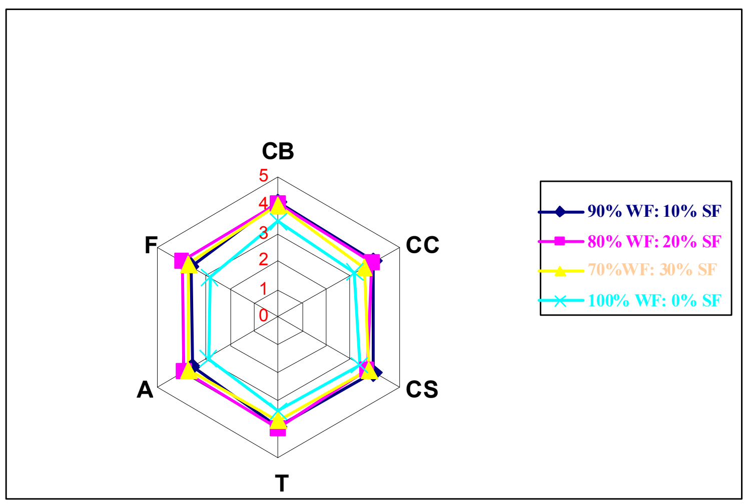
The crust color of bread (CC) - the surface must have a uniform tone -, is directly related to the percentage of substitution. The highest acceptability was observed for 90% WF: 10% SF; however, the difference to 80% WF: 20% SF were not significant.

The crumb structure (CS) is a characteristic that is related to the size of the cells. It must own the same porosity throughout the bread and be free of holes. We observed significant differences (p ‹0.05) between 100% WF: 0% SF and 80% WF: 20% SF.

The texture (determined by the sense of the tact), indicates the flexibility and smoothness of the crumb. The ideal texture must be smooth and velvety. We observed that treatment 80% WF: 20% SF presents a higher acceptability, which is significant different compared to treatment 100% WF: 0% SF.

The aroma was described as sweet and delicious. The ideal loaf has a pleasant aroma of wheat. On basis of this description we observed that a larger acceptance is obtained with treatment 80%WF: 20%SF, with significant differences in comparison with treatment 100% WF: 0% SF.

The flavor is the most important attribute of good bread. It is the possession of pleasant flavor. We observed that treatment 80% WF: 20% SF presents the highest acceptance, showing significant differences with treatment 100% WF: 0% SF. Figure 3 represents the sensorial profiles of the different treatments obtained of substitution from the averages.



CB: color of bread crust; CC: crumb color of bread; CS: crumb structure; T: texture;
A: aroma; F: flavor

Figure 3. Sensorial profiles of the different treatments obtained of substitution from the averages

Principal component analysis

We applied to the ACP taking the average values from the variables of each variety of the total of evaluators (Table 5). Both first components explain the 97.2% of the total variability. The CP1 explains the 91.56% and CP2 the 0.05% of the total variance of the variables. The contribution of the six attributes to CP1 and CP2 is given in table 5 by correlations.

Table 5. Correlation between attributes and the first two components

Attributes	CP1	CP2
Color of bread crust	0.42	-0.03
Crumb color of bread	0.41	-0.38
Crumb structure	0.40	-0.45
Texture	0.41	-0.20
Aroma	0.39	0.65
Flavor	0.41	0.43

The CP1 is positive for color of bread crust; crumb color of bread, crumb structure, texture, flavor and aroma. The CP2 is positive with flavor and aroma and negative for the color of bread crust; crumb color of bread, crumb structure and texture.

Projecting the variables to both axes and associating them with the sensorial attributes (figure 4) the following was observed: the treatment 70% WF: 30% SF is associated with the flavor and aroma but do not have a direct relation with color of bread crust; crumb color of bread, crumb structure and texture. On the other hand, treatment 90% WF: 10% SF obtained a direct association with color of bread crust; crumb color of bread, crumb structure and texture but does not have a good relation in accordance to the flavor and aroma. Based on the comparison, it is possible to affirm that the treatment: 90% WF: 10% SF, showed a major acceptability as far as the color of bread crust; crumb color of bread, crumb structure and texture is concerned. On the other hand, the treatment 70%WF: 30% SF, shows to relate with intrinsic flavor and aroma. However, the "best" relates to all sensory attributes, which was observed for treatment 80% WF: 20% SF; this treatment obtained the highest acceptance (Fig. 4).

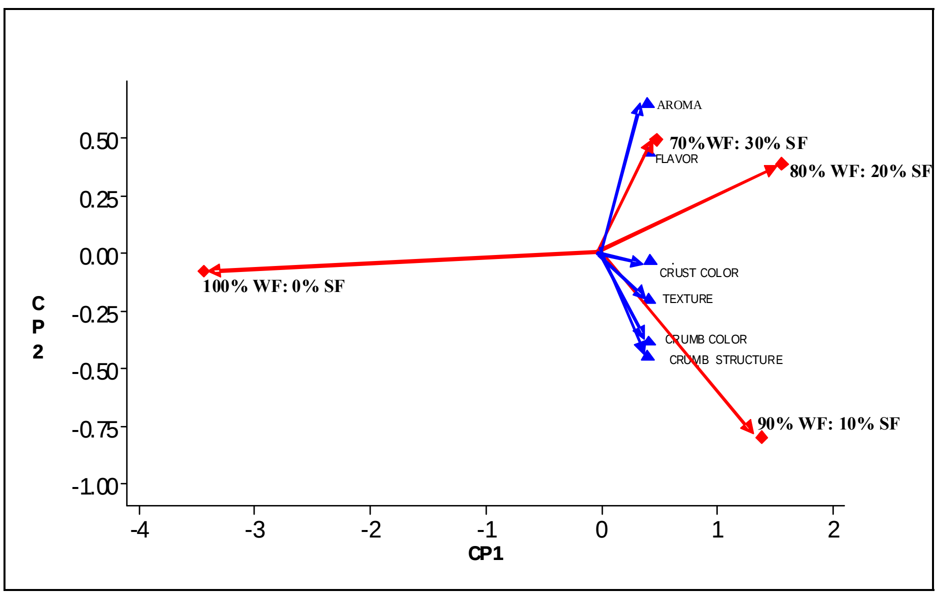


Figure 4. Plot of the correlations of variables and variables projection to the plane of the first two components

Texture profile analysis

The results of analysis of the texture profile presented in figure 5 by a test of uniaxial compression. The treatment 70%WF: 30%SF has a greater hardness due to the nature of the structural characteristics of the bread (for example a smaller volume). This is probably a result of the difficulty that the leavening finds to degrade alcohol starches and CO2. The last one allows the mass to increase the volume. This limitation is possible to be attributed to the deficient formation of the gluten. These evaluations endorse the results of the sensorial evaluation.

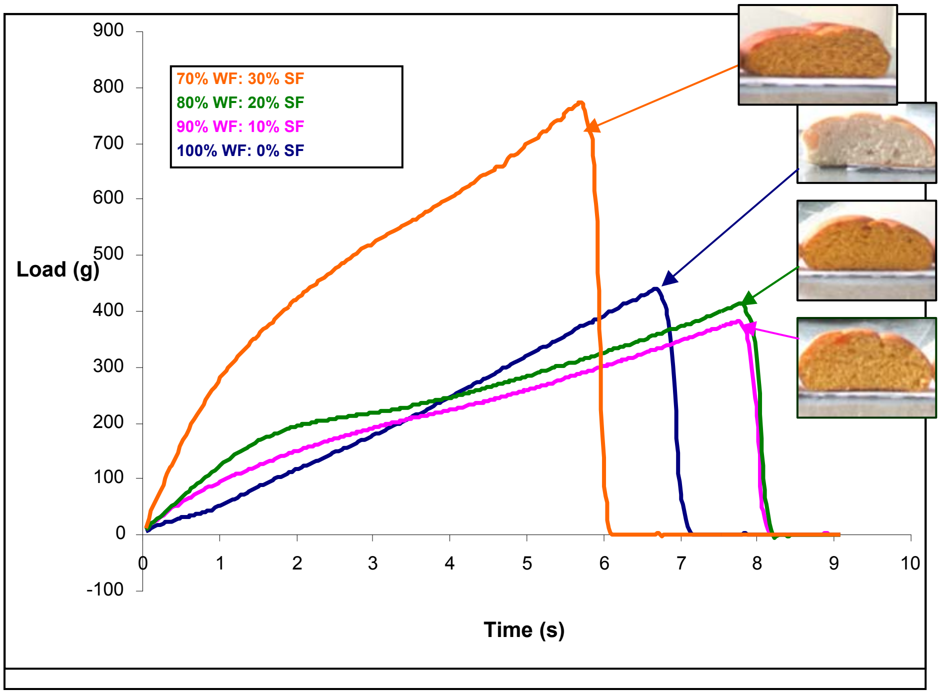


Figure 5. Curves of compression uniaxial to constant speed

Conclusions

The results of this study demonstrate that the flour substitution of wheat by flour of sweet potato in the treatment (70%WF: 30% SF) increase the percentage of humidity, fiber, fat, ash and content of β-carotene. The qualitative analyses show an intrinsic relation of the aroma and flavor in the treatment 70%WF: 30%SF. However, the treatment that presents a better relation with all the sensorial attributes is 80%WF: 20%SF that obtained highest acceptability.

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