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Evaluation of the nutritional and sensory quality of functional bread assortments obtained from wheat flour and carrot powder *(Daucus carota L.)*

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Abstract

The results presented in this paper are part of a complex study, which aims at the development of some bread assortments, specially designed to meet the requirements of a market segment of as many consumers as possible, with various tasty, and with high nutritional value products. In the context of obtaining such products, this study sought alternatives for the partial substitution of wheat flour with other high nutritional ingredients. Based on these considerations, the purpose of this study was to determine the sensorial, physico-chemical properties of bread with carrot powder. Wheat flour was supplemented with three different concentrations of carrot powder (30%, 50% and 70%). In case of sensory evaluation, incorporation of carrot powder recorded the highest scores for all quality attributes of the assortment with 50% substitution. The results showed that the addition of 50% carrot powder resulted in a bread assortment with volume, porosity and low elasticity, but with a high acceptability. Overall, carrot powder could be incorporated up to a level of 50% into bread, in order to provide its beneficial health effects, without changing significantly the bread quality.

Keywords: bread quality, carrot powder, sensorial and physico-chemical characteristics.

1. Introduction

The scientific and technological evolution of recent years has been influencing and visibly influences the life and feeding style of the modern individual. Nowadays, consumed food is processed, refined, concentrated so that it is as easy to prepare and consume as possible, to produce gustatory sensations and to relieve the hunger without taking into account the body's needs and the long-term effects on health [1].

The increasing incidence of nutrition diseases and the increasing costs of treating them, has alarmed nutritionists and the authorities.

Rediscovering the influence of diet on health, has led to the emergence of functional foods, as foods with preventive and ameliorative effects of various non-communicable chronic conditions [1, 2].

The most accessible way to provide the population with vitamins and micronutrients is the supplementary fortification of everyday food and consumer products, especially flour and bakery products, with these substances. However, the fortification of foods must not diminish their nutritional qualities and their quality, particularly not to substantially alter the taste or assimilation of other nutrients contained therein, not to reduce the shelf-life and not to alter the product's harmlessness characteristics, respectively [2].

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Referring to these observations, the purpose of this paper was to optimize high nutritional bread assortments, as well as to improve its sensory, nutritional and technological attributes through the addition of CP. In this sense, the following analyzes were carried out: sensory and physicochemical parameters of bread with 30%, 50% and 70% CP added. The use of carrots in the manufacture of classical bread is justified on the basis of their complex composition.

The carrot (*Daucus carota* L.*)* is one of the most popular root vegetables grown around the world and is the most important source of dietary carotenoids in Western countries including the United States [3]. Nutritional quality of food supplements based on carrot powder have been reported to be a good source of β-carotene, fiber and many essential micronutrients and functional ingredients [4]. In recent years, carrot consumption and its products have steadily increased due to their recognition as an important source of natural antioxidants, in addition to the fact that the anticancer activity of β-carotene is a precursor of vitamin A [5].

The beneficial effect of carrots on health is due to the high intake of vitamin A, vitamin K, nutritive fibers, potassium, vitamin B6, vitamin C, niacin, vitamin B1, pantothenic acid, phosphorus, folic acid, vitamin E and vitamin B2 [6, 7].

The water content varies between 86-95% and an average portion contains about 1% carbohydrates and a low amount of lipids and proteins [5, 8]. Thus, the carrot increases the nutritional value of the bread, changes the rheological properties of the dough and ultimately the sensory quality, thus being a common ingredient and with potential in the development of a new generation of healthy food [6].

2. Materials and Methods

2.1. Materials

All raw materials used for bread preparation have been purchased from hypermarkets and specialized stores.

Steps in the preparation of carrot powder: carrots were washed, cleaned and cut into slices of 2-3 mm thick. The obtained carrot slices were then placed in a single layer on the trays of a household desiccator (Scarlett SC 421) and dried for 24 hours at 60°C. The dry carrots were milled with a grind mill (Grindomix 200) to obtain a fine powder, that is, the carrot powder (particle size 160-270 μm), which was introduced into hermetically sealed containers, deposited in a cool chamber until the following operations.

2.2. Methods

2.2.1. Proximate composition of wheat flour and carrot powder

For determining the average chemical composition of wheat flour (WF) and carrot powder (CP) the following chemical characteristics were determined: moisture, fat content, ash content, fiber content and carbohydrate content, according to standard method A.O.A.C. 1995 [9]; protein content by the Kjeldahl method according to standard method A.A.C.C. 2000, No. 46-10 [10].

2.2.2. Technological process for obtaining bread with carrot powder

In this study we have obtained 4 types of bread, as it follows: a control sample – (100% wheat flour 650 type), bread with 30% CP addition, bread with 50% CP addition and bread with 70% CP addition, respectively. The bread formulations are presented in *Table 1.*

Table 1. Formulas for bread with carrot powder

Ingredients (%)	**Bread samples**			
	Control bread (CB)	**Bread with 30% CP (B30CP)**	**Bread with 50% CP (B50CP)**	**Bread with 70% CP (B70CP)**
Wheat flour 650 type	**100**	**70**	**50**	**30**
Carrot powder	**0**	**30**	**50**	**70**
Yeast	2.5			
Salt	2			
Water	56			

After sieving, the wheat flour was added in the Hauser DM601 mixer and homogenized with carrot powder at speed 1 for 5 minutes; then the salt, the emulsified yeast with the warm water and the remaining water were added and the mixing continued at speed 1 for 5 minutes and then at speed 2 for 10 minutes, until a homogeneous dough was obtained. The dough thus obtained was divided into 500 g pieces, molded, put into trays and then left to rest for 40 minutes. After being leavened, the dough trays were placed in the oven and subjected to baking operation at 220°C for 25 minutes. After baking, the bread were cooled at room temperature, then packed in cardboard boxes and stored at temperatures of 18-20ºC [11].

2.2.3. Sensory evaluation of bread with carrot powder

The bread samples obtained according to the method described in paragraph 2.2.2., were submitted to sensory indices evaluation [12]. Bread assortments were served to the 20 participants who evaluated the color, appearance, flavor, texture, taste, smell, appearance and general acceptance scores. Twenty male and female students of Food Processing Technology between the ages of 18 and 35 were participants on the panel. Panelists were instructed to evaluate each attribute using a 1 - 9 hedonic scale. Samples coded with a three digits were offered to them. Each data point from sensory analysis represents an average of twenty panelists. Panelists were given water at room temperature to cleanse the mouth before tasting the samples from each formulation. All four samples were served, one at a time, to each taster.

2.2.4. Physical parameters of bread with carrot powder

Some physical parameters of bread including volume, porosity, height/diameter ratio and elasticity were determined [12].

2.2.5. Chemical evaluation of bread with carrot powder

The bread samples obtained according to the method described in paragraph 2.2.2., were submitted to chemical evaluation aiming: moisture, fat, protein, crude fiber, carbohydrate, ash according to A.O.A.C. and A.A.C.C. standard method (paragraph 2.2.1.) [9, 10].

3.Results and discussion

3.1. Proximate composition of wheat flour and carrot powder

The results obtained from the proximate analysis of the wheat flour and carrot powder are shown in *Table 2*. The results obtained with regard to the chemical composition of WF and CP highlight their functional potential, potential due mainly to the significant protein (12.48%), fiber (19.12%) and ash (6.42%) intake of WF that reflect the content of mineral substances (iron, magnesium, potassium, copper, zinc, etc.) of CP. According to these results, WF and CP can be considered important "protein sources", "fiber sources" and "mineral sources", as the protein content ranges between 9.36% to CP and 12.48% to WF, the fiber between 1.62% at WF and 19.12% at CP and the ash ratio between 0.64% at WF and 6.42% at CP, results that are consistent with those obtained by Hussein, (2013) and Humaira (2013) [6, 13].

Table 2. Chemical composition of raw materials

Chemical composition (%)	Flour samples	
	Wheat flour 650 type	Carrot powder
Moisture	14.32±0.18	8.32±0.25
Fat	1.65±0.29	2.42±0.16
Protein	12.48±0.26	9.36±0.24
Crude fiber	1.62±0.16	19.12±0.35
Carbohydrates	69.29±0.11	54.36±0.06
Ash	0.64±0.33	6.42±0.21

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

The WF's relative moisture was 14.32% compared to 8.32%, making the use of CP in the baking technology to determine the absorption of more water in the dough. Regarding the fat content of the analyzed samples, it can be seen that WF has a lower fat content (1.65%) than CP (2.42%). Compared to other studies [6, 15], the carbohydrate content of the analyzed samples reveals that WF has

a higher carbohydrate content of 69.29% compared to CP that contains 54.36%, which contributes to the lowering of the glycemic index of the products obtained from these two flours. The chemical composition of the composite flours has been shown to affect both physicochemical properties and nutritional quality of their products.

3.2. Sensory evaluation of bread with carrot powder

The sensory evaluation results reveal significant differences between control sample and bread with CP added in different levels. The obtained four assortments of bread with carrot powder, were sensory evaluated using 9-point hedonic scale by a number of 20 tasters. Hedonic ratings for product attributes and overall likeability are presented in *Table 3*. Substituting 30%, 50% and 70% WF with CP in the recipe for the manufacture of bread, led to the obtaining of samples with optimum sensory attributes. Following the sensory analysis of the four assortments of breads (Control bread – CB; Bread with 30% CP – B30CP; Bread with 50% CP – B50CP; Bread with 70% CP – B70CP), using the 9-point Hedonic scale, it resulted that bread assortment with 50% CP was the most appreciated in sensory terms. The increasing level of CP had a positive effect on bread characteristics as higher scores were given to the samples containing up to 30% CP (texture: 7.49%; taste: 7.41%; smell: 6.85%) and 50% CP (texture: 7.88%; taste: 7.86%; smell: 7.55%) compared to the control sample (texture: 6.84%; taste: 6.68%; smell: 6.35%). It has been primarily attributed to terpenoids and sugars which are mainly responsible for carrots flavor of CP [14]. The addition of a higher level of CP (70%) had a negative effect on texture (7.43%), and also on smell (7.38%) and taste (7.29%). The Hedonic rating for flavor was the highest for B50CP sample (7.12%), followed by the B30CP (6.68%) while the lowest was registered for control sample (6.31%). Sensory rating of bread for color shows that replacement of WF with CP affects the color, which decreases from 6.86% in CB to 6.26% in B70CP samples.

The color of B50CP sample (6.51%) was rated significantly lower than control sample (6.86%) showing that the replacement of WF with CP affects the color. The coloration of the crust was uniform, golden reddish - darker than the blank sample, which exhibited a golden yellow crust. Similar observations were found by Tanska *et al*., (2007) and Hussein, (2013) [6, 15] for dried carrot and carrot powder incorporated bread.

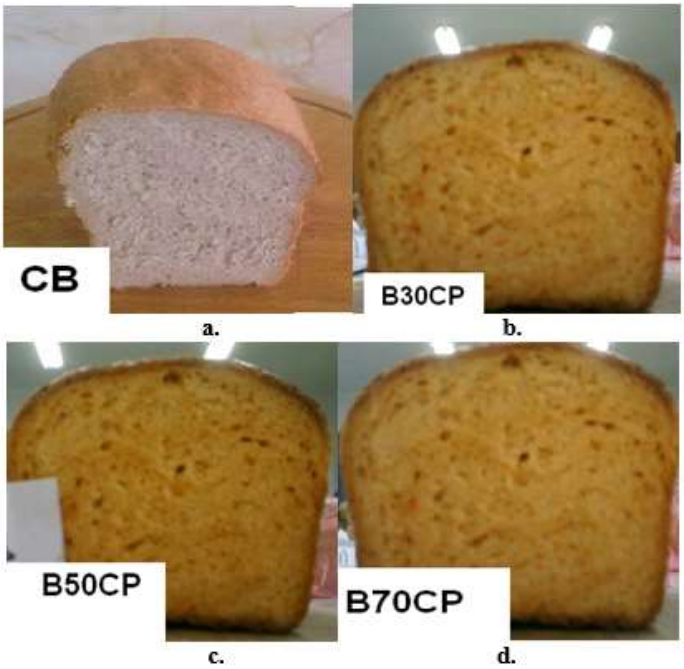

Figure 1. The assortments of breads: **a.** Control bread – CB; **b.** Bread with 30% CP – B30CP; **c.** Bread with 50% CP – B50CP; **d.** Bread with 70% CP – B70CP

Table 3. Quality attributes scored in sensory assessment of bread with carrot powder

Parameters	Bread samples			
	Control bread (CB)	Bread with 30% CP (B30CP)	Bread with 50% CP (B50CP)	Bread with 70% CP (B70CP)
Color	6.86±0.14	6.69±0.27	6.51±0.13	6.26±0.24
Flavor	6.31±0.03	6.68±0.17	7.12±0.22	6.56±0.06
Texture	6.84±0.25	7.49±0.23	7.88±0.07	7.43±0.24
Taste	6.68±0.04	7.41±0.02	7.86±0.16	7.29±0.03
Smell	6.35±0.09	6.85±0.04	7.55±0.23	7.38±0.81
Appearance	6.38±0.39	6.49±0.45	7.22±0.09	7.05±0.09
Overall acceptability	6.45±0.03	6.88±0.03	7.56±0.04	6.18±0.03

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

The results obtained in terms of appearance were the following: the bread was well-grown, the shape was well contoured, undistorted, the surface of the crust did not exhibited cracks, the crumb was non-brittle, well grown, porous, not moist. Values obtained in terms of bread samples aspect, were: 7.22% for B50CP and 7.05% for B70CP versus CB, which recorded a value of 6.38%. The overall general acceptability score of the bread samples analyzed in this study increased for B30CP to 6.88% and to 7.56% for B50CP, compared to CB sample (6.45%) and decreased to 6.18% for sample B50CP because this proportion has negatively affected the taste, smell, color and dullness of the product [6]. According to the data presented in *Table 3*, it can be noticed that sensory values for bread samples fall within the first two categories of quality: "very good" and "good". Synthesizing these data, it can be seen that the 50% CP addition to WF has proven to be the optimal proportion to be added in order to obtain the most appreciated range of bread from a sensory point of view.

3.3. Physical properties of bread with carrot powder

The physical characteristics of the bread obtained from wheat flour and carrot powder are presented in *Table 4*. From the data presented there, we can see that the volume, the porosity, the height/diameter (H/D) ratio and the elasticity of the bread decreased significantly with the CP increased substitution with. The volume of the blank sample was higher than the volumes of all bread assortments with the addition of CP, so the CB sample had a volume of 295 cm3 / 100 g of product, and decreased to 275 cm3 / 100 g of product at sample B50CP and 268 cm3 / 100 g product at sample B70CP. Similar observations were found by Hussein, (2013) [6] for carrot powder incorporated bread

But even if the volume of analyzed bread assortments decreased proportionally with the added CP ratio, the products obtained were proportional, specific to the assortment, not flattened or overbaked

Table 4. Physical properties of bread with carrot powder

Parameters	Bread samples			
	Control bread (CB)	Bread with 30% CP (B30CP)	Bread with 50% CP (B50CP)	Bread with 70% CP (B70CP)
Volume (cm^3/100g product)	295±0.03	282±0.32	275±0.06	268±0.42
Porosity (%)	92.48±0.12	85.77±0.13	83.56±0.22	80.36±0.22
Ratio (H/D) (cm)	0.498±0.22	0.492±0.09	0.486±0.23	0.480±0.08
Elasticity (%)	97.82±0.12	96.12±0.18	93.98±0.02	90.88±0.12

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

Table 5. Chemical evaluation of bread with carrot powder

Chemical composition (%)	Bread samples			
	Control bread (CB)	Bread with 30% CP (B30CP)	Bread with 50% CP (B50CP)	Bread with 70% CP (B70CP)
Moisture	30.22±0.12	32.05±0.06	33.94±0.11	35.63±0.10
Fat	2.26±0.04	2.49±0.16	2.64±0.05	2.79±0.24
Protein	10.26±0.25	10.08±0.15	9.97±0.54	9.85±0.02
Crude fiber	3.17±0.08	7.70±0.34	10.72±0.08	13.74±0.42
Carbohydrates	52.05±0.04	46.27±0.04	42.42±0.53	38.56±0.06
Ash	2.04±0.72	3.39±0.02	4.29±0.09	5.19±0.21

All determinations were done in triplicate and the results were reported as average value ± standard deviation (SD).

The value of the H/D ratio shows the degree of bread's development, so a final product is considered to be well developed if the ratio ranges between 0.4 ÷ 0.5cm and if it exceeds 0.5 cm is considered to be deformed, bulging. From the data presented in *Table 4* it can be seen that by the addition of CP, the H / D ratio is within limits, so if the CB sample had a ratio of 0.498cm, it dropped to 0.480cm at sample B70CP.

Regarding elasticity (%) of bread fortified with CP with different proportions, the results showed that the addition of 70% CP in the dough determined a decrease of elasticity [15] to 90.88 % compared with control sample, whose elasticity was 97.82 % (*Table 4*). The other samples studied, B30CP and B50CP have registered 96.12 % and 93.98 % elasticity of final product. The results regarding porosity are shown in Table 3. Thus, the CB sample exhibited a high porosity (92.48%), thus well-developed pores with more developed and more uniform pores compared to the sample with 70% CP having the lowest porosity (80.36%). The latter having a small, lower and less developed crumb.

3.4. Nutritional parameters evaluation of bread with carrot powder

Chemical evaluation of bread WF and CP-based are shown in Table 5. From the data presented in *Table 5* it could be noticed that crude protein and total carbohydrate slightly decreased in the bread samples, while fat, ash and crude fiber contents increased with increasing the levels of CP. This may be due to the relative high contents of ash and fiber in CP than those of WF. These results are confirmed by those obtained by [8]. From the data presented in Table 5, it can be seen that the moisture content of all samples with CP added, was higher than that of the CB sample (30.22%), ranging from 32.05% for sample B30CP to 35.63% for sample B70CP. An explanation of these higher values of bread samples than CBs is the ability to absorb a larger amount of water by the fibers present in CP [15] than in WF. Centralizing the results obtained with regard to the chemical composition of the bread samples analyzed in this study (*Table 5*), it was found that the addition of CP in the bread making formulation with CP added, resulted in a significant increase in nutrient content and thus, the products obtained can be characterized as having a high functional potential, being considered as "fiber sources" and "mineral sources. Thus fiber content varies between 7.70% and 13.74% compared to 3.17% in the CB sample and the ash content ranges between 3.39% and 5.19% compared to 2.04% in the CB sample. The fat content was higher than in the case of CB (2.26%), ranging from 2.49% to sample B30CP to 2.79% for sample B70CP. Regarding the carbohydrate content of the samples analyzed in this study it decreased proportionally with the percentage of added CP thus, from 46.27% (B30CP) to 38.56% (B70CP), compared to the CB sample having a carbohydrate content of 52.05%.

However, the average fiber, ash, protein, fat and carbohydrate content of analyzed bread samples can be considered low compared to other studies [6] that reported a fiber content of 1.60%, ash - 2.20%, protein - 9.45%, fat - 3.91% and carbohydrate 82.84% at 8% CP compared to WF.

4. Conclusions

Carrot powder investigated in this study can be considered a suitable ingredient for bread supplementation due to its high nutritional value. Bread made from wheat flour and carrot powder has

an increased content of nutrients such as protein, fiber, fat and ash, and a low carbohydrate content.The study has shown that 50% carrot powder could be used as wheat flour substitute to produce bread that would be well accepted by the consumers. The scores for sensorial attributes like taste, flavor, texture, smell and appearance except for colour, were generally superior to that of wheat bread. Therefore, the bread with carrot powder had better overall acceptability scores than the control bread assortments. Regarding physical characteristics, the addition of carrot powder (30%, 50% and 70%) to the ingredients of bread samples causes a decrease in volume, porosity, elasticity and H/D ratio of final product compared with the control sample.

By correlating the results obtained with respect to the sensory and physio-chemical analyzes of the bread samples, we can appreciate that the recipe established for obtaining the bread with 50% carrot powder addition can be successfully applied on an industrial scale, thus obtaining good bakery products both nutritionally and qualitatively. A market study for these new assortments of bread and their impact on consumers could be a further study in this field.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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