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STUDY ON EFFECTS OF ARTICHOKE FLOUR ADDITION IN BREAD

***Sorina ROPCIUC[1], Ana LEAHU[1], Cristina DAMIAN[1], Laura Carmen APOSTOL[1]**
[1]*Faculty of Food Engineering, Stefan cel Mare University, 13th University Street, 720229, Suceava, Romania*
sorina.ropciuc@fia.usv.ro; sorinaropciuc@yahoo.com
*Corresponding Author
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Abstract: *The increase of the fiber content in bread is a major challenge in the baking industry. In this study, the quality characteristics of flour and bread mixture obtained by adding artichoke flour , as a source of fiber, was determined. The physico-chemical characteristics of flour were analyzed: gluten content, acidity of artichoke flour added at 0%, 10%, 20%, 30 % and 40%. Bread made with and without the addition of artichoke flour has been evaluated for specific volume, color and porosity. The addition of artichoke flour decreased water absorption capacity of the flour, reduced the amount of gluten in the dough and increased acidity of the flour mixture. The bread samples obtained by substituting the whole wheat flour by artichoke flour were analyzed in terms of acceptability and quality. For this objective five bread samples were analyzed and the color of bread and a series of physical parameters (diameter, sample mass, height / diameter core porosity) were determined.*

Keywords: artichoke flour, inulin, quality bread, wheat flour.

1. Introduction

Bread is considered one of the important foods from the nutritionists because is a source of carbohydrates, protein, fiber, vitamins, micronutrients and antioxidants. Food fibers, in particular the soluble, have a number of beneficial effects including prebiotic activity, increased mineral absorption and prevention of diseases such as Type II diabetes, cardiovascular disease and colorectal cancer [1]. Whereas the fiber content of white bread flour is only 2-3%, the feeding ensures full intake of fiber, 7-8% of dry matter [2]. However, these propositions cover only a small part of recommended daily intake. Because of this the present study aims at increasing the fiber content of bread by total or partial replacement of wheat flour with flours from other sources [3].
Artichoke flour has a low calorific value, nearly fat free and starch. The interest component of the artichoke is inulin, a dietary fiber with linear structure that is included of fructans class. The inulin content of artichoke flour exceed 50% of dry matter. The use of inulin is not considering only increase the fiber content of products, but also numerous beneficial effects on human health. Thereby, inulin is recommended in the prevention and treatment of obesity and diet followed by people suffering from diabetes. Inulin also has the prebiotic activity, role in improving bowel function and increase immunity [4]. The enrichment bread with functional ingredients is important for the consumers and for the baking industry. In order to increase the fiber content of bread it may be carried addition of inulin content products at high levels, such as artichoke flour. Artichokes is classified in the genus *Helianthus* L., family *Asteraceae*; the plant is also known as the "artichoke", "Jerusalem artichoke", "turnip". The name artichoke was attributed due to the similarity that exists between taste and

texture of the boiled artichoke tubers (*Cynara scolymus* L.). Artichoke tubers contain about 80% water, 15% carbohydrates and 1-2% protein. The principal carbohydrate from artichoke is inulin of which proportions varies from 7-30% of tuber fresh weight (about 50% dry) [5-7].

The use of inulin from artichoke is not considering only the increase of the fiber content from the products but also many health benefits evidenced by previous studies [8]. Therefore, inulin is recommended in the treatment of obesity and diets followed by people suffering from diabetes. Inulin has also prebiotic activity that is involved in the improvement of intestinal function and the growth of immunity and plays a role in preventing osteoporosis and maintaining bone health.

In technological terms, partial substitution of wheat flour with artichoke flour in different percentages significantly change the quality and mechanical properties of the dough [6]. The addition of fiber to the flour leads to changes in the technological parameters, changes that directly determines the quality of the bread. A potential effect of the addition of fiber volume is the decrease of the volume by reducing the percentage of gluten content from the dough and consequently reducing the capacity of the dough to retain fermentation gases [7-9]. Another aspect to be evidenced and studied is the fact that most of the fibers determine the increase of hydration capacity of the flour, which in economic terms, it constitutes an advantage because from the same amount of flour you can obtain more products. The study has as its objective: the effect of the addition artichoke flour and the quality of bread from whole wheat flour.

2. Materials and methods

2.1. Materials

2.1.1. Wheat flour

For the proposed determination whole wheat flour sample derived from S.C. Mopan Suceava S.A. were used. The flour chemical composition was determined according to Romanian standard methods: moisture (SR EN ISO 712:2010), ash content (SR EN ISO 2171:2010), wet gluten content, (SR 90:2007), acidity (SR 90:2007).

Artichoke flour

In order to obtain artichoke flour tubers were washed, peeled and cut into thin slices. Drying was carried out in an oven at a temperature of 40°C. After cooling, flour obtained by milling the dried slices of artichoke got used to prepare bread.

2.2. Methods

Preparing the mixture of wheat flour meal with artichokes flour

The amount of artichoke flour that was a flour-specific substitution of whole wheat was at the rate of 0%, 10%, 20%, 30% and 40%.

The dough was prepared using the technique of direct manufacturing. For dough preparation food processor was used. The dough for each bread sample was prepared separately using the amounts from the ingredients listed. The dry ingredients (flour and salt) were introduced into the food processor bowl, and the yeast was first dissolved in water and then added over the rest of the ingredients. The dough was left to rise for 30 minutes. After initial fermentation, the dough was shaped imparting to specific loaf shape and put in baking tray. The final step was the fermentation in pan for 15 minutes. The baking process of the bread was held in an electric furnace at 200°C for 30 minutes. After baking the bread was left to cool to room temperature before being analyzed.

Physical and quality parameters of bread
For assessing the influence of the characteristics of artichoke flour, bread samples were evaluated to determine elasticity, volume, porosity and other characteristics. Determinations were made at 6 hours after baking for all the bread samples.

Bread volume, elasticity and porosity were determined according to SR 91:2007.
The determination of bread sample colors was measured using portable spectrophotometer. For the assay were used two slices of each bread sample and the measurement was repeated at least twice. Results are expressed in the parameters of the Cartesian system's CIEL * a * b * namely L * - brightness (0 - black 100 - white), a * - green (-) and red (+) and b * - blue (-) and yellow (+).

Statistical analysis
To calculate the mean values and standard deviations of the analysis results, Microsoft Office Excel software was used.
In order to achieve the correlative links and to establish the optimal proportion of artichoke flour XLSTAT statistical software was used.

3. Results and discussion

3.1. Physical and chemical properties of wheat flour

Based on the flour acidity there can be assessed the level of freshness, alteration or compliance storage. The acidity of the flour is determined by processes of decomposition of fats from the wheat germ, in wheat flour's case or tuber plant composition, or from artichoke flour. Values obtained for the acidity of wheat flour (blank) and flour mixtures with artichoke flour are expressed in Table 1. *The variation of acidity* according to the proportion of added artichoke flour is shown in Fig. 1.

Table 1.
Acidity of flour used to obtain samples of bread

Sample	Acidity level
Wheat flour	2.6
10% artichoke flour mix	3.2
20% artichoke flour mix	3.8
30% artichoke flour mix	4.2
40% artichoke flour mix	4.4

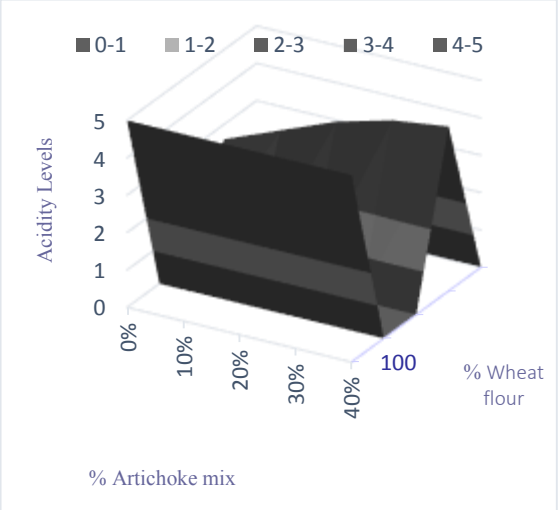

Fig. 1. Variation of acidity according to the proportion of artichoke flour from the mixture

The addition of artichoke flour mixture causes an acidity increase of the mixture-wheat flour and artichoke flour up to 40%. For the latter one the determined acidity is lower than 30% artichoke flour mixture one.

The capacity of hydration

The wheat flour used in the production of the control sample has a water absorption capacity of 53%. In contrast, the hydration ability of artichoke flour is 31%. The variation of the hydration capacity according to the modification of the composition of the mixture of the flour is shown in Fig. 2.

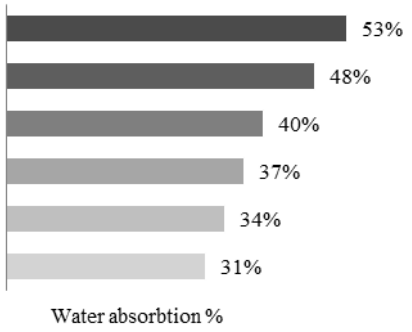

Fig. 2. The variation of hydration capacity of the mixture according to the proportion of artichoke flour

Partial substitution of wheat flour with artichoke flour changes the hydration capacity [10]. Moreover, the greater the proportion of artichoke flour, the amount of water required is reduced [11]. So a substitution of 10% of wheat flour changes the hydration artichoke flour reduce capacity by 5%. For artichoke flour proportion of 20%, 30% and 40% of the mixture the water absorption decreases by 3% for each 10% increase in the amount of flour artichoke. Values and similar trends were obtained by Gedrovica and Karklina (2011) for mixtures of wheat flour and artichoke flour in identical proportions to those examined in this study [12]. The decrease in water uptake can be attributed to the content of low molecular weight carbohydrates and oligosaccharides typically of the artichoke wheat flour [13]. Another factor that causes a reduced hydration capacity of mixtures with artichoke flour is the high inulin content, which account for about 50% of dry matter [14]. Inulin forms a barrier around the starch molecule limiting the possibility of fixing [15-16]. For this reason artichoke flour has a hydration capacity of 31%, almost twice lower than the wheat flour's one.

Wet gluten content

Another important parameter on which depends the quality of flour and which influence the development of bread is the gluten content. The modification of this parameter with the increase of the addition of flour artichoke is the shown in Fig. 3.

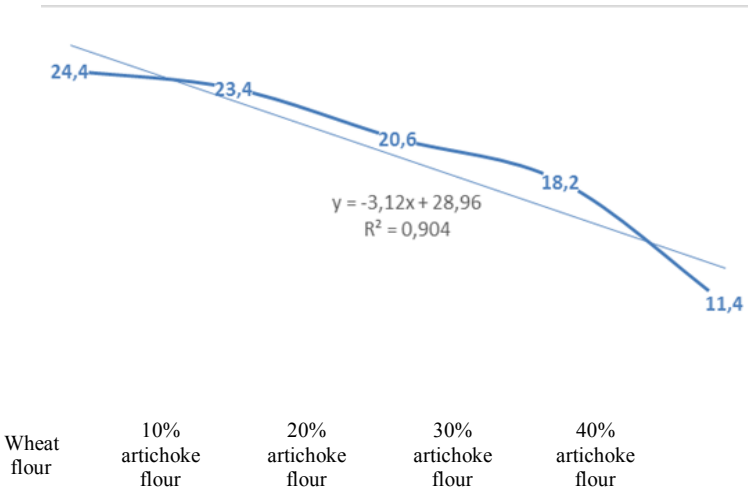

Fig. 3. Variation of wet gluten content according to the proportion of added arthicoke flour from the mixture

In the formation of gluten are involved water and two characteristic protein of wheat flour: gliadin and glutenin. First determine extensibility, and the latter dough elasticity. From the wheat flour a wet gluten content of 24.4% was determined. As artichoke flour does not contain glycine and glutenin, it has been expected a reduction in the proportion of gluten with the increase of the amount of artichoke flour used. Therefore, a wet gluten content of 23.4%, as determined for the sample with 10% artichoke flour is brought to one of 11.4% in the case of wet gluten sample with 40% arthicoke flour. Role in reducing wet gluten content has inulin from the artichoke flour, which prevents water fixing and thereby determining the formation of gluten network.

In order to obtain a high quality bread there should be used mixtures of wheat flour with acidity, hydration capacity, and the optimal gluten content.

3.2. Bread flour quality

Sensory analysis

The score obtained for each feature senzorial bread samples in Fig. 4. For the blank, represented by wholemeal bread wheat was obtained the maximum score for the cores. Core and shell color appearance were less popular, while porosity and taste convened lowest scores (4.6 points).
Sensory analysis showed that the most popular bread samples made from a mixture of wheat flour and meal of artichokes flour were the proportions of 10% and 20% meal of artichokes flour. They were given the maximum score for the color of flesh. Compared with the sample of wholemeal bread, bread crumb color with the addition of 10% and 20% was considered superior by tasters. Another highly appreciated sensorial feature (denoted by 5 points) if 20% of the sample was bread peel appearance. Samples with 10% and 20% meal of artichokes flour obtained equal scores for the cores (4.8 points) and taste (4.6 points). Less than appreciated by tasters were 30% bread with artichoke flour and the 40% meal of artichokes flour. The latter obtained the lowest score (3.2 points) for the cores, porosity and taste. Scoring is justified by the fact that with the increase of the amount of wheat flour dough substituted structure is changed and thereby the degree of development of bread during the baking process. In this case the addition of artichoke flour has a significant influence on core, general appearance and on its porosity. Based on these observations it can be concluded that in the case of bread made from flour mix is not recommended the proportions greater than 30% of arthicoke flour.

3.3 Physical parameters of quality

In order to assess the development of artichoke bread with flour after baking the mass and diameter of each sample, the ratio height / diameter and core porosity was measured. The results are expressed in Table 2. It is noted that the addition of artichoke flour results in a decrease in the weight of the bread. The variation is justified by the reduced hydration capacity of the flour, as well as low-gluten content of the dough obtained in a high quantity of flour.
Similar values obtained for the bread weight and diameter decrease with increasing content arthicoke flour.

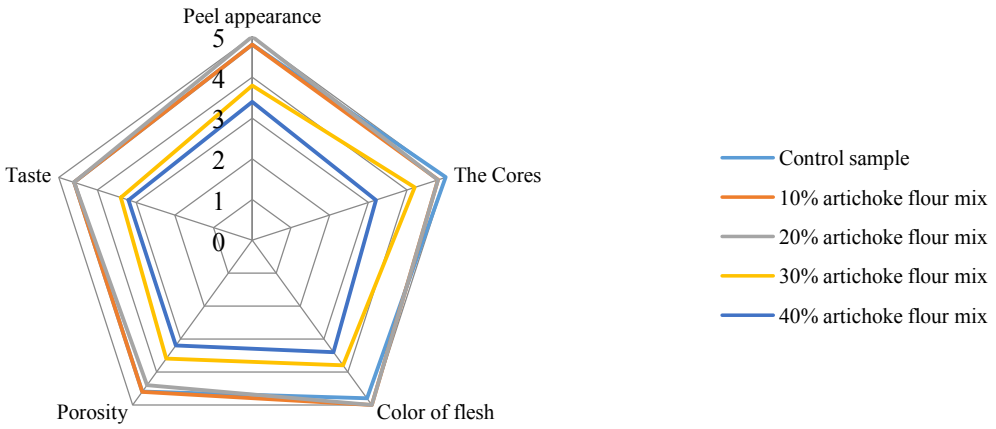

Fig. 4. Graphical representation of the values obtained for the samples sensory characteristics of bread with added artichoke flour

Table 2.
The values of the physical parameters of bread samples

Sample	Weight, g	Diameter, cm	Height / Diameter Relation	Porosity, % vol.
Wheat Bread	155	8	1.03	71
Bread with 10% artichoke flour	146.5	7.4	1.06	68
Bread with 20% artichoke flour	135.9	6.5	1.07	53
Bread with 30% artichoke flour	128.7	6.1	1.10	50
Bread with 40% artichoke flour	96.9	5.2	1.13	30

There is generally no significant differences between height and diameter of bread; exceptions are samples with 30% and 40% arthicoke flour at low height and larger diameter highlights their inappropriate development.
Last but not least, it has been observed a reduction in porosity determined by increasing the amount of wheat flour substituted with the artichoke flour. The difference between the highest and the lowest is 13%, which shows that the effect is not very pronounced. The porosity of the bread is in direct correlation with the gluten content of the flour used so that the use of large amounts of artichoke flour bread leads to a low porosity [17].

Bread Color

In order to study the effect of the addition of artichoke flour has on the color of bread samples was used for color measurement system CIEL * a * b * values obtained are noted in Table 3. The analysis followed Cartesian measurement of the brightness of the system, namely (L *) and hue color (a *, green-red and b * the blue-yellow) and determining the differences in these parameters between the blank (wholemeal bread wheat) and samples of bread with artichoke flour.
The amounts presented in the table shows that the addition of artichoke flour leads to a significant change in the color of bread. Except for the sample with 30% artichoke flour, bread characteristic brightness decreases with increasing amounts of flour from artichoke. Therefore, 40% flour bread with artichoke flour presents the darker color than the rest of the evidence. A similar trend of brightness on bread samples was observed by Rubel et al. (2014) after an addition of 2.5 to 5 g of flour artichoke. The value obtained by researchers for the 5g flour-artichoked bread was the lowest (61.51 ± 2.05). For all measured parameters, color sample meal on bread with artichoke 20% was significantly different from that of other samples. This sample is darker than 30% added artichokes flour and presents the most prominent shades of red and yellow. Consequently, the measured values for the difference in color and shades of red and yellow with 20% of artichokes flour and blank were higher. Determined color difference was 8.56, amounting to almost three times higher than that obtained for the remaining samples. The measured value for the difference between reds was 3.74, while the difference in shades of yellow was 7.11. Modifying the color of bread with artichoke flour has been attributed to the high content of inulin, which undergoes decomposition during the baking process, resulting in strong Maillard reactions [14]. The sample showing color close to that of the control sample is 10% artichok flour. If you prefer bread with characteristics similar to full it is recommended proportions of 10% and 30% artichokes flour. The use of smaller quantities of artichoke flour also provides a corresponding development of the bread, ensuring a diameter, height and an optimal porosity of the core. Incidentally, bread with added 10% and 20% artichoke flour

samples were most appreciated sensory attributes.

3.4 The statistical interpretation of experimental data

Pearson Matrix offers the opportunity to see which are the statistically significant correlations between variables taken two by two. For example, bond strong positive correlation is indicated by the correlation coefficient $r^2 = 0.974$ between gluten and porosity. It is estimated that the higher gluten content, porosity increases (in the study, which has no general condition, strong gluten flours don't lead to high porosity).Inverse correlation stands between hydration capacity and the height / diameter relation ($r^2 = -0.955$).

The principal component analysis (PCA) were plotted correlations Fig. 5, the types of bread obtained and analyzed variables. PCA analysis shows that bread with added 10 and 20% artichokes flour are blends best correlate significantly with the most important features we appreciate the flour mixture and those bread: Glute, hydration capacity, porosity and ground.

From optimal mathematical model (Fig. 6) the addition of artichoke flour mixed with wheat flour is between 18.2 to 20.6%, the content leads to bread with quality features ideal of sensory and technological standpoint.

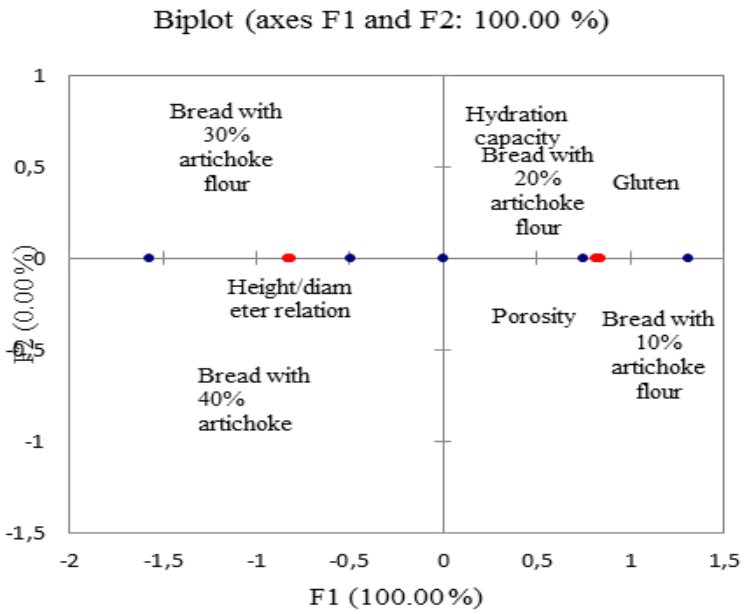

Fig. 5. Graphical representation of the main components

Table 3.
Influence of the addition of artichoke flour on the bread color

Sample	L*	a*	b*	dL	da	db	dE[1]
Wheat Bread	61.8	4.9	17.5				
Bread with 10% artichoke flour	61.0	4.8	20.82	-0.7	0.4	3.3	3.4
Bread with 20% artichoke flour	58.8	8.1	24.6	-2.9	3.7	7.1	8.5
Bread with 30% artichoke flour	59.8	4.88	19.88	-1.9	0.49	2.37	3.12
Bread with 40% artichoke flour	58.3	4.37	19.14	-3.4	-0.01	1.64	3.84

[1]color difference

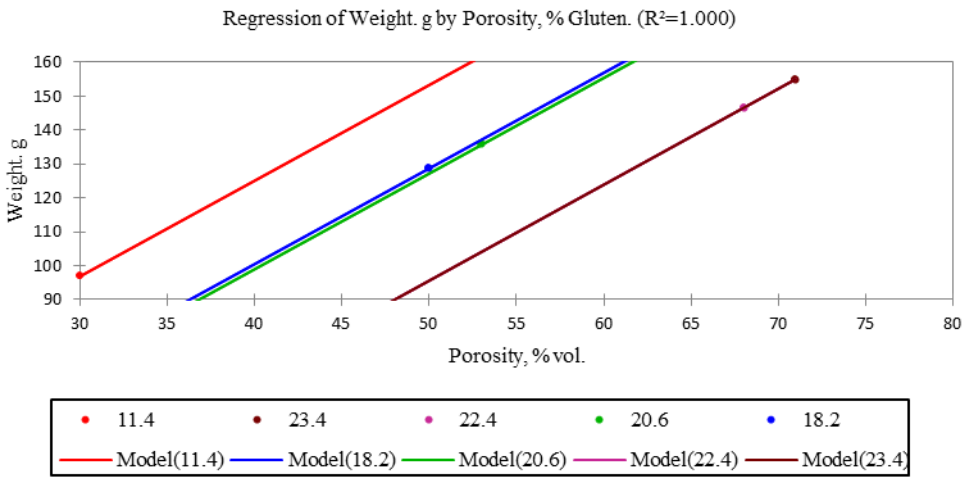

Fig. 6. Regression curve of the optimal artichoke flour addition

4.Conclusion

The use of artichoke flour as an ingredient in the preparation of bread aimed to increase the fiber content and to obtain a product with beneficial effects on consumer health. To study the effect of the addition of artichoke flour on product quality five samples of bread were used. A sample obtained from wheat flour and four samples of bread from a mixture of wheat flour and artichokes flour in different proportions varring between 10% and 40% were prepared.

Issues involved were characteristics of mixtures of flour and dough, acceptability and quality of finished products.

A first condition for obtaining a quality bread is to use an flour with optimal composition. For the analysis of the quality of wheat flour mixtures, artichoke flour - the pH, hydration ability and wet gluten was determined. It was concluded that the samples with a lower acidity presents artichoke flour and optimal hydration capacity and high gluten content. Therefore, the use of mixtures with 10% and 20% artichoke flour produced a corresponding porosity volume.

Finished product quality assessment was performed by sensory analysis, color measurement and determination of physical parameters (diameter and mass of the sample, the height / diameter core porosity). The obtained data supporting previous observations, that the addition of 10-20% artichoke flour gives a bread with improved quality and sensory attributes.

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