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Effects of Several Purple Potato Additions on Bread Quality

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ABSTRACT
Potato cultivars with purple flesh represent an efficient and natural source of antioxidants, this vegetable having high content in polyphenols (especially anthocyanin pigments). The research goal of this work was to evaluate the anthocyanin and polyphenols content of several Romanian potato varieties (Albastru-Violet de Gălănești and Christian) and the effects of these potatoes (add to dough in different proportions) on several bread quality indicators. The bread quality depends on physical and chemical properties and on several signs like: flavor and taste, external appearance, crumb porosity and texture, bread's volume. In this research experiment, beside the total polyphenols and anthocyanin content, the analysis performed on bread (prepared using different potatoes addition 5%, 15% and 30%) were sensorial and physic chemical analysis (product volume, crumb porosity, height/diameter ratio, moist and acidity). Experimental results indicated that 15% purple potato cultivar added on the dough was the most indicate proportion to be used in bread processing.

Keywords **-** anthocyanin, bread, polyphenols, purple potato.

I. INTRODUCTION

Food prepared with potato tubers containing polyphenols in flesh could be an excellent sources of natural antioxidants [1]. Anthocyanin, the phytochemical which appears in various potato varieties, known especially for its health promoting effects in red wine, have a strong effects because their antioxidant properties [1,2]. The health promoting properties of anthocyanin are determined by its antioxidant capacity [3,4,5,6]. The health promoting features are for example protection against degenerative illnesses and boosting the immune system [4,7,8]. Having a high consumption in Romania, the potato has an important position as a basic food, the interest for this vegetable is increasingly for the consumer, nutritional medicine and the food processing industry (e.g. potato crisps production). The goal of this research work to estimate the anthocyanin and polyphenols content of some potato cultivars probably useful for bakery industry and the influence of the potato addition (in dough) on several bread quality indicators. The bread is one of the most important human food product, being needful for daily feed because their energetic value. The effect of bread and bakery products consumption on the people health is major because this kind of food never miss from consumer's meal [9, 10]. Researcher target concerns to improve the quality of this kind of food, to obtain baking products with high nutritive value, with pleasant taste and flavor, which have the capacity to maintain themselves fresh for a long time, but also correction the bread products imperfections [11, 12]. Moreover, the orientation of food producers to traditional, natural and healthy products is known and present in food technology research. In this regard, the goal of this paper was to obtain several high nutritional value bread products, improving the texture features and the bioactive compounds content by addition potato composition from flesh colored cultivars (material with high level of anthocyanin and polyphenols content). The use of this adjuvant in common bread preparing could be justified because its complex composition in nutrients like: sugars, proteins, microelements (potassium, phosphorus) and polyphenols [4, 13,14,15,16]. Potatoes are a good source of amino acids [17]. Approximately half of the potato tuber nitrogen is protein. Potatoes supply proteins which are rated higher in quality than those of soybeans by some nutritionists [18]. The protein from potato tubers are ones of the most digestible vegetal proteins. Also, because of the mineral elements high content of the potato, it helps in maintaining a good equilibrium of human body acidity [3,4, 6]. Interesting are the special sensorial properties of the purple potatoes (color, taste and flavor) dues to their polyphenols composition and content [3,14,19].

The experimental studies in this work research aimed to evaluate the effects of purple flesh potato addition (in dough) on the bread quality, on their chemical composition (particular on the level of TAC and TPC). So, by changing the classical bread recipe, these experiments aimed to verify if beside a better nutritive compounds contribution, the purple flesh potatoes used contribute or not to obtaining a bread with a special color, taste and flavor.

II. MATERIAL AND METHOD

2.1. Potato material used for bread

Potato varieties used in experiments were Christian (roumanian variety, white flesh potato) and Albastru-Violet de Gălănesti (roumanian cultivar, colored flesh potato, a population found in Romania, Morar et al., 2004) [20]. This vegetables used for bread obtaining was harvested from the organic fields of National Institute for Research and Development for Potato and Sugar Beet Brasov. Tuber appearance was evaluated based on tuber size, shape and eye depth. Potato used for bread obtaining (tubers raw and boiled 30 minutes) were tested for evaluation the total content of anthocyanin (TCA) and polyphenols (TCP). The similar bioactive compounds content were tested in bread products.

2.2. Bread obtaining technological process

We used a common technological process and the recipe used was the following: flour 1000g; water 57%; yeast 2,5%; salt 2%; potato paste addition in different amounts: 5%, 15% and 30%. The potato paste was obtained by hydro thermally processing the unpeeled raw potato for 30 minutes at water boiling temperature, then cooling it, peeling and mashing it with a mixer [21]. In the same time, a witness sample without potatoes paste addition was performed. The parameters of the technological process were as follow: kneading 20 minutes/28^{o}C, fermentation 40 minutes /35^{o}C, baking 5 minutes/140^{o}C and 60 minutes /180^{o}C.

2.3. Evaluation of the bread products quality

2.3.1. Bread sensory analysis

The bread variants obtained was subjected to sensorial examination: form, crumb aspect, bread aspect, volume, consistency and chewing comparison, smell, taste, microbiological alteration signs, foreign bodies (as SP-3232-97"Bread, loaf product and bakery specialties. Analysis methods").

2.3.2. Bread physic-chemical analysis.

The bread variants obtained after the above described method were submitted to the physic chemical exam, testing the following indicators: the product volume, crumb porosity, high/diameter ratio, moist and acidity (according to SP-3232-97 "Bread, loaf product and bakery specialties. Analysis methods"). Total polyphenols content (TPC) was evaluated by Folin Ciocalteu method expressed as mg gallic acid equivalents (GAE) per 100 grams fresh product [22]. Total anthocyanin content was estimated by a pH differential method [19, 23, 24].

2.4. Evaluation of TAC and TPC in potatoes (raw and boiled) and bread products

2.4.1. Extraction of the samples

Purple potato in amount of 1g (±0.2 g) was homogenized in 20 ml of 1% acidified ethanol. For the bread we used 2g (±0.2 g). The extracts were filter and the solvent was evaporated. The crude extracts were stored in sealed containers at room temperature until use. All experiments were conducted four times, the results are expressed as mean ± standard deviation.

2.4.2. Evaluation of total monomeric anthocyanin content (TAC)

Anthocyanin content was estimated by pH differential method [19,23,24,33,34], based on the property of these pigments to change the color in accordance with the pH value. Two dilutions of the same sample were prepared, the first one in potassium chloride buffer (0.025M, pH 1.0) and the second one in sodium acetate buffer (0.4M, pH 4.5), pH being adjusted with HCl 0.2N. After equilibration at room temperature for 15 minutes, the absorbance of these two dilutions was read at 510 nm and 700 nm using a UV-Vis Microplate Reader (Sunrise-Basic Tecan, Swizerland). Total monomeric anthocyanin was calculated as follows:

$$A = (A_{510nm}-A_{700nm})_{pH=1} - (A_{510nm}-A_{700nm})_{pH=4.5} \quad (1)$$

$$TAC(\%w/w) = (A/\varepsilon L) \times MW \times DF \times (V/W_t) \times 100 \quad (2)$$

The symbols used in these relations are the following: A=absorbance calculated with equation 1; ε=molar extinction coefficient (26900L/mol cm); L= the optical path length in centimeters (1cm); MW=molecular weight of the reference pigment Cyanidin 3-glucoside (449.2 g/mol); DF= dilution factors; V=volume; W_t=sample weight. The total anthocyanin content was calculated and expressed as mg Cyanidin 3-glucoside (cy-3glu) equivalents/ 100 g fresh weight (FW).

2.4.3. Evaluation of total polyphenols content (TPC)

For this analysis, the Folin Ciocalteu method was used and the results were expressed as mg gallic acid equivalents (GAE) per 100 grams FW [22]. To 0.5 ml of test sample extract, 1.5 ml (1:10 v/v diluted with distilled water) Folin Ciocalteu reagent was added and allowed to stand 5 minutes at laboratory temperature. After 5 minutes, 2ml of 7.5% of sodium carbonate was added. These mixtures were incubated for 90 minutes in the dark with intermittent shaking. After incubation,

development of a blue color was observed. Finally, absorbance of blue color in different samples were measured at 725nm using a spectrophotometer (DR2800, Hach, USA). The phenolic content was calculated as gallic acid equivalents GAE/g on the basis of standard curve of gallic acid. The results were expressed as gallic acid equivalents (GAE)/100g FW. All determinations were carried out four times.

2.5. Statistical interpretation

Regarding the bread products, each set of comparable assay was conducted with the same ingredients, after the similar recipe (with the exception of the content of potato paste add to the dough). The bread indicators analysis were performed in three repetitions and the tests for evaluation antioxidants content (TAC, TPC) were made in four repetitions. Analysis of variance (ANOVA) and Duncan's multiple range test were used to analyze the data.

III. RESULTS AND DISCUSSION

3.1. Potatoes samples evaluation

Regarding the starch, protein and fat content of the potatoes samples used in this research experiment, these provide a rough idea about the purple potato nutrition value (table 1). As it was mentioned in the literature [4, 16, 25, 26], usually, the purple potatoes calories are slightly higher than those of the white ones, which can be explained by their higher carbohydrate content. Don't be concerned about the higher number of calories in the purple variety. It just means it provides more energy than a white one.

Table 1. Evaluation of potatoes samples added to the dough (mean values±SD)

Potato sample	**Dry matter (% FW)**	**Starch ** (%)**	**Proteins* (% dwb)**	**Fat**	**Calories**
Purple flesh potatoes (Albastru-Violet de Gălănesti)	23.2±0.110	17.1±0.099	3.273±0.104	0	-
White flesh potato (Christian variety)	22.1±0.085	16.2±0.124	6.890±0.083	0	-
Purple potato (Brown, 2005; Burmeister, 2011)	-	16.15-17.84	2.45	0	100
White potato (Brown, 2005; Burmeister, 2011)	-	16.05-17.14	1.75	0	71

*Mean values for 4 repetitions ± standard deviation. Analysis were made on dried tuber tissue. The proteins % was determined using the nitrogen % content (Kjeldal method).
**The tests were made to the row tubers before bread preparation. Tissue was taken from tubers stored at 6-8^{o}C six months after harvest. Abbreviations: FW. = fresh weight; dwb = dry weight basis; SD=standard deviation.

Level of potatoes antioxidants content (anthocyanin and polyphenols) is more important for the nutritional quality at the bread products obtained with this kind of vegetable. The objective of this study was to understand the effects of various additions of potatoes paste (from two Romanian cultivars), on several properties of the bread variants and on the total polyphenols (TPC) and anthocyanin (TAC) content of this bakery products. Also, the potatoes paste supplemented bread quality appreciation was performed by correlating the content of antioxidants (polyphenols, anthocyanin) with sensory and physic-chemical analysis of the bread products.

The values of TAC and TPC of potatoes samples used in this experiments (table 2) showed that raw purple potatoes Albastru-Violet de Gălănesti (used in bread obtaining process) are a good source of anthocyanin (163.26 ±12.716 mg cy-3glu /100g FW) and that the level of these compounds decreased significantly using different cooking techniques (e.g. boiling). However, the level of phenolic compounds (originally 3195.940±156.538 mg GAE / 100g FW) increased in the boiled potatoes (table 2).

3.2. Bread products quality evaluation

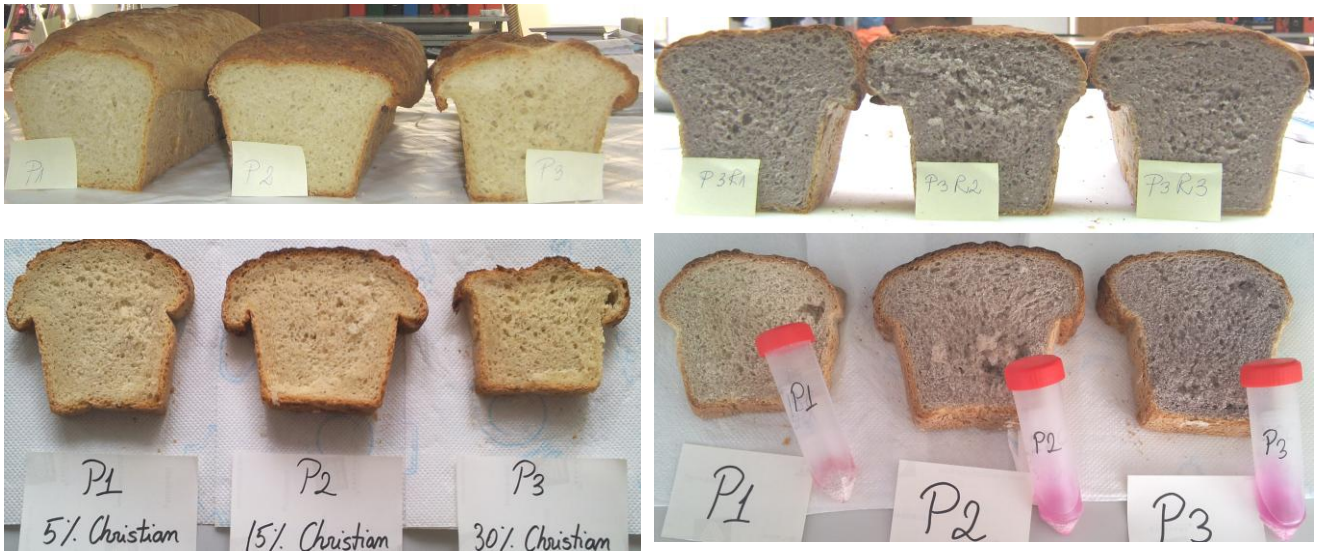
3.2.1. Bread products sensory evaluation

The points scale method was used. The sensory features of the bread products obtained according to the recipe (described in material and method) are presented in table 3. These features are in accordance with standard SP-3232-97. The bread was well done, the shape was a correct one excepting the variant P'3 (addition 30% potato paste from Christian variety), without deformation, crumb didn't have cracks. The inside was well done, with proper porosity, not wet. The color of the crumb was uniform, golden for the variant P_0, darker than the witness for variants with potato Christian variety paste addition and purple for the products with colored flesh potato paste addition (figure 1B).

Table 2. The polyphenols and anthocyanin content of the potatoes samples used for bread obtaining *

	TAC (mg cy-3glu /100g FW)		TPC (mg gallic acid equivalents /100g FW)	
Potato sample	**Fresh**	**Boiled**	**Fresh**	**Boiled**
Purple flesh potatoes (Albastru-Violet de Galanesti)	163.26±12.716	113.397±25.851	3195.940±156.538	3448.956±286.439
White flesh potato (Christian variety)	21.69±1.036	18.03±0.824	156.236±37.328	194.624±16.118

*Mean values for 4 repetitions ± standard deviation
Abbreviations: TAC = total anthocyanin content; TPC=total polyphenols content.



A **B**

Fig. 1. Bread products obtained with different % potatoes (Christian variety) addition in dough (A). Bread products obtained with flesh purple potatoes (Albastru-Violet de Gălănesti variety) addition in dough and extracts in 1% acidified ethanol from each purple potatoes paste supplemented bread variants (after 48 hours from cooking) (B).

For all the variants, the color of the crumb was without dark spots. The taste and the smell were pleasant, more intense for the bread with 30% potatoes paste addition (P3 and P3').

3.2.2. Bread physic-chemical evaluation

The physic-chemical features for all bread variants products are presented in table 4. Excepting the porosity values, all these indicators quality were in accordance with standard SP-3232-97. In all cases in which potatoes paste was added, the products were proportional, specific to assortment, the products were not excessively flattened or curved.

Analyzing the porosity values, the pores aspect was maintained specially for bread with potato (purple flesh) 15% paste addition. As show in table 4, the values for samples volume was higher than the witness except the sample with color potatoes paste variant P1 (5% addition). Also, for sample with 15 % potatoes addition, the porosity was more accentuated and the crumb was darker because of the Maillard compounds formed during baking. For 30% potatoes paste addition sample (variants P'3 and P3), the porosity and elasticity were reduced by the bigger potatoes content and smallest flour content and their gluten content. The moisture of the samples with potato paste addition was higher than the witness, between 37.94 ±1.799% (bread with 30% color potatoes paste addition) and 39.64 ±1.635% (bread with 5% color potatoes paste addition). This increase was because on the one hand of the water from potatoes paste and on the other hand of the colloidal processes (the coagulation of protein substances and starch jellification) from baking. The acidity of samples with colored potatoes addition was higher comparing with the witness, varying between 1.51±0.010 (bread with colored potatoes paste addition 5%) to 2.065±0.085 (bread with colored potatoes paste addition 30%) because of the presence of the organic acids.

Preliminary experimental data obtained for sensorial and physical-chemical analysis for bread with potatoes added suggested that this addition could be used in bakery process. Figure 1 presents types of bread obtained with purple colored potatoes paste (figure 1B) and with potatoes paste from Christian variety (figure 1A).

Table 3. Sensorial characteristics evaluation of bread with potatoes paste addition trough points scale method

Product characteristics	**Points**						
	Bread without potato (Witness)	**Bread with potato (white flesh) addition**			**Bread with potato (colored flesh) addition**		
		5%	**15%**	**30%**	**5%**	**15%**	**30%**
Variants	**P_0**	**P'1**	**P'2**	**P'3**	**P1**	**P2**	**P3**
Form, exterior aspect, volume	2	2,5	3	2	2.5	3	4
Crumb aspect	1.5	2	2.5	2.5	2	4	3
Consistency and chewing comparison	1.5	2	2.5	1	2	3	2.5
Bread aspect	2	2.5	2.5	1	2	3	3
Smell	2	2.5	2	3	2	3	3
Taste	1.5	2.5	2	3	2.5	3	3
Points	10.5	11.5	14.5	12.5	13.5	19	18.5
Qualification	Satisfactory	Good	Good	Good	Good	Very good	Very good

3.3. Evaluation of TAC and TPC in bread products with different potatoes additions

As show the values presented in table 2, the cultivar used (purple potato) was rich in anthocyanin and registered high levels (similar with others flesh colored cultivars) of these bioactive compounds for the raw peeled potato and for the boiled one respectively. Overall, the cooking techniques (boil for the paste obtaining, bake in bread) were responsible for a statistically significant ($p<0.05$) decrease in the amount of anthocyanin (expressed as Cyanindin-3-glucoside, Cy-3-glu) when compared with the raw potatoes (figure 3). A sever decrease was observed for the polyphenols level content (expressed as gallic acid equivalents, GAE) too (figure 3). It should be noted, however, that the level of anthocyanin and polyphenols in baked products was significantly different to the content present in raw and boiled potatoes. As seeing in figure 3, the losses were significantly specially for the total anthocyanin content (change relative to raw potatoes). Despite severe loss of these compounds due to cooking, all the bread types products obtained with flesh colored potatoes paste (particular with 15% and 30% purple potatoes paste addition) retained amounts of all these bioactive compounds due to higher initial levels of the potatoes. The values of TAC and TPC in bread products are presented in figures 2A & B. Relative to the witness (bread control without potatoes) both anthocyanin and polyphenols content were statistically significant ($p<0.05$) higher in the bread product with 30% flesh colored potatoes paste addition (26.495±0.267mg Cyanindin-3-glucoside/100g, respectively 928.052 ± 103.072 mg gallic acid equivalents/100g, respectively 545.101±52.492 mg gallic acid equivalents/100g).Good results regarding the TAC and TPC were obtained for the bread variants with 15% flesh potatoes paste addition (14.031±0.167 mg Cyanindin-3-glucoside/100g, respectively. Anthocyanin (flavonoids responsible for the color found in purple potatoes like Albastru-Violet de Gălănesti variety are secondary metabolites (phytochemicals), which are proven to have health benefits; meaning that purple potatoes can be considered a functional food [4]. Being known for their antioxidant, anti-inflammatory and antimicrobial properties [4, 7, 8], polyphenolic compounds are a large group of phytochemicals divided into the following classes; flavonoids, phenolic acids, tannins and stilbenes [27]. Research has shown that their consumption can decrease the risk of chronic diseases, such as heart disease, type 2 diabetes and cancer [7, 28, 29, 30].

Table4. Physic-chemical features for the bread products supplemented with potatoes

Product characteristics							
	Bread without potato (Witness)	**Bread with potato (white flesh) paste addition**			**Bread with potato (colored flesh) paste addition**		
		5%	**15%**	**30%**	**5%**	**15%**	**30%**
Variants	**P_0**	**P'1**	**P'2**	**P'3**	**P1**	**P2**	**P3**
Product volume (cm^3/100g product)	229.6 ±9.200	241.9 1±1.690	257.2 ±1.700	231.3 ±3.200	216.42 ±7.216	388.64 ±8.302	311.29 ±10.733
Crumb porosity (% volume) min. 74%	81.91 ±0.166	73.42 ±0.253	70.08 ±1.873	69.32 ±0.405	68.71 ±0.911	75.14 ±0.557	68.01 ±0.941
High/Diameter ratio	13.275 ±0.025	12.25 ±0.050	12.4 ±0.100	13.1 ±0.100	10.6 ±0.050	11.4 ±0.100	13.1 ±0.100
Moisture (%) max 45%	36.61 ±0.090	39.64 ±0.153	39.64 ±0.387	37.95 ±1.725	39.64 ±1.635	39.64 ±0.774	37.94 ±1.799
Acidity (acidity degrees/100g product) max 3%	1.38 ±0.010	1.37 ±0.010	1.41 ±0.010	1.607 ±0.007	1.51 ±0.010	1.61 ±0.010	2.065 ±0.085

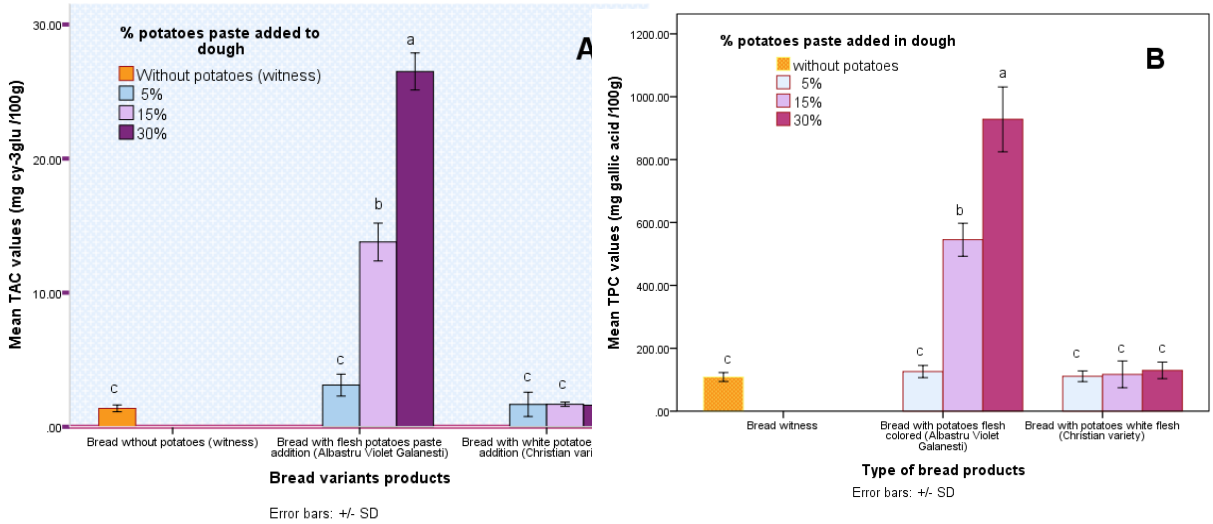


Fig. 2. Evaluation of total anthocyanin content (A) and polyphenols content (B) in bread products obtained with different potatoes addition. Data presented are the mean (n=4 repetitions) ± SD. Values not followed by the same letter are significantly different (P=0.05) according to Duncan's test. (TAC = total anthocyanin content; TPC=total polyphenols content; SD=standard deviation).

Thus, the presence of these compounds in bread products with purple potatoes paste addition could be useful for the consumers. But the anthocyanin and polyphenols stability can, however, be affected by several factors such as pH, light, oxygen, enzyme activity, concentration, ascorbic acid and sugars [31, 32, 33, 34]. It should be noted that the content of phenolic / anthocyanin compounds and their stability is also dependent on factors such as genotype, agronomic factors, storage conditions after the harvest, processing and cooking methods [5, 35, 36,16, 26, 37]. Although there are many studies demonstrating the effect of these compounds on health, which is responsible in classifying potatoes as a functional food, we need to take in consideration that the levels of polyphenols found in raw and cooked tubers will be different. However to our knowledge there has been no

detailed investigation published on the effect of cooking techniques on the levels of total polyphenols content (TPC), total anthocyanin content (TAC) of the specific cultivars Albastru-Violet de Gălănesti. In this work we assessed the effect of cooking in bread (different proportions of potatoes added in bread) on bioactive compounds from potatoes paste added, that means the changes of TAC and TPC in bread variants relative to the raw and boiled potatoes used in experiments.

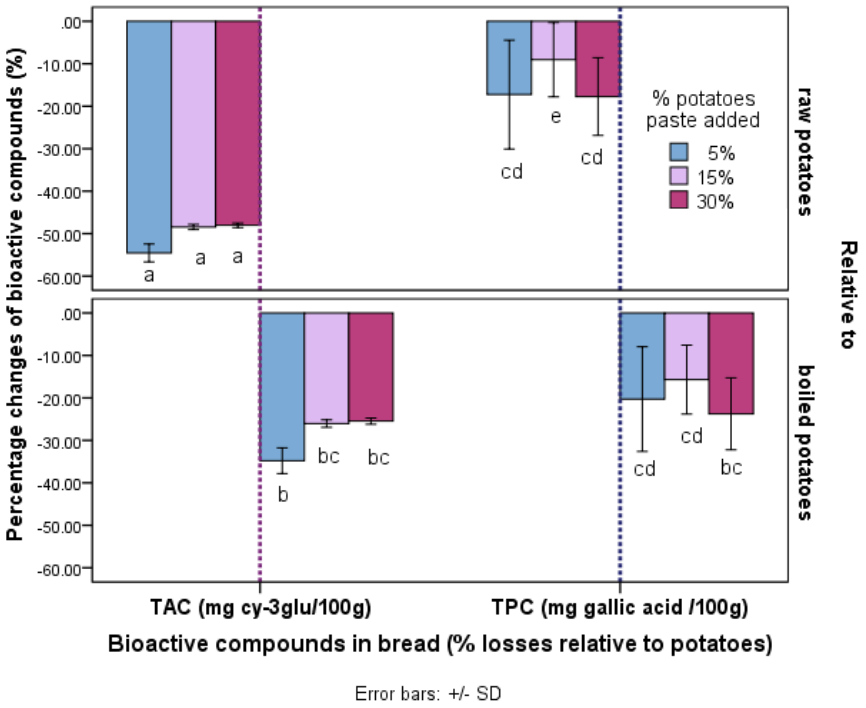


Fig. 3. Change in total anthocyanin and polyphenols content of the bread variants relative to raw and boiled potatoes paste used in experiments. Percentage of losses of these bioactive compounds. Data presented are the mean (n=4 repetitions) ± standard deviation. Values not followed by the same letter are significantly different (P=0.05) according to Duncan's test. (TAC = total anthocyanin content; TPC=total polyphenols content; SD=standard deviation).

The results obtained clearly demonstrate the presence of bioactive compounds in the uncooked Albastru-Violet de Gălănesti potato and that cooking (boiled and baking for bread obtaining) interferes with the level of these compounds. There are some contradictory results related to the effect of cooking on the levels of anthocyanin and polyphenols content. Our results are partly in accordance with a study performed by Perla et al., 2012 [38], which found a reduction of anthocyanin, however Lachman et al., 2012 [26], noticed an increase in the levels of these compounds. The level of polyphenols present in vegetables varies considerably and the effect of cooking methods on these compounds is highly dependent of the vegetable tested [39]. The reduction of TPC in this work is in accordance with results previously published by Perla (2012) [38]. However, Blessington et al. [40] registered an increase of TPC in baked and microwaved potato when compared with raw and boiled potatoes. The differences found in the literature can be related to different cooking methods and extraction procedures. On the other hand it should be pointed out that the composition in anthocyanin and total polyphenols is dependent on various factors such as, cultivar, climatic conditions and altitude, as well as the storage conditions of the tubers [26].

Albastru-Violet de Gălănesti potato cultivar is a rich source of polyphenolic compounds, including anthocyanin. Boiling, added in different percentage in dough and cooking for bread obtaining, in the case of this cultivar, leads to a decrease in the amount of anthocyanin. The cooking methods used in this study had a detrimental effect on the levels of TAC and TPC. Despite severe loss of these compounds due to cooking, several bread products obtained with purple potatoes paste (particular with 15% and 30% potatoes addition) retained larger amounts of all these bioactive compounds due to higher initial levels of the potatoes.

IV. CONCLUSIONS

A special bread assortment was obtained using purple potatoes supplement in the dough. In this way sugars, proteins, vitamins, mineral salts, antioxidants like polyphenols and anthocyanin were added to the bakery products, improving their quality. Additionally, using potato in bread dough, a quantity of flour from total height could be substituted and total gluten content decreased. For this reason, bread with potatoes is recommended for the people with low tolerance on gluten.

Beside improving the nutritional value, the advantages of purple potatoes addition (particular for the variants supplemented with 15% and 30% potatoes paste), as secondary helping ingredient of the bread are: rinsing the bread volume, improving the crumb structure and increasing the shelf life of bread, an interesting purple color of the crumb as result of the natural sugars, organic acids and antioxidants (anthocyanin and polyphenols) content. Also, 15% purple potatoes addition had the strongest influence on the dough features, improving the crumb quality (porosity, elasticity).

Relative to the bread without potatoes, in the bread product with 30% flesh colored potatoes paste addition, both anthocyanin and polyphenols content were statistically significant ($p<0.05$) higher. Good results regarding the TAC and TPC were obtained for the bread variants with 15% potatoes addition.

Thus, the experimental data suggest that purple potato (from Albastru-Violet de Gălănesti variety) addition could be used in bakery for obtain a special and challenge bread product.

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