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CHARACTERISTICS OF STARCH BREADS ENRICHED WITH RED POTATOES

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ABSTRACT

Starch breads may often be low in nutritional value, in comparison to traditional products, as they contain less dietary fibre, protein and micro and macro elements. As an effect a risk of mineral deficiencies and digestive problems caused by lack of dietary fibre could be expected in persons adhering to gluten free diet. To eliminate such problems, a continuous research on gluten-free bread nutritional enrichment, has been done in recent years. Raw material used to enrich gluten free products should include: inulin, lupine, radish, soy, lucerne sprouts, oilseeds, different type of dried fruits. Among the most commonly used raw materials, there are flours from gluten free cereals and pseudocereals such as buckwheat, amaranth and maize are very popular. It seem that valuable alternative could be considered a red, purple or pink potatoes as starch breads additives. The aim of this work was to investigate the effect addition of freeze-dried color potatoes on crude fiber, polyphenols, anthocyanins and flavonoids and nutritional value of gluten free breads. It could be concluded, that freeze-dried color (red, purple, pink) potatoes enriched the gluten free breads (starch breads) with health promoting bioactive components, like polyphenols, and highly valuable protein. The most promising additive was Magenta Love red potato variety lyophilisates, because gluten free breads enriched with this component were characterized by high protein content and the highest content of free and bound polyphenols, flavonoids, anthocyanins. The presence of all these components increased the nutritional and pro-health value of gluten free product as starch bread.

Keywords: starch bread; color potatoes; pro-health components; nutritive components; crude fibre

INTRODUCTION

Starch breads are also called gluten free breads. Such breads are the backbone of gluten free diet, i.e. the only effective way of celiac disease treatment, quite often diagnosed among children, youth adult and elderly people. Celiac disease is gluten dependant body malfunction, lasting a whole life period intolerance of alcohol soluble gluten fraction. This protein is present in cereal grains: wheat (gliadin), rye (secalin), barley (hordein) and oat (avenin). It is congenial, autoimmune disease **(McGough and Cummings, 2005; Brouns et al., 2013)**. It occurs in people with congenital predisposition, and reveals in different ages, at the time of consumption of gluten containing food products. About 1% of population is affected by this disease. This disease is the most often diagnosed in persons at 30 to 50 years old, and women are affected twice as often as men **(McGough and Cummings, 2005; Brouns et al., 2013; Capriles et al., 2015)**.

Celiac disease forced a total removal of wheat, rye, barley and oat gluten containing food product from diet. Due to recipe composition, gluten free products such as starch bread are prepared using starch and hydrocolloids, and for that reason their nutritional value is lower than their traditional equivalents. Such type of products can create deficiency of protein, mineral compounds and dietary fiber among people with celiac disease. For such reason people with gluten intolerance could suffer from physic and mental retardation, poor resistance, anemia, osteoporosis etc. **(Hamer, 2005)**. For those reasons the role of dietetics is to enrich gluten free breads with gluten free components having a high nutritional value. Enrichment of gluten free products is important both for producers, as well as for consumers, aware of nutritional and dietetic value of consumed food. Raw material used to enrich gluten free products should include pseudocereals flours, inulin, lupine, radish, soy, lucerne sprouts, oilseeds, dried fruits. One of the additives increasing nutritional value of gluten free breads are soy proteins, which are characterized by high nutritional value, due to the presence of completely protein, but on the other hand soy can be a potent allergen **(Diowksz and Pawłowska, 2010)**. It seems that as a good alternative could be considered a red, purple or pink potatoes as gluten free breads additives. Their presence can increase nutritional value of starch breads, due to the occurrence of completely protein (with high lysine content) **(Desborough, 1985)**, and the bioactive

components such as polyphenols **(Lachman et al., 2009)**. Such reasons decided to make a research on gluten-free breads with addition of freeze-dried red, purple and pink potatoes.

The aim of this work was to investigate the effect addition of above mentioned freeze-dried color potatoes on crude fiber, polyphenols, anthocyanins and flavonoids and nutritional value of gluten free breads.

MATERIAL AND METHODOLOGY

Material

Material of the study was starch breads with 5% addition of freeze-dried red, purple and pink potatoes (lyophilisates). Additionally material in the first stage of this work was freeze-dried red, purple and pink, yellow potatoes.

Methodology

The following chemical analyses were performed on 10 samples:

1. Content of basic nutritional components was performed by the method of **AOAC (1995)**.
2. Content of crude fibre according to Ankom^{220} Fiber Analyzer manufacturer methodologies (ANKOM technology, New York, USA).
3. Content of vitamin C, by methods PN-78/A-74702 (1978).
4. Total phenolic content (TPC) (free; free and bound phenolic compounds) by spectrophotometric method (spectrophotometer type helios gamma100-240, England), according to **Swan and Hillis (1959)**, expressed in mg catechin.g^{-1} d.m. sample.
5. Content of anthocyanins using spectrophotometrically method (spectrophotometer type helios gamma100-240, England), according to **Fuleki and Francis, (1968)** and **Lee et al. (2005)**.
6. The content of flavonoids using spectrophotometrically method (spectrophotometer type helios gamma100-240, England), according to **Quettier -Deleu et al. (2000)**.
7. Antioxidant activity by Reducing power methods, by spectrophotometric method (spectrophotometer type helios gamma100-240, England), according to **Oyaizu (1986)** expressed in Trolox Equivalent Antioxidant Capacity - TEAC (mg Tx.g^{-1} d.m. sample).

In this publication the following abbreviations were used:
BS; ML; V; S; Ro – freeze-dried potatoes (lyophilisates) varieties: Blue Star, Magenta Love, Violeta, Saturna, Rosalind, respectively;
Control – control bread; SB +5BS; SB +5ML; SB +5V; SB+5Ro – starch bread with share of freeze-dried potatoes (varieties: Blue Star, Magenta Love, Violeta, Rosalind, respectively).

Statistical analysis

The results were statistically compared basing on the Duncan's test, at the significance level 0.05, with the use of computer programme Statistica 8.0PL. All the measurements were done at least induplicate. Correlation coefficient was measured with the use of computer programme Statistica 8.0PL.

RESULTS AND DISCUSSION

In the first stage of this work freeze-died of red potatoes variety Magenta Love, purple potatoes (Violeta and Blue Star varieties), pink (Rosalind variety) and yellow (Saturna variety) were characterized to indicate those with the highest nutritional and pro-health value, in order to apply them as enrichment of gluten free breads.

The content of selected nutritional components, including vitamin C, in the freeze-dried potatoes was summarized in Table 1.

It was observed, that the highest level of protein was in freeze-dried pink potatoes variety Rosalind, and the lowest in Blue Star variety. The freeze-dried red potatoes variety Magenta Love had about 11.4% higher protein content than in Violeta variety (purple potatoes), and 6% higher than in freeze-dried yellow potatoes variety Saturna.

Lipid content in potatoes lyophilisates was relatively constant, regardless of variety, about 1.2 g.100 g^{-1} d.m. Starch, a storage material in the plant, content was at constant level in red (Magenta Love variety), purple (Violeta and Blue Star varieties) and yellow (Saturna variety) potatoes lyophilisates, but in case of pink variety (Rosalind) was about 4.4% lower as compared to other samples (Table 1).

Crude fiber content was the highest in freeze-dried purple potatoes variety Violeta, and the lowest in freeze-dried samples prepared from Saturna and Rosalind varieties (Table 1). In other freeze-dried samples it was at constant level – about 0.54 g.100 g^{-1} (Table 1).

It was discovered, that vitamin C content was constant in freeze-dried samples, regardless of variety, with exception for freeze-dried pink potatoes (variety Rosalind), where content of vitamin C was about 35% lower (Table 1).

Although, in the available literature there is no data concerning nutrition composition and vitamin C content in freeze-dried potato samples, but observed values are consistent with findings related to raw potatoes **(Leszczyński, 2000; Wroniak, 2006; Burlingame et al., 2009; Rady and Guyer, 2015)**.

Bioactive compounds from polyphenols groups are health promoting, due to anticancerogenic, antimutagenic, antiphlogistic and antiallergic action **(Scalbert, 2005)**, and they were present in the investigated potatoes lyophilisates (Table 2).

It was observed, that the highest content of free polyphenols was discovered in freeze-dried red potatoes (variety Magenta Love), and the lowest in freeze-dried yellow potatoes (variety Saturna). The free polyphenols content in remaining freeze-dried samples was in the following order: Violeta >Blue Star >Rosalind. Analogical tendency was observed for free and bound polyphenols content in all investigated freeze-dried samples. Content of polyphenols was in agreement with other authors findings. According to **Kita et al. (2015)** the amount of polyphenols in red and purple potatoes was 250 – 526 mg gallic acid.100 g^{-1}, and **Lachman et al. (2009)** results indicated on 455 – 481 mg gallic acid.100 g^{-1} d.m.

In case of flavonoids, the highest content of these compounds was observed in freeze-dried red potatoes Magenta Love variety, and the lowest in Blue Star (purple potatoes) (Table 2). The remaining freeze-dried samples were characterized by constant flavonoids content – about 0.145 mg quercetin .g^{-1} d.m. In case of anthocyanins, their

Table 1 Content of nutritive compounds, crude fibre ,vitamin C in freeze-dried potatoes.

Samples	Content of protein ($g.100g^{-1}$ ±SD)	Content of fat ($g.100g^{-1}$ ±SD)	Content of starch ($g.100g^{-1}$ ±SD)	Content of crude fibre ($g.100g^{-1}$ ±SD)	Content of vitamin C ($g.100g^{-1}$ ±SD)
BS	6.23 ± 0.15^{a}*	1.19 ± 0.11^{a}	74.21 ± 2.13^{b}	0.53 ± 0.02^{b}	0.087 ± 0.02^{b}
ML	9.07 ± 0.1^{d}	1.30 ± 0.10^{a}	71.37 ± 1.80^{b}	0.55 ± 0.01^{b}	0.073 ± 0^{b}
V	8.14 ± 0.13^{b}	0.99 ± 0.17^{a}	75.2 ± 1.90^{b}	0.57 ± 0^{c}	0.076 ± 0.011^{b}
S	8.59 ± 0.2^{c}	1.09 ± 0^{a}	73.93 ± 1.2^{b}	0.48 ± 0.02^{a}	0.081 ± 0.017^{b}
Ro	9.57 ± 0.32^{e}	1.24 ± 0^{a}	70.43 ± 0^{ab}	0.49 ± 0^{a}	0.051 ± 0.010^{a}

Note: *Different letters in column denote mean values that statistically differ one from another (Duncan test, at $\alpha = 0.05$).

Table 2 Content of phenolic compounds in freeze-dried potatoes.

Samples	Content of free phenolic compounds (mg catechin.g^{-1} dm ±SD)	Content of free and bound phenolic compounds (mg catechin.g^{-1} dm ±SD)	Content of flavonoids (mg quercetin.g^{-1} dm ±SD)	Content of anthocyanins (mg cyanidin-3-glucoside.g^{-1} ±SD)	Reducing power (mg TX.g^{-1} ±SD)
BS	3.064 ± 0.042^{c}*	5.312 ± 0.049^{c}	0.05 ± 0^{a}	0.985 ± 0^{c}	11.47 ± 0.51^{c}
ML	7.530 ± 0.091^{e}	11.657 ± 0.444^{e}	0.373 ± 0^{c}	1.853 ± 0^{e}	29.14 ± 0.63^{e}
V	5.067 ± 0^{d}	7.479 ± 0.115^{d}	0.137 ± 0^{b}	1.788 ± 0.003^{d}	16.72 ± 0.17^{d}
S	2.081 ± 0.031^{a}	3.581 ± 0.120^{a}	0.143 ± 0.011^{b}	0.009 ± 0.002^{a}	8.97 ± 0.5^{a}
Ro	2.971 ± 0.011^{b}	4.257 ± 0.075^{b}	0.152 ± 0.018^{b}	0.043 ± 0.004^{b}	10.34 ± 0.27^{b}

Note: *Different letters in column denote mean values that statistically differ one from another (Duncan test, at $\alpha = 0.05$).

content was the highest in freeze-dried red potatoes Magenta Love variety. Their content was 5% higher as compared to Violety lyophilisate and 47% as compared to Blue Star lyophilisate. Pink potatoes lyophilisate (Rosalind variety) had 43 times lower anthocyanins content than Magenta Love lyophilisate. Among all investigated lyophilisates, the lowest anthocyanins content was observed in yellow potatoes one (Saturna). The amount of previously mentioned compounds was consistent with other author's findings **(Leszczyński, 2000; Teow et al., 2007; Lachman et al., 2009)**.

The antioxidant activity of different colors potatoes lyophilisates could be ordered in the following way: Saturna >Rosalind >Blue Star >Violeta >Magenta Love that was consistent with TPC, flavonoids and anthocyanins content (Table 2). That was confirmed by strong correlations between TPC and FRAP ($r^2 = 0.993$), flavonoids content and FRAP ($r^2 = 0.877$), anthocyanins content and FRAP ($r^2 = 0.810$).

Concluding, among all investigated lyophilisates from different potatoes varieties, the most beneficial from nutritional and pro-health point of view were red and purple ones, especially from Magenta Love variety.

Taking into consideration a growing number of world's celiac disease occurrences, it should be introduced a new products enriched with gluten free raw material with high nutrition and health promoting load. Previously described lyophilisates of red, purple and pink potatoes seems to be a perfect solution, because they are a good source of protein and phenolic compounds. For that reason at second stage of this work the starch breads with addition of aforementioned lyophilisates were investigated. Table 3 summarized the content of nutrients (protein, fat, starch), crude fibre and vitamin C in starch bread with share of freeze-dried potatoes (lyophilisates).

It was discovered, that introduction of freeze-dried potatoes caused an increase in protein content, and the highest increase was observed for two breads supplemented with red potatoes lyophilisate (Magenta Love variety), about 32% more than the control, and pink variety Rosalind – 46%. It should be recognized, that a tuberin biological value is comparable to egg white **(Desborough, 1985)**. Addition of such protein will lead to increase a nutritional value of final product.

Content of lipids and starch in breads decreased, independently of added lyophilisates type, about 28% for lipids and 5% for starch. A decrease of starch content could be explained by its partial replacement by potatoes lyophilisates (Table 3).

The amount of crude fiber was the highest in control sample, and addition of potato lyophilisates caused a small decrease of this component. It was also observed almost a total disappearance of vitamin C after a baking process (thermal treatment), that can be connected with its thermolability **(Burgos et al., 2009)** (Table 3).

The content of bioactive components in starch breads with addition of potato lyophilisates was summarized in Table 4.

Introduction of lyophilisates led to increase in content of free polyphenols in starch breads as compared to control sample. Analogous tendency was observed for free and bound polyphenols in discussed samples, but the highest increase of free and bound polyphenols (2.3 fold) was observed for bread with addition of red potatoes lyophilisates (Magenta Love variety).

A very important issue in this work was to perform an analysis of high molecular mass polyphenols (flavonoids), because their amount determines the antioxidative activity in the main respect. The amount of aforementioned compounds was summarized in Table 4. It was observed,

Table 3 Content of nutritive compounds, crude fibre, vitamin C in starch breads with freeze-dried potatoes.

Samples	Content of protein ($g.100g^{-1}$ ±SD)	Content of fat ($g.100g^{-1}$ ±SD)	Content of starch ($g.100g^{-1}$ ±SD)	Content of crude fibre ($g.100g^{-1}$ ±SD)	Content of vitamin C ($g.100g^{-1}$ ±SD)
Control	2.14 ±0.02[a]*	4.29 ±0.20[b]	93.28 ±0[b]	0.60 ±0[c]	-
SB+5BS	2.37 ±0.03[b]	3.15 ±0.13[a]	89.04 ±1.5[a]	0.56 ±0.01[a]	-
SB+5ML	2.83 ±0.10[c]	3.02 ±0.11[a]	88.84 ±1.72[a]	0.56 ±0.02[a]	-
SB+5V	2.41 ±0.02[b]	3.07 ±0.10[a]	89.17 ±1.29[a]	0.59 ±0[b]	-
SB+5Ro	3.13 ±0.04[d]	3.17 ±0[a]	88.97 ±1.34[a]	0.50 ±0.05[a]	-

Note: *Different letters in column denote mean values that statistically differ one from another (Duncan test, at $\alpha = 0.05$).

Table 4 Content of phenolic compounds in starch breads with freeze-dried potatoes.

Samples	Content of free phenolic compounds (mg catechin.g^{-1} dm ±SD)	Content of free and bound phenolic compounds (mg catechin.g^{-1} dm ±SD)	Content of flavonoids (mg quercetin.g^{-1} dm ±SD)	Content of anthocyanins (mg cyanidin-3-glucoside.g^{-1} ±SD)	Reducing power (mg TX.g^{-1} ±SD)
Control	nd	0.652 ±0.012[a]	0.012 ±0[a]	nd	0.53 ±0.22[a]
SB+5BS	0.021 ±0.001 [a]*	0.693 ±0.007[c]	0.033 ±0.012[b]	0.121 ±0.011[b]	1.92 ±0.17[c]
SB+5ML	0.167 ±0.009[c]	1.511 ±0.065[e]	0.087 ±0.019[c]	0.187 ±0.023[d]	3.75 ±0.54[e]
SB+5V	0.066 ±0.002[b]	0.900 ±0.071[d]	0.045 ±0[b]	0.156 ±0.008[c]	2.43 ±0.23[d]
SB+5Ro	0.019 ±0.003[a]	0.678 ±0.006[b]	0.049 ±0.01[b]	0.017 ±0[a]	1.54 ±0.11[b]

Note: *Different letters in column denote mean values that statistically differ one from another (Duncan test, at α=0.05), nd – not determined.

that all lyophilisates made from red, purple and pink potatoes caused an increase of these compounds in gluten free breads within 175 – 625% range, as compared to control. As for anthocyanins there were absent in control sample. The addition of lyophilisates into investigated breads leaded to emergence of anthocyanins, although their level was low. Anthocyanins are a group of potent compounds with high health promoting effect (anticancerogenic, decreasing blood pressure, suppressing chronic diseases) **(Teow et al., 2007)**.

Although baking process decreases the content of polyphenols, flavonoids, and especially anthocyanins (which are particularly thermolabile) **(Rein, 2005; Zielinski et al., 2009; Alvarez-Jubele et al., 2010)**, but addition of lyophilisates of red and purple potatoes, guarantees the increase of bioactive compounds (free and bound polyphenols, flavonoids and anthocyanins) in gluten free breads, which was documented by increased pro-health value of such products.

The elevated level of aforementioned bioactive compounds increased the antioxidant activity of starch breads supplemented with potato lyophilisates as measured by FRAP method in comparison to control sample (Table 4). That was confirmed by strong correlations: TPC between FRAP ($r^2 = 0.897$), flavonoids content and FRAP ($r^2 = 0.930$), anthocyanins content and FRAP ($r^2 = 0.955$). Analogous research **(Korus et al., 2012)** dealing with gluten free breads supplemented with defatted blackcurrant and strawberry seeds reported an increase in polyphenols content within 92 – 130% range (as observed for blackcurrant seeds) and 5 –12 fold increase in polyphenols content for strawberry seeds in comparison control. Moreover **Korus et al. (2012)** observed 60 – 80% increase of protein content after supplementation with fruit components.

CONCLUSION

It could be concluded, that freeze-dried red, purple and pink potatoes enriched the gluten free breads with health promoting bioactive components, like polyphenols, and highly valuable protein. The most promising additive was Magenta Love potato variety lyophilisates, because gluten free breads enriched with this component were characterized by high protein content and the highest content of free and bound polyphenols, flavonoids, anthocyanins. The presence of all these components (bioactive and nutrient) increased the nutritional and pro-health value of gluten free product as starch bread.

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