Studii şi Cercetări Ştiinţifice
Chimie şi Inginerie Chimică, Biotehnologii, Industrie Alimentară

2020, **21** (3), pp. 379 – 393

Scientific Study & Research
Chemistry & Chemical Engineering, Biotechnology, Food Industry

ISSN 1582-540X

ORIGINAL RESEARCH PAPER

INFLUENCE OF ROSEHIP POWDER ADDITION ON QUALITY INDICATORS OF MIXTURES OBTAINED WITH DIFFERENT TYPES OF WHEAT FLOUR

Nicoleta PIRCU VARTOLOMEI[1], Vasilica Alisa ARUŞ[2], Alina Mihaela MOROI[2], Dumitru ZAHARIA[3], Maria TURTOI[1*]

[1]Dunarea de Jos University of Galati, Cross-border Faculty, 47 Domneasca St., 800008 Galati, Romania
[2]Vasile Alecsandri University of Bacau, Faculty of Engineering, 157 Marasesti St., 600115 Bacau, Romania
[3]SC Dizing SRL, Brusturi, 617106 Neamt, Romania

*Corresponding author: maria.turtoi@ugal.ro

Received: June, 06, 2020
Accepted: September, 17, 2020

Abstract: This study was focused on the chemical analysis of the mixtures of wheat flour with rosehip powder. Different types of wheat flours, i.e., white flour (WF), intermediate wheat flour (IWF), whole wheat flour (WWF) and wheat flour with bran (WFB), and various amounts of rosehip powder (Rp), i.e., 3, 6, 9, 12, 15, 18, and 21 % were used to obtain several flour mixtures whose proximate composition and physical properties were determined. The data show that chemical composition of the flours is modified by the addition of Rp: the moisture, protein and wet gluten content decreases and the ash content increases with an increased addition of Rp. One-way ANOVA showed significant differences ($p < 0.05$) between flour mixtures, separately for each type of flour. The in-depth analysis of the quality indicators of flours reveals that the wet gluten content corresponds to the optimal level only for all the WF-Rp mixtures. This leads to the selection of the WF-Rp to obtain bread and study the influence of Rp addition on bread properties in future research.

Keywords: *ash content, moisture, protein content, rosehip powder, wheat flour, wet gluten content, quality attributes*

INTRODUCTION

Bread is one of the most popular and consumed food worldwide [1] and is a staple food in many regions and countries [2]. It is generally baked from wheat flour, water, salt and yeast as leavening agent [3]. Since wheat flour is the main ingredient due to its baking performance related to its gluten protein content, bread properties depend on both flour quality and the breadmaking method [4].
After processing the grains of wheat to obtain flour, some beneficial substances are largely lost due to bran and germ removal [5]. Moreover, natural fibers, famous for their nutritional value, are eliminated almost completely during milling [6]. Therefore, wheat flour has a lower or even very low (i.e. white flour) content in vitamins, minerals and fibers, compared to the whole wheat [7].
Since deficiencies in flour quality must be compensated to obtain an acceptable product, the addition of other ingredients to flour is widely used in bakery, such as flour of other cereals: rye [8, 9], rice [10, 11], oat [12 – 14], barley [15], maize [16]; pseudo-cereals: sorghum (17], buckwheat [18, 19], millet [20, 21], tef [22, 23]; legumes: chickpea [24 – 26], pea [24, 27 – 29], and fruits: apple [30, 31], banana [32], chestnut [33, 34], date, pear [30]. Other ingredients used in researches to replace wheat flour in different proportions are: potato [35, 36], cassava starch [37], rice bran [38], chia seeds and flour [39 – 41], bean pods fiber [42], modified starch from pea [43] or by-products such as bagasse [44], chilli spent residue [45], dry onion skin [46], or grape pomace [47].
Rosehip (*Rosa canina* L.) fruits are rich sources of biologically active compounds including important dietary antioxidants [48, 49]: vitamins (C, A, E, and B), bio-flavonoids, carbohydrates, and mineral salts (calcium, potassium, phosphorus, and magnesium). The high antioxidant activity is especially attributed to the ascorbic acid that ranges from 100 mg/100 g to 1,400 mg/100 g [49 – 53]. Carotenoids are mainly represented by lycopene and *β*-carotene, with traces of lutein and zeaxanthin [54], tocopherols include α- and *γ*-tocopherols [55) and phenolic compounds include flavonoids (glycoside derivatives of quercetin) and proanthocyanidins [56, 57]. Rosehip fruits are also used as a natural remedy for a variety of health problems [58, 59].
The aim of this paper is to study the influence of rosehip powder addition on the physical-chemical properties of different wheat flours and to conclude which mixtures could be used in bakery, for further researches.

MATERIALS AND METHODS

Materials

Wheat flours

Several samples of wheat flours were purchased either from local milling companies (Dizing SRL, Brusturi, Neamt and Pambac SA, Bacau) or from the local market and analysed (data not shown). One sample of each type of flour was selected, codified as follows: white flour (WF) 550 type, intermediate wheat flour (IWF) 900 type, whole wheat flour (WWF) 1250 type and wheat flour with bran (WFB) 1350 type. The physical-chemical properties of the selected flour samples are presented in the results and discussion section (Table 2).

Rosehip powder

The rosehip (*Rosa canina* L.) fruits were collected from Dofteana area, Bacau County at the harvesting time in order to be matured and have the higher content of bioactive compounds. The achenes (real fruits) containing the seeds, the dried sepals and the remain of anthers and filament were discarded and the hypanthium (fleshy shell or pulp) was dried in atmospheric conditions to avoid the loss of vitamins.

The rosehip powder was prepared by grinding the dried pulp of rosehip fruits by an ultra-centrifugal laboratory mill type ZM 200 Retsch (18.000 rpm, 4 min) and sieving the powder with sieves of different size to select the particles having around 180 μm size. The rosehip powder was stored in airtight brown glass jars, in dark and cold until use. The physical-chemical properties of the rosehip powder are presented in the results and discussion section (Table 3).

Mixtures of wheat flour and rosehip powder

The mixtures were obtained through the addition of different quantities of rosehip powder to the wheat flour samples: 3, 6, 9, 12, 15, 18 and 21 %, resulting 28 mixtures whose symbols are presented in Table 1.

Table 1. *Mixtures of wheat flour and rosehip powder (symbols)*

Rosehip powder (R_p) addition, [%]	Wheat flour samples			
	WF 550 type	IWF 900 type	WWF 1250 type	WFB 1350 type
3.0	WF-$Rp_{3.0}$	IWF-$Rp_{3.0}$	WWF-$Rp_{3.0}$	WFB-$Rp_{3.0}$
6.0	WF-$Rp_{6.0}$	IWF-$Rp_{6.0}$	WWF-$Rp_{6.0}$	WFB-$Rp_{6.0}$
9.0	WF-$Rp_{9.0}$	IWF-$Rp_{9.0}$	WWF-$Rp_{9.0}$	WFB-$Rp_{9.0}$
12.0	WF-$Rp_{12.0}$	IWF-$Rp_{12.0}$	WWF-$Rp_{12.0}$	WFB-$Rp_{12.0}$
15.0	WF-$Rp_{15.0}$	IWF-$Rp_{15.0}$	WWF-$Rp_{15.0}$	WFB-$Rp_{15.0}$
18.0	WF-$R_{p\ 18.0}$	IWF-$Rp_{18.0}$	WWF-$Rp_{18.0}$	WFB-$Rp_{18.0}$
21.0	WF-$Rp_{21.0}$	IWF-$Rp_{21.0}$	WWF-$Rp_{21.0}$	WFB-$Rp_{21.0}$

Chemicals and reagents

Ethanol (C_2H_5OH, min. 95 % w/w), concentrated sulphuric acid (98 %), copper sulphate ($CuSO_4{\cdot}5H_2O$), boric acid (H_3BO_3), hydrochloric acid (HCl) and borax ($Na_2B_4O_7{\cdot}10H_2O$) of analytical grade were purchased from Merck (Darmstadt, Germany). Calcium chloride, natrium hydroxide, natrium chloride and phenolphthalein of analytical grade were purchased from Sigma-Aldrich (Steinheim, Germany).

Methods

Determination of physical-chemical properties of wheat flours and rosehip powder

The proximate composition and physical properties of the wheat flours and rosehip powder were determined according to the official methods of analysis of the Association of Official Analytical Chemists [60] and in force standards.

Thus, the wheat flour content of moisture, ash, total protein and wet gluten, and the sedimentation index were determined by an INFRATEC 1241 apparatus according to SR 90:2007 [61] (moisture), SR EN ISO 2171:2010 [62] (ash), SR EN ISO 20483:2014 [63] (Kjeldahl method, protein = total nitrogen × 6.25), SR EN ISO 21415-1:2007 [64] (wet gluten), SR 90:2007 [61] (sedimentation index). Other determined properties were:

dry gluten content (SR EN ISO 21415-3:2007) [65], gluten deformation index, acidity, water holding capacity, maltose index, falling index, and granulosity (SR 90:2007) [61]. The proximate composition of rosehip powder was determined as follows: moisture, ash and total protein content by the same methods used for the wheat flours, content of carbohydrates by Luff-Schoorl iodometric method (AOAC, 920.183) [60], lipids by organic solvent extraction (Soxhlet method) (AOAC, 983.23) [60] and ascorbic acid (vitamin C) by indophenol method (AOAC, 967.21) [60].

Mixtures quality evaluation

The proximate composition of mixtures was determined according to the official methods as described by AOAC [60]. INFRATEC 1241 apparatus was used to determine the moisture, ash, protein and wet gluten content considering these the most important quality parameters.

Color evaluation

The color of flour samples and mixtures of flours with rosehip powder was determined by using the Pekar Colour Test (Slick Test, AACCI Method 14-10.01) [66].

Calculation and statistical analysis

Each experiment was carried out in duplicate and the results were provided as average ± SD (standard deviation). Excel programme of Microsoft Office 2010 software was used for calculations, plots and to analyze the data by one-way analysis of variance (ANOVA) then tested by least significant difference (LSD) for mean comparison when level $p \leq 0.05$.

RESULTS AND DISCUSSION

Physical-chemical characteristics of wheat flour samples

The four selected samples: WF 550 type, IWF 900 type, WWF 1250 type and WBF 1350 type, according to Materials and methods, were analyzed to determine the physical-chemical characteristics: moisture, ash, protein, wet and dry gluten content, gluten deformation index, acidity, water holding capacity, maltose index, falling index, granulosity and sedimentation index (Table 2).

Analyzing the data presented in Table 2, the following statements are done:

- The moisture content of all wheat flour samples corresponds to standard limits, 14.0 ± 0.5 %;
- The ash content corresponds to the flour type: 0.55 ± 0.01 % (g/100 g of flour) for WF, 0.90 ± 0.02 % (IWF), 1.25 ± 0.03 % (WWF) and 1.35 ± 0.01 % (WFB);
- The protein content is similar to the values presented in literature, e.g. 12.40 % (WF 550 type) and 16.20 % (wheat flour 1200 type) (Bordei, Table 1.3, p. 15) [67]; The protein content depends on the extraction degree and the content of wheat in proteins. However, the quality of wheat proteins is more important than the content. The quality of wheat flour proteins is due to the gluten content which is expressed as wet and dry gluten.

Table 2. *Physical-chemical properties of wheat flour samples*

Physical-chemical properties	Wheat flour samples			
	WF 550 type	IWF 900 type	WWF 1250 type	WFB 1350 type
Moisture, [%]	14.15±0.017	14.20±0.011	13.80±0.002	14.25±0.012
Ash content, [%]	0.550±0.002	0.900±0.009	1.250±0.010	1.350±0.002
Protein content, [%]	14.75±0.005	13.50±0.005	12.80±0.004	14.10±0.011
Wet gluten content, [%]	34.10±0.068	30.03±0.081	27.30±0.081	29.00±0.109
Dry gluten content, [%]	12.40±0.017	11.50±0.023	10.15±0.013	11.60±0.012
Gluten deformation index,[mm]	6	7	8	11
Acidity, degrees of acidity	2.20±0.030	3.20±0.024	3.60±0.041	3.90±0.034
Water holding capacity, [%]	59.60±0,010	61.50±0.010	61.00±0.012	62.00±0.015
Maltose index, [mg/10 g]	1.7	1.9	2.1	2.2
Falling index, [s]	324±2	330±3	310±5	328±3
Granulosity max., [µm]	180	180	190	190
Sedimentation index	25.35±0.015	26.15±0.021	21.00±0.017	27.75±0.019

Notes: WF – white flour; IWF – intermediate wheat flour; WWF – whole wheat flour; WFB – brown wheat flour

- The wet gluten is high for flours of small extraction due to the presence of proteins of endosperm which are gluten forming proteins. All the flour types have the wet gluten content higher than 27 % that is the minimum value for a flour used to obtain bread with good quality (Bordei, Table 1.18, p. 88) [68];
- The dry gluten follows the variation of wet gluten;
- According to the deformation index (D, mm) of gluten, WF, IWF and WWF are very good for baking (D values range between 5 and 10 mm), and WWB is good for baking (D value ranges between 10 and 15 mm) (Burluc, p. 28) [69];
- The acidity of wheat flour samples is similar to the values presented in literature: the ranges 2.0–2.2 degrees of acidity for WF and 3.0-4.0 degrees of acidity for high extraction flours (Bordei, p. 36) [67];
- The water holding capacity (mL of water absorbed by 100 g of flour at kneading to form a dough with the best rheological properties and a best possible bread) is high for all wheat flour samples indicating that the quality of bread will be also high;
- Maltose index has values which indicate a good capacity of all wheat flour samples to form fermentescible glucides (Bordei, p. 40) [67];
- Falling number has values slightly higher than 300 s showing a relatively poor content in α-amylase of all wheat flour samples (Burluc, p. 29) [69] that lead to a bread with rather dry crumb;
- Granulosity of wheat flour samples correspond to the extraction type: WF and IWF flour contain 10-20 % particles with 180-190 µm and the rest with lower dimensions, WWF and WFB contain around 70 % of particles with 190-200 µm or higher due to the presence of particles from embyio and outside layer (Bordei, p 35) [67];
- The sedimentation index of all wheat flour samples ranges between 20 – 39, indicating a very good baking quality.

As a conclusion, all the wheat flour samples are good for baking.

Physical-chemical characteristics of rosehip powder

The content of moisture, carbohydrates, fibers, protein, fats, ash and vitamin C were determined for the rosehip powder (Table 3).

Table 3. *Physical-chemical properties of rosehip powder*

Moisture [%]	Carbohydrates [%]	Fibers [%]	Proteins [%]	Fats [%]	Ash [%]	Vitamin C [mg/100 g]
13.40±0,13	65.00±0.21	8.63±0.23	4.89±0.11	0.76±0.10	6.50±0.07	820±35

The rosehip powder has the moisture content lower than wheat flours and a high content of vitamin C which belongs to the interval 100 - 1.400 mg/10 g [49 – 53]. It also has a high ash content indicating a high content of mineral salts, low lipid and protein contents, and high levels of fibers and carbohydrates.

Proximate composition of mixtures of different wheat flours with rosehip powder

All the mixtures of wheat flours with rosehip powder (Table 1) were analyzed and moisture, ash, protein and wet gluten contents were determined. The results of the chemical composition of wheat flour with addition (0, 3, 6, 9, 12, 15, 18 and 21 %) of rosehip powder are shown in Figures 1 - 4.

Moisture

The moisture content of all flours decreases with the increase of the amount of rosehip addition (Figure 1) because the rosehip powder has a lower value of the moisture (13.40 ± 0.13 %) than the wheat flours (13.80 - 14.25 ± SD %). Thus, the moisture content decreased from 14.15 ± 0.0170 % to 13.972 ± 0.0276 % for WF-Rp mixtures, from 14.201 ± 0.0113 % to 14.005 ± 0.0955 % for IWF-Rp mixtures, from 13.806 ± 0.0021 % to 13.648 ± 0.0127 % for WWF-Rp mixtures, and from 14.25 ± 0.012 to 14.101 ± 0.0078 % for WFB-Rp mixtures. The statistical analysis by one-way ANOVA and LSD showed significant differences ($p < 0.05$) between the flour mixtures (Table 4).

The results are consistent with several literature data. Thus, Soto-Maldonato *et al.* [70] reported lower moisture content after the addition of overripe banana flour to wheat flour used to obtain muffins product. Also, Wambua *et al*. [71] reported lower moisture content when replaced the wheat flour with 5, 10, 15, 20, 25 and 30 % cassava flour. Thus, they also found that the moisture decreased significantly ($p < 0.05$) with the increase in substitution of wheat flour with cassava flour [71].

In another study, Dhen *et al*. [72] substituted the wheat flour with apricot kernels flour in the range of 4 - 24 %. The moisture of flour blends decreased from 13.45 to 8.91 % for wheat flour replacement with increased level of apricot kernels flour due to the low-moisture of apricot kernels flour (5.52 %) in comparison with wheat flour. The authors consider that the lower values of moisture avoid the microbial growth during the storage of flours [72].

The moisture of several composite flours obtained with cassava and soybean flours was also influenced by the individual moisture of each ingredient and the range of addition [73]. Thus, the substitution of wheat flour (moisture: 14 %) with cassava flour (moisture: 8.51 %) and soybean flour (moisture: 6.63 %) lead to composite flours with moisture content ranging from 9.37 % to 11.94 % [73].

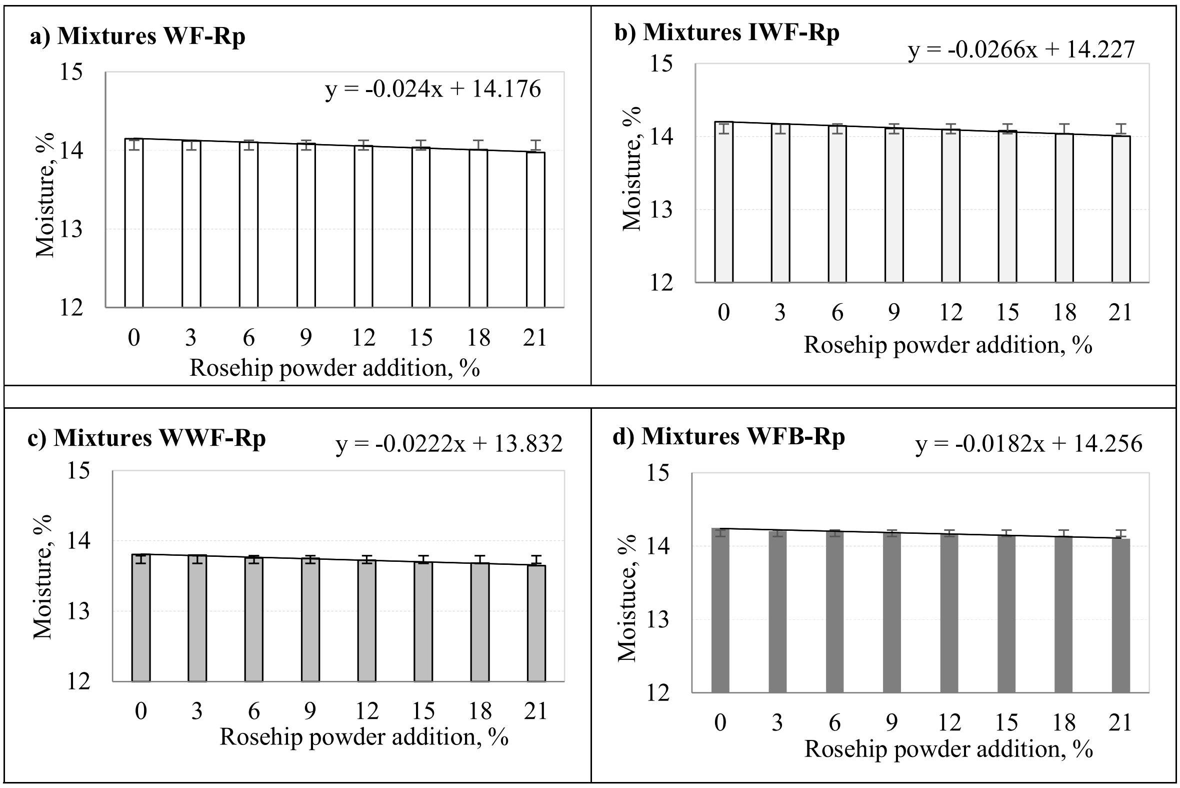

Figure 1. *Moisture variation of mixtures of wheat flours with rosehip powder*

Table 4. *The results of the moisture analysis by ANOVA single factor*

Mixtures	WF-Rp	IWF-Rp	WWF-Rp	WFB-Rp
P-value	$2.75 \cdot 10^{-5}$	0.010674	$7.66 \cdot 10^{-6}$	$7.71 \cdot 10^{-6}$

Ash content

The ash content is related to the content in minerals. It also influences the color of flours and of bread and gives a reference of the extraction degree of flour from the grains. The ash content of wheat flours corresponds to the type of flour: 0.55 % (WF type 550), 0.90 % (IWF type 900), 1.25 % (WWF type 1250) and 1.35 % (WFB type 1350) (Table 2), while the ash content of the Rp is several times higher (6.5 %; Table 3) than that of wheat flours. Consequently, the addition of Rp to wheat flours determines the increase of the ash content of the flour mixtures (Figure 2).

Thus, the ash content increases from 0.55 ± 0.0021 % to 1.60 ± 0.0064 % for WF-Rp mixtures, from 0.90 ± 0.0099 % to 1.901 ± 0.0304 % for IWF-Rp mixtures, from 1.25 ± 0.0106 % to 1.154 ± 0.002 % for WWF-Rp mixtures, and from 1.351 ± 0.0021 % to 2.255 ± 0.021 % for WFB-Rp mixtures. Increasing ash content is associated with the high concentration of minerals in Rp, such as calcium, potassium, phosphorus, magnesium, and iron [48].

It is worth to mention that the color of flours determined using the Pekar method is in good correlation with the ask content. Because the Pekar method gives only qualitative information the results related to the color of flours are not discussed here.

The ANOVA single factor and LSD used for statistical analysis of the showed significant differences ($p < 0.05$) between the flour mixtures (Table 5).
The results are consistent with Al-Sahlany *et al.* [74] who reported higher ash content after the addition of 1, 5 and 10 % banana peels flour to wheat flour. Also, Dhen *et al.* [72] obtained flour blends with higher ash content ranging from 0.70 % to 1.10 % due to the higher ash content of apricot kernels flour (2.76 %) compared to the ash content of wheat flour (0.64 %).

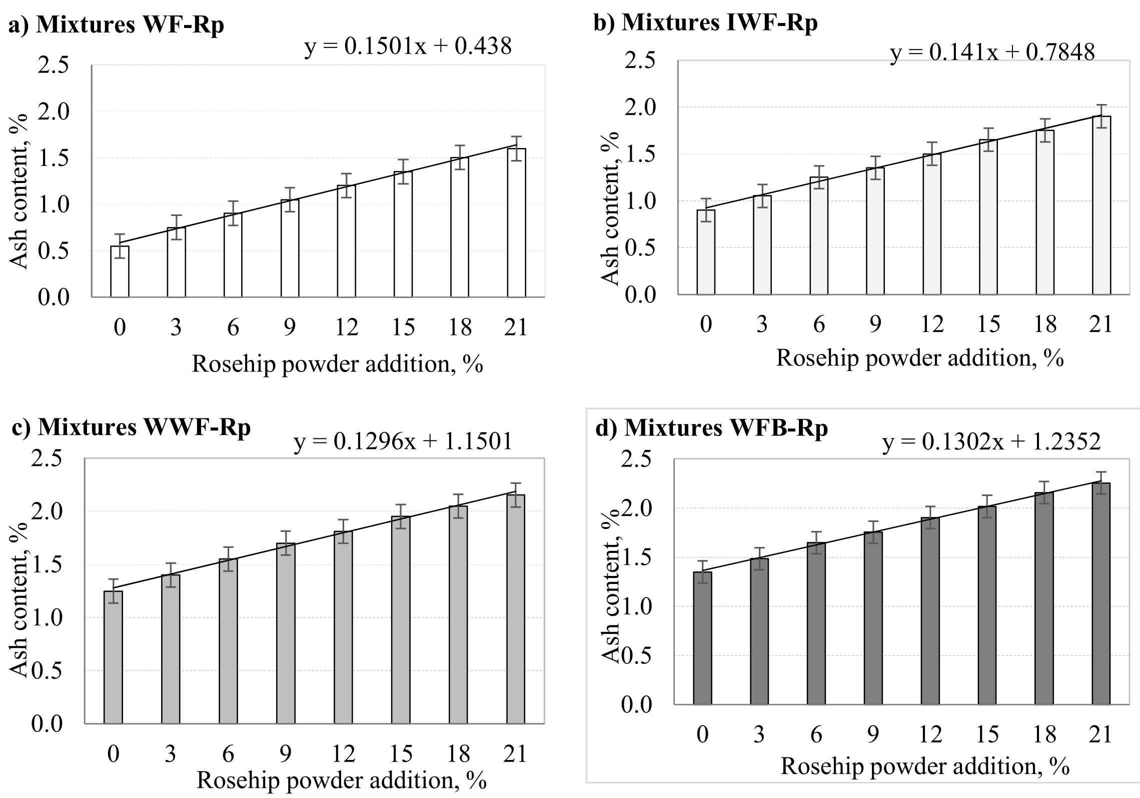

Figure 2. *Ash content variation of mixtures of wheat flours with rosehip powder*

Table 5. *The results of the ash content analysis by single way ANOVA*

Mixtures	WF-Rp	IWF-Rp	WWF-Rp	WFB-Rp
P-value	$8 \cdot 10^{-12}$	$1.5 \cdot 10^{-11}$	$6.5 \cdot 10^{-13}$	$4.5 \cdot 10^{-14}$

Protein content

The protein content of rosehip powder (4.89 ± SD %, Table 3) is smaller than that of each type of wheat flour (12.80 - 14.75 ± SD %, Table 2). Logically, any addition of rosehip powder to the wheat flours leads to a decrease of the protein content of the mixture. Indeed, the decrease of the protein content of flour mixtures is inversely proportional to the addition of the rosehip powder (Figure 3). Thus, the protein content decreased from 14.75 ± 0.0049 % to 13.006 ± 0.0417 % for WF-Rp mixtures, from 13.50 ± 0.0049 % to 12.00 ± 0.0064 % for IWF-Rp mixtures, from 12.80 ± 0.042 % to 11.43 ± 0.0099 % for WWF-Rp mixtures, and from 14.102 ± 0.0106 % to 12.503 ± 0.014 % for WFB-Rp mixtures. The statistical analysis of protein content by one-way

ANOVA and LSD showed significant differences ($p < 0.05$) between the flour mixtures (Table 6).
The results are consistent with Al-Sahlany *et al.* [74] who reported lower protein content after the addition of 1.5 and 10 % banana peels flour to wheat flour. Similarly, Díaz *et al*. [75] reported a decrease of the protein content of flours after the addition of 17, 34 and 50 % Jerusalem artichoke flour to wheat flour for biscuits formulation. Wambua *et al*. [71] outlined a significant decrease ($p < 0.05$) of the protein content of wheat flour substituted with 5, 10, 15, 20, 25, and 30 % cassava flour because cassava flour has a very low protein content of 3 - 4 %.

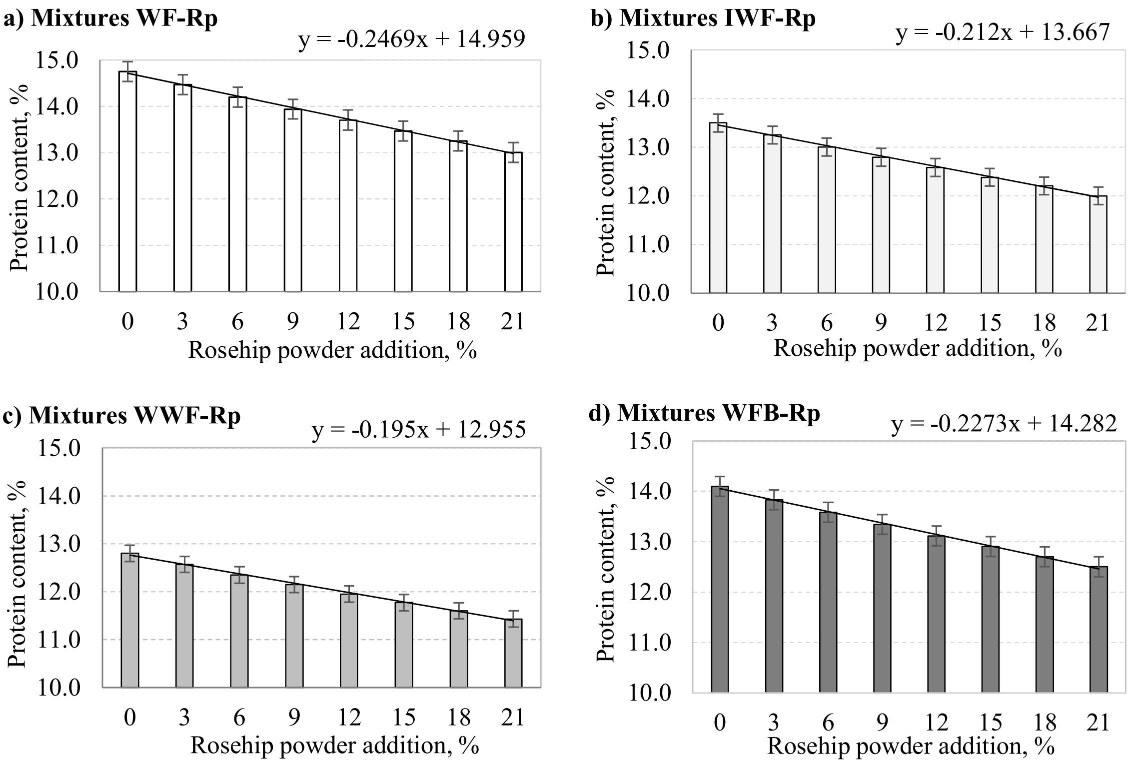

Figure 3. *Protein content variation of mixtures of wheat flours with rosehip powder*

Table 6. *The results of the protein content analysis by single way ANOVA*

Mixtures	WF-Rp	IWF-Rp	WWF-Rp	WFB-Rp
P-value	$6.26 \cdot 10^{-13}$	$1.06 \cdot 10^{-12}$	$2.89 \cdot 10^{-14}$	$2.04 \cdot 10^{-14}$

Even though the protein content of flours decreases with Rp addition, the values are higher than 10.5 % for all 28 flour mixtures, which means that from the point of view of protein content, all mixtures correspond to breadmaking requirement for a good quality bread (Bordei, p. 79) [68].

Wet gluten content

The wheat flour quality is primarily attributed to the wet gluten quality because it is the main protein in wheat flour that influences the rheological properties of the dough [76]. The wet gluten content in wheat flours varies between 27.30 % for WWF, and 34.10 % for WF (Table 2). The Rp contains no gluten-forming proteins. Therefore, the wet gluten content of all flours decreases with the increase of the amount of rosehip addition (Figure 4). Thus, the wet gluten content decreases from 34.102 ± 0.0686 % to 28.204 ± 0.0389 % for WF-Rp mixtures, from 30.032 ± 0.0813 % to 24.801 ± 0.0226 % for IWF-Rp mixtures, from 27.356 ± 0.0813 % to 22.501 ± 0.0255 % for WWF-Rp mixtures, and from 29.005 ± 0.1096 % to 24.00 ± 0.0177 % for WFB-Rp.

The decrease of wet gluten content is significant ($p < 0.05$) according to the single way ANOVA and LSD statistical analysis (Table 7).

The results are consistent with Al-Sahlany *et al.* [74] who reported lower gluten content in wheat flour substituted with 1.5 and 10 % banana peels flour.

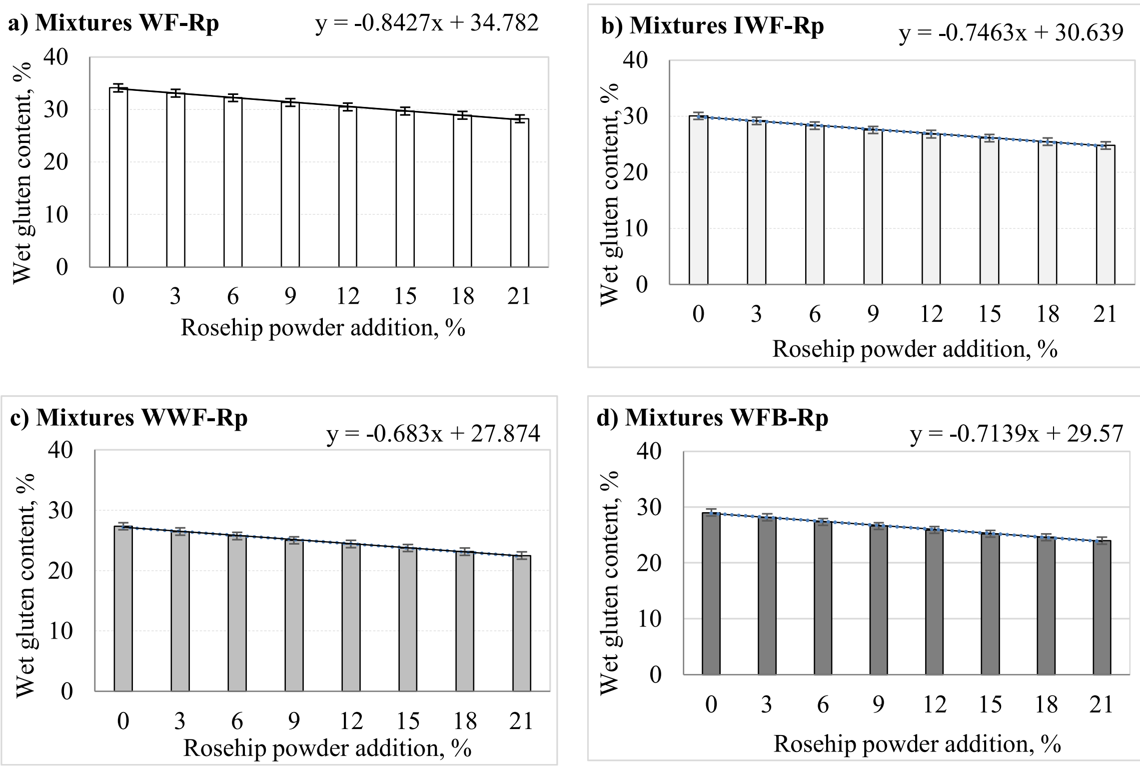

Figure 4. *Wet gluten variation of mixtures of wheat flours with rosehip powder*

Table 7. *The results of the wet gluten analysis by single way ANOVA*

Mixtures	WF-Rp	IWF-Rp	WWF-Rp	WFB-Rp
P-value	$1.11 \cdot 10^{-14}$	$3.09 \cdot 10^{-14}$	$7.39 \cdot 10^{-14}$	$8.35 \cdot 10^{-14}$

Also, Franco-Miranda *et al.* [76] reported a reduction of the gluten content when Lima bean or cowpea hydrolysates were added at 1 or 3 % to wheat flour for making *concha*-type Mexican sweet bread.

The formation of gluten and the level and quality of the gluten-forming proteins are essential in breadmaking processes [3]. According to Bordei (Table 1.18, p. 88) [68], the optimal level of wet gluten of wheat flour from which a good quality bread is obtained are to be between 27 and 32 %. Thus, the flours that have an adequate content of wet gluten are: all the WF-Rp mixtures, the IWF-Rp mixtures with 3, 6, and 9 % Rp substitution, and the WWB-Rp mixtures with 3 and 6 % Rp substitution.

This analysis allows the selection of the appropriate type of flour to be used in future research, consisting in bread obtaining from wheat flour with the addition of rosehip powder. Therefore, the selected type of flour is the white wheat flour.

CONCLUSIONS

The study reveals that chemical composition, in terms of moisture ash, protein and wet gluten contents, of mixtures obtained by the addition of rosehip powder to different types of flour (WF, IWF, WWF and WWB) is modified. The moisture, protein and wet gluten content decreases and the ash content increases with a higher percentage of Rp added to wheat flours and the data show significant differences ($p < 0.05$) between flour mixtures, separately for each type of flour. The values of protein content are higher than 10.5 % for all the flours, thus all the mixtures can be used in breadmaking to obtain good quality bread. However, the wet gluten content of several mixtures of wheat flour and Rp is lower than the minimum level of this quality indicator, 27 %, for a bread of good quality, e.g. IWF with 12, 15, 18, and 21 % Rp addition, all WWF and WWB with 9, 12, 15, 18, and 21 % Rp. Therefore, because the wet gluten content of all the mixtures of white flour with Rp corresponds to the optimal level of a flour that can be used to obtain a bread of good quality, the WF-Rp mixtures are selected for the future research, to obtain bread and study the influence of Rp addition on bread properties.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the logistical support of Dizing S.R.L. Company, Brusturi, Neamt County.

REFERENCES

1. Schmalbruch, S.: How bread is eaten in 27 countries around the world, *Insider*, October 17, **2016**, accessed June 2019;
2. Cauvain, S.: Introduction to breadmaking in *Breadmaking* (Editor: Cauvain, S.), Woodhead Publishing, **2012a**, 1-8;
3. Cauvain S.: Breadmaking: an overview in *Breadmaking* (Editor: Cauvain, S.), Woodhead Publishing, **2012b**, 9-31;
4. Dewettnick, K., VanBockstaele, F., Kühne, B., VandeWalle, D., Courtens, T.M., Gellynck X.: Nutritional value of bread: Influence of processing, food interaction and consumer perception, *Journal of Cereal Science*, **2008**, **48**, 243-247;
5. Heiniö, R.L., Noort, M.W.J., Katina, K., Alam, S.A., Sozer, N., de Kock, H.L., Hersleth, M., Poutanen K.: Sensory characteristics of wholegrain and bran-rich cereal foods - A review, *Trends in Food Science, Technology*, **2016**, **47**, 25-38;
6. Heshe, G.G., Haki, G.D., Woldegiorgis, A.Z., Gemede, H.F.: Effect of conventional milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread, *Food Science, Nutrition*, **2016**, **4** (4), 534-543;
7. Kumar, P., Yadava, R.K., Gollen, B., Kumar, S., Verma, R.K., Yadav, S.: Nutritional Contents and Medicinal Properties of Wheat: A Review, *Life Sciences and Medicine Research*, **2011**, **22**, 1-10;
8. Döring, C., Nuber, C., Stukenborg, F., Jekle, M., Becker, T.: Impact of arabinoxylan addition on protein microstructure formation in wheat and rye dough, *Journal of Food Engineering*, **2015**, **154**, 10-16;

9. Cardoso, R.V.C., Fernandes, Â., Sandrina, A., Heleno, S.A., Rodrigues, P., Gonzaléz-Paramás, A.M., Barros, L., Ferreira, I.C.F.R.: Physicochemical characterization and microbiology of wheat and rye flours, *Food Chemistry*, **2019**, **280**, 123-129;
10. Torbica, A., Hadnađev, M., Dapčevič, T.: Rheological, textural and sensory properties of gluten-free bread formulations based on rice and buckwheat flour, *Food Hydrocolloids*, **2010**, **24**, 626-632;
11. Wu, T., Wang, L., Li, Y., Qian, H., Liu, L., Tong, L., Zhou, X., Wang, L., Zhou, S.: Effect of milling methods on the properties of rice flour and gluten-free rice bread, *LWT - Food Science and Technology*, **2019**, **108**, 137-144;
12. Hager, A.-S., Ryan, L.A.M., Schwab, C., Gänzle, M.G., O'Doherty, J.V., Arendt, E.K.: Influence of the soluble fibres inulin and oat β-glucan on quality of dough and bread, *European Food Research and Technology*, **2011**, **232**, 405-413;
13. Rieder, A., Holtekjølen, A.K., Sahlstrøm, S., Moldestad, A.: Effect of barley and oat flour types and sourdoughs on dough rheology and bread quality of composite wheat bread, *Journal of Cereal Science*, **2012**, **55**, 44-52;
14. Fraś, A., Gołębiewski, D., Gołębiewska, K., Mańkowski, D.R., Boros D.: Triticale-oat bread as a new product rich in bioactive and nutrient components. *Journal of Cereal Science*, **2018**, **82**, 146-154.
15. Blandino, M., Locatelli, M., Gazzola, A., Coïsson, J.D., Giacosa, S., Travaglia, F.: Hull-less barley pearling fractions: Nutritional properties and their effect on the functional and technological quality in bread-making, *Journal of Cereal Science*, **2015**, **65**, 48-56;
16. Aprodu, I., Banu, I.: Influence of dietary fiber, water, and glucose oxidase on rheological and baking properties of maize based gluten-free bread, *Food Science and Biotechnology*, **2015**, **24** (4), 1301-1307;
17. Sibanda, T., Ncube, T., Ngoromani, N.: Rheological properties and bread making quality of white grain sorghum-wheat flour composites, *International Journal of Food Science and Nutrition Engineering*, **2015**, **5** (4), 176-182;
18. Nikolić, N., Sakač, M., Mastilović, J.: Effect of buckwheat flour addition to wheat flour on acylglycerols and fatty acids composition and rheology properties, *LWT - Food Science and Technology*, **2011**, 44, 650-655;
19. Liu, W., Brennan, M., Serventi, L., Brennan, C.: Buckwheat flour inclusion in Chinese steamed bread: potential reduction in glycemic response and effects on dough quality, *European Food Research and Technology*, **2017**a, **243**, 727-734;
20. Singh, K.P., Mishra, A., Mishra, H.N.: Fuzzy analysis of sensory attributes of bread prepared from millet-based composite flours, *LWT - Food Science and Technology*, **2012**, **48** (2), 276-282;
21. Wang, Y., Compaoré-Sérémé, D., Sawadogo-Lingani, H., Rossana Coda, R., Katina, K., Maina, N.H.: Influence of dextran synthesized in situ on the rheological, technological and nutritional properties of whole grain pearl millet bread, *Food Chemistry*, **2019**, **285**, 221-230;
22. Ronda, F., Abebe, W., Pérez-Quirce, S., Collar, C.: Suitability of tef varieties in mixed wheat flour bread matrices: A physico-chemical and nutritional approach, *Journal of Cereal Science*, **2015**, **64**, 139-146;
23. Shumoy, H., Van Bockstaele, F., Devecioglu, D., Raes, K.: Effect of sourdough addition and storage time on in vitro starch digestibility and estimated glycemic index of tef bread, *Food Chemistry*, **2018**, **264**, 34-40;
24. Angioloni, A., Collar, C.: High legume-wheat matrices: an alternative to promote bread nutritional value meeting dough viscoelastic restrictions, *European Food Research and Technology*, **2012**, **234**, 273-284;
25. Hefnawy, T.M.H., El-Shourbagy, G.A., Ramadan M.F.: Impact of adding chickpea (*Cicer arietinum* L.) flour to wheat flour on the rheological properties of toast bread, *International Food Research Journal*, **2012**, **19** (2), 521-525;
26. Mohammed, I., Ahmed, A.R., Sengea, B.: Dough rheology and bread quality of wheat-chickpea flour blends, *Industrial Crops and Products*, **2012**, **36**, 196-202;
27. Mondor, M., Guévremont, E., Villeneuve, S.: Processing, characterization and bread-making potential of malted yellow peas, *Food Bioscience*, **2014**, **7**, 11-18;
28. Villeneuve, S., Mondor, M.: Processing and bread-making potential of proteins isolated from malted and non-malted pea seeds by ultrafiltration/diafiltration, *Food Bioscience*, **2014**, **8**, 33-36;

29. Lu, Z.-H., Donner, E., Liu, Q.: Effect of roasted pea flour/starch and encapsulated pea starch incorporation on the in vitro starch digestibility of pea breads, *Food Chemistry*, **2018**, **245**, 71-78;
30. Bchir, B., Rabetafika, H.N., Paquot, M., Blecker, C.: Effect of pear, apple and date fibres from cooked fruit by-products on dough performance and bread quality, *Food and Bioprocess Technology*, **2014**, **7**, 1114-1127;
31. Lauková, M., Kohajdová, Z., Karovičová, J.: Effect of hydrated apple powder on dough rheology and cookies quality, *Potravinarstvo Scientific Journal for Food Industry*, **2016**a, **10** (1), 506-511;
32. Ho, L.-H., Aziz, N.A.A., Azahari, B.: Physico-chemical characteristics and sensory evaluation of wheat bread partially substituted with banana (*Musa acuminata* X *balbisiana* cv. Awak) pseudo-stem flour, *Food Chemistry*, **2013**, **139**, 532-539;
33. Dall'Asta, C., Cirlini, M., Morini, E., Rinaldi, M., Ganino. T., Chiavaro E.: Effect of chestnut flour supplementation on physico-chemical properties and volatiles in bread making, *LWT - Food Science and Technology*, **2013**, **53**, 233-239;
34. Moreira, R., Chenlo, F., Torres, M.D., Rama, B.: Fine particle size chestnut flour doughs rheology: Influence of additives, *Journal of Food Engineering*, **2014**, **120**, 94-99;
35. Lauková, M., Kohajdová, Z., Karovičová, J.: Effect of incorporating potato dietary fibre to wheat dough on the quality of baked rolls, *Acta Chimica Slovaca*, **2016**b, **9** (1), 14-18;
36. Liu, X., Mu, T., Yamul, K.D., Sun, H., Zhang, M., Chen, J., Fauconnier, M.L., Andrea, P.V.: Evaluation of different hydrocolloids to improve dough rheological properties and bread quality of potato-wheat flour, *Journal of Food Science and Technology*, **2017**b, **54** (6), 1597-1607;
37. Ortolan, F., Brites, L.T.G., Montenegro, F.M., Schmiele, M., Steel, C.J., Clerici, M.T.P.S., Almeida, E.L., Chang, Y.K.: Effect of extruded wheat flour and pre-gelatinized cassava starch on process and quality parameters of French-type bread elaborated from frozen dough, *Food Research International*, **2015**, **76**, 402-409;
38. Teng, Y., Liu, C., Bai, J., Liang, J.: Mixing, tensile and pasting properties of wheat flour mixed with raw and enzyme treated rice bran, *Journal of Food Science and Technology*, **2015**, **52** (5), 3014-3021;
39. Coelho, M.S., Salas-Mellado, M.M.: Effects of substituting chia (*Salvia hispanica* L.) flour or seeds for wheat flour on the quality of the bread, *LWT - Food Science and Technology*, **2015**, **60** 729-736;
40. Steffolani, E., Martinez, M.M., León, A.E., Gómez, M.: Effect of pre-hydration of chia (Salvia hispanica L.), seeds and flour on the quality of wheat flour breads, *LWT - Food Science and Technology*, **2015**, **61** (2), 401-406;
41. Fernandes, S.S., Salas-Mellado, M.M.: Addition of chia seed mucilage for reduction of fat content in bread and cakes, *Food Chemistry*, **2017**, **227**, 237-244;
42. Fendri, L., Chaari, F., Maaloul, M., Kallel, K., Ghribi-Aydi, D.: Wheat bread enrichment by pea and broad bean pods fibers: Effect on dough rheology and bread quality, *LWT - Food Science and Technology*, **2016**, **73**, 584-591;
43. Sanz-Penella, J.M., Wronkowska, M., Soral-Śmietana, M., Collar, C., Haros, M.: Impact of the addition of resistant starch from modified pea starch on dough and bread performance, *European Food Research and Technology*, **2010**, **231**, 499-508;
44. Rodriguez-Sandoval, E., Polanía-Gaviria, L.Y., Lorenzo, G.: Effect of dried cassava bagasse on the baking properties of composite wheat bread, *Journal of Texture Studies*, **2017**, **48**, 76-84;
45. Sowbhagya, H.B., Soumya, C., Indrani, D., Srinivas, P.: Physico-chemical characteristics of chilli spent residue and its effect on the rheological, microstructural and nutritional qualities of bread, *Journal of Food Science and Technology*, **2015**, **52** (11), 7218-7226;
46. Gawlik-Dziki, U, Świeca, M., Dziki, D., Baraniak, B., Tomiło, J., Czyż, J.: Quality and antioxidant properties of breads enriched with dry onion (*Allium cepa* L.) skin, *Food Chemistry*, **2013**, **138**, 1621-1628;
47. Karnopp, A.R., Figueroa, A.M., Los, P.R., Teles, J.C., Simões, D.R.S., Barana, A.C., Kubiaki, F.T., de Olivera, J.G.B., Granato, D.: Effects of whole-wheat flour and bordeaux grape pomace (Vitis labrusca L.) on the sensory, physicochemical and functional properties of cookies, *Food Science and Technology*, *Campinas*, **2015**, **35** (4), 750-756;
48. Demir, F., Özcan, M.: Chemical and technological properties of rose (*Rosa canina* L.) fruits grown wild in Turkey, *Journal of Food Engineering*, **2001**, **47** (4), 333-336;

49. Bhave, A., Schulzova, V. Chmelarova, H., Mrnka, L., Hajslova, J.: Assessment of rosehips based on the content of their biologically active compounds, *Journal of Food and Drug Analysis*, **2017**, **25** (3), 681- 690;
50. Ercisli, S.: Chemical composition of fruits in some rose (*Rosa* spp.) species, *Food Chemistry*, **2007**, **104**, 1379-1384;
51. Nojavan, S., Khalilian, F., Kiaie, F.M., Rahimi, A., Arabanian, A., Chalavi, S.: Extraction and quantitative determination of ascorbic acid during different maturity stages of *Rosa canina* L. fruit, *Journal of Food Composition and Analysis*, **2008**, **21**, 300-305;
52. Ropciuc, S., Cenușă, R., Căpriță, R., Crețescu, I.: Study on the ascorbic acid content of rose hip fruit depending on stationary conditions, *Scientific Papers: Animal Science and Biotechnologies*, **2011**, **44** (2), 129-132;
53. Roman, I., Stănilă, A., Stănilă, S.: Bioactive compounds and antioxidant activity of *Rosa canina* L. biotypes from spontaneous flora of Transylvania, *Chemistry Central Journal*, **2013**, **7** (1), 73-82;
54. Andersson, S.C., Olsson, M.E., Gustavsson, K.E., Johansson, E., Rumpunen K.: Tocopherols in rosehips (*Rosa* spp.) during ripening, *Journal of the Science of Food and Agriculture*, **2012**, **92**, 2116-2121;
55. Barros, L., Carvalho, A.M., Morais, J., Ferreira I.: Strawberry-tree, blackthorn and rose fruits: detailed characterization in nutrients and phytochemicals with antioxidant properties, *Food Chemistry*, **2010**, **120**, 247-254;
56. Gao, X., Bjork, L., Trajkovski, V., Uggla, M.: Evaluation of antioxidant activities of rosehip ethanol extracts in different test systems, *Journal of the Science of Food and Agriculture*, **2000**, **80**, 2021-2027;
57. Hvattum, E.: Determination of phenolic compounds in rosehip (*Rosa canina*) using liquid chromatography coupled to electrospray ionization tandem mass spectrometry and diode-array detection, *Rapid Communication Mass Spectrometry*, **2002**, **16**, 655-662;
58. Chrubasik, C., Duke, R.K., Chrubasik, S.: The evidence for clinical efficacy of rose hip and seed: A systematic review, *Phytotherapy Research*, **2006**, **20**, 1-3;
59. Chrubasik, C., Roufogalis, B.D., Müller-Ladner, U., Chrubasik S.: A systematic review on the *Rosa canina* effect and efficacy profiles, *Phytotherapy Research*, **2008**, **22**, 725-733;
60. AOAC 1990. Official methods of analysis of the Association of Official Analytical Chemists (15th ed. / edited by Kenneth Helrich. ed.), Arlington, Va.: Association of Official Analytical Chemists;
61. SR 90:**2007**. Făină de grâu, Metode de analiză (Wheat flour. Analysis methods);
62. SR EN ISO 2171:**2010**. Cereale, leguminoase şi produse derivate. Determinarea conţinutului de cenuşă prin calcinare (Cereals, pulses and by-products - Determination of ash yield by incineration);
63. SR EN ISO 20483:**2014**. Cereale şi leguminoase. Determinarea conţinutului de azot şi calculul conţinutului de proteină brută, Metoda Kjeldhal (Cereals and pulses - Determination of the nitrogen content and calculation of the crude protein content. Kjeldahl method);
64. SR EN ISO 21415-1:**2007**. Grâu şi făina de grâu. Conţinut de gluten. Partea 1: Determinarea glutenului umed printr-o metodă manuală (Wheat and wheat flour - Gluten content - Part 1: Determination of wet gluten by a manual method);
65. SR EN ISO 21415-3:**2007**. Grâu şi făină de grâu. Conţinut de gluten. Partea 3: Determinarea glutenului uscat din gluten umed printr-o metodă de uscare la etuvă (Wheat and wheat flour - Gluten content - Part 3: Determination of dry gluten from wet gluten by an oven drying method);
66. AACCI Method 14-10.01. Slick Test. Pekar Colour Test;
67. Bordei, D., Bahrim, G., Pâslaru, V., Gasparotti, C., Elisei, A., Banu, I., Ionescu, L., Codină, G.: *Controlul calității în industria panificației: metode de analiză* (*Quality control in breadmaking: methods of analysis*), Editura Academica, Galați, **2007**, 15-40;
68. Bordei, D.: *Tehnologia modernă a panificației* (*Modern breadmaking tehcnology*), AGIR Publishing House, Bucharest, **2004**, 79-89;
69. Burluc, R.M.: *Tehnologia panificației* (*Technology of breadmaking*), Dunarea de Jos University of Galati, **2007**, 28-29;
70. Soto-Maldonato, C., Concha-Olmos, J., Cáceres-Escobar, G., Meneses-Gómez, P.: Sensory evaluation and glicaemic index of a food developed with flour from whole (pulp and peel) overripe banana (*Musa cavendishii*)-mediated degradation, *Journal of the Agriculture and Food Chemistry*, **2018**, **61** (6), 1397-1404;

71. Wambua, M., Matofari, J.W., Faraj, A.K, Lamuka, P.O.: Effect of different cassava varieties (*Manihot esculenta*) and substitution levels in baking of wheat-cassava composite bread on physical properties and sensory characteristics, *African Journal of Food Science and Technology*, **2016**, **7** (6), 131-139;
72. Dhen, N., Rejeb, I.B., Martínez, M.M., Román, L., Gómez, M., Gargouri, M.: Effect of apricot kernels flour on pasting properties, pastes rheology and gels texture of enriched wheat flour, *European Food Research and Technology*, **2017**, **243**, 419-428;
73. Tharise, N., Julianti, E., Nurminah, M.: Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour, *International Food Research Journal*, **2014**, **21**(4), 1641-1649;
74. Al-Sahlany, S.T.G., Al-Musafer, A.M.S.: Effect of substitution percentage of banana peels flour in chemical composition, rheological characteristics of wheat flour and the viability of yeast during dough time, *Journal of the Saudi Society of Agricultural Sciences*, **2018**, **19** (1), 87-91;
75. Díaz, A., Bomben, R., Dini, C., Viña, S.Z., García, M.A., Ponzi, M., Comelli, N.: Jerusalem artichoke tuber flour as a wheat flour substitute for biscuit elaboration, *LWT-Food Science and Technology*, **2019**, **108**, 361-369;
76. Franco-Miranda, H., Chel-Guerrero, L., Gallegos-Tintoré, S., Castellanos-Ruelas, A., Betancur-Ancona, D.: Physicochemical, rheological, bioactive and consumer acceptance analyses of *concha*-type Mexican sweet bread containing Lima bean or cowpea hydrolysates, *LWT - Food Science and Technology*, **2017**, **80**, 250-256.