Scientific Papers. Series B, Horticulture. Vol. LXVI, No. 1, 2022
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

COMPARATIVE STUDY OF TEXTURAL PROPERTIES OF ORIGINAL BREADS CONTAINING VEGETABLES POWDERS AND ROMANIAN COMMERCIALLY AVAILABLE RYE BREAD

Georgiana-Roxana TOMOȘOIU, Stelica CRISTEA, Corina Nicoleta PREDESCU, Liliana TUDOREANU

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: roxana.ghibaldan8@gmail.com

Abstract

Functional and personalized foods have generated a growing interest for the general public and nutritionists. Bread is one of the most popular food being a versatile option for developing functional and personalized assortments. Vegetables powders of spinach, grape seeds, tomato seeds, carrot, tomato fruits, beetroot or broccoli have been added to bread dough to improve its phenolic content, textural properties, storage and shelf life. The present research is comparing the textural properties of three assortments of commercially available Romanian sliced rye bread (FT, SV, CR), which is a healthier alternative to wheat bread, with three assortments of manufactured white bread containing lyophilized powder of hawthorn (P2) and rosehips berries (P3) and grapeseed powder (P4). Cohesiveness was significantly different between the original assortments and the commercial ones however the cohesiveness of the P2, P3 and P4 bread assortments were not significantly different. No significant difference was also observed for the cohesiveness of the FT, SV and CR rye breads. The springiness index was not significantly different between all tested breads (P = 0.198), however the chewiness of P4 was significantly different compared to the commercial assortments but not significantly different compared to P2 and P3. The lack of difference between the springiness index of the two groups of beads indicates that the proposed original bead assortments can be a healthier alternative to rye breads, thanks to their exceptional phenolic content and mineral concentrations.

Key words*: bread, lyophilized hawthorn and rosehips berries, grapeseed powder, textural properties, phenols, minerals.*

INTRODUCTION

Functional and personalized foods have generated a growing interest for the general public but also for the medical world. Bread is the most consumed food but also one of the most versatile foods that can be personalized and fortified, responding to the needs of a wide range of people from those with gluten intolerance to those with cardiovascular disease or diabetes. The incorporation of different vegetable powders to bread improved nutritional values such as fiber content, polyphenol content, antioxidant levels, and at the same time can improve its rheological properties.

Similary, Junejo et al. (2021) reported that adding spinach powder to bread has dramatically improved the textural (hardness and chewiness) and antioxidant (free radical diphenylpicrylhydrazyl and fluorescence recovery after photobleaching) properties of bread. These results indicated that incorporation of spinach powder enriched the functional and nutritional properties of bread that may help to design healthier food products. The addition of lupine and flaxseed to the wheat bread improved its nutritional profile (Wandersleben et al., 2018).

Tomato seeds flour is an important source of proteins and has been reported to contain high levels of minerals by Sogi et al. (2002) therefore its addition to bread or bakery products will improve the nutritional value of these products. The texture profile analysis performed on bread enriched with tomato seeds flour revealed that tomato seeds flour addition has significant effects on the texture parameters of bread samples; the hardness, cohesiveness, chewiness and elasticity of the bread increases (Mironeasa et al., 2016). Similarly, the incorporation of pineapple core fiber (5, 10, and 15%, w/w flour basis) increased the hardness and gumminess of Chinese steam bread, while decreased the cohesiveness, specific volume and elasticity (Shiau, Wu, & Liu, 2015).

The texture analysis showed that the addition of chia seeds in bread caused a decrease in the hardness of the crumb and increased the nutritional value of the bread. Liu el al. (2018) suggested that the incorporation of oat bran into wheat flour decreases specific volume and softness of Chinese steamed bread and decreased the glycemic response.

Although the rye breads are known to have several health benefits and have similar healthiness perceptions among age groups, their consumption is limited (Sandvik et al, 2017) The present paper presents the textural properties of three original assortments of bread containing powders of lyophilized hawthorn and rosehips berries and grapeseed powder compared to commercially available rye bread in the attempt to identify healthier bread assortment with a larger acceptability among consumers.

MATERIALS AND METHODS

Preparation of original bread assortments

Three original varieties of breads were prepared by addition of lyophilized hawthorn fruit powder, lyophilized rosehip fruit powder and grape seed powder. The powders selected for bread fortification have functional properties such as maintaining blood pressure at normal values, increase resistance to mental exertion, improve peripheral and main blood circulation, prevent cardiovascular accidents, prevent hyperlipidemia, and may act as diuretic, hypotensive, astringent and vasodilator. At the same time, they have hepatoprotective, anti-inflammatory, regenerating, healing effect, prevent avitaminosis, stimulate immunity through the antiviral potency of interferon, prevent atherosclerosis and are indicated in the treatment of gout and rheumatism. These powders contain major bioactive substances such as tannins, bioflavonoids, vitamins B1, B2, B3, C, A, P, PP, anthocyanins, flavonoids, and tartaric, citric, malic, caffeic, ursolic, oxalic, nicotinic, chlorogenic acids as well as sorbitol, choline, glucose, fructose, pectin, volatile oils, triterpenes, mineral salts, and carotenoids.

The original bread recipe consists of the following basic ingredients: white wheat flour 000, water, salt, raw sugar, baking yeast, cold pressed sunflower oil. To the basic ingredients the 3 types of functional powders were added (2.5%), namely grape seed powder (P4), lyophilized hawthorn fruit powder (P2) and lyophilized rosehip fruit powder (P3)

Bead preparation: after mixing the ingredients, the dough was kneaded for 30 minutes, then the samples were left to rise at 25°C for 30 minutes. After fermentation, the samples were placed in the oven at 180°C for 60 minutes. After baking, the samples were left to cool and then packed in plastic bags to avoid dehydration.

Figure 1. Bread with addition of lyophilized hawthorn fruit powder (P2)

Figure 2. Bread with addition of lyophilized rosehip fruit powder (P3)

Figure 3. Bread with addition of grape seeds powder (P4)

Bread samples preparation for rheological analysis

All assortments of original bread were kept in the refrigerator for 12 hours before analysis. The bread was kept at room temperature for one hour before analysis. Measurements were made 4 days after bread baking

The commercial rye bread was bought from local supermarkets. Three companies producing rye bread were chosen, and their products were purchased and then coded as SV, CR, FT.
All bread assortments, including the comercial ones, were cut into cylinders with a diameter of 13 mm and height between 17 mm and 25 mm. Each sample height was measured before analyzing each bread sample. For each bread assortment were analyzed 15 samples.

Textural analysis
Textural analysis was performed using the TPA (Texture Profile Analysis) test (double compression test). The texture profile analysis was performed using a Texture Analyzer TA Plus (Llyod Instruments) within the Interdisciplinary Laboratory for the Study and Modeling of the Accumulation of Heavy Metals in the Food Chain of University of Agronomic Sciences and Veterinary Medicine.
The analyzed textural parameters were: hardness at first compression, cohesiveness, chewiness, and springiness index for all bread assortment. Double compression tests were performed at speeds of 5 mm / s to mimic the masticatory process.

Data statistical analysis
Statistical data analysis was performed using MedCalc software to compare the original and commercial bread assortments. ANOVA analysis was used to identify the significant differences between the rheological parameters measured for the selected bread assortments. The post-hoc test used is the Tukey test. When ANOVA generated $p > 0.05$, the Tukey test was no longer required because there were no significant differences between the samples analyzed. When ANOVA residuals were not normally distributed, ANOVA was replaced by the nonparametric tests Kruskal-Wallis.

RESULTS AND DISCUSSIONS

The textural parameters used to compare the rheological properties between the original assortments and the commercial ones are hardness (after the first compression) cohesive-ness, chewiness and springiness index (Table 1).

Table 1. Hardness, cohesiveness, chewiness and springiness index for original bread assortments and commercially available rye bread

	HARDNESS FOR THE FIRST COMPRESSION (N)		COHESIVENESS		CHEWINESS (J)		SPRINGINESS INDEX	
BREAD TYPE	MEAN	SD*	MEAN	SD	MEAN	SD	MEAN	SD
P2	21.1300	8.6331	0.2827	0.0342	0.0479	0.0227	0.7563	0.1315
P3	9.0111	3.2711	0.3107	0.0492	0.0201	0.0104	0.6891	0.2274
P4	13.6417	4.5189	0.3101	0.0278	0.0346	0.0095	0.7737	0.1637
CR	30.6960	23.8040	0.2083	0.0489	0.1001	0.0675	0.7521	0.1185
SV	46.3120	25.4120	0.2101	0.0384	0.1515	0.0588	0.7885	0.0860
FT	31.5960	11.3150	0.1821	0.0279	0.0772	0.0263	0.7244	0.1371

*SD = Standard Deviation

These four parameters were choose due to the information they can provide on the internal structure of the new bread assortments as well as of the commercially available rye bread: the hardness during first compression is the maximum force required to obtain the maximum deformation established for the first compression which can be considered a measure of the response of the bread during mastication compression between molars; cohesiveness represents the intensity of the internal bonds that form the structure of the sample offering information on the internal structural modifications due to fruits and seed powder addition to the bread recipe; chewiness represents the energy needed for the complete destruction of a solid sample giving useful information on the consumers perception during mastication; the springiness index is the ability of the product to return to its original shape after the first compression and it is a good indicator of the structure response when bread is tested for freshness by hand compression.

Table 2. Testing residuals normality for ANOVA for the hardness data

Hardness - Shapiro-Wilk test for Normal distribution **(Residuals)**	W=0.7854 reject Normality (P<0.0001)

In order to accept the results of the ANOVA analysis for hardness the residuals normality (Table 2) was tested. The Shapiro-Wilk test for residuals of cohesiveness lead to rejection of Normality, therefor the nonparametric test Kruskal-Wallis was used (Table 3).

Table 3. Kruskal-Wallis test for Hardness during first compression (N)

Data	Hardness1 (N)
Factor codes	Type_of_bread
Sample size	154
Corrected for ties Ht	83.0790
Degrees of Freedom (DF)	5
Significance level	P < 0.000001

The Kruskal-Wallis test showed that hardness during compression is significantly different for the bread assortments (P < 0.000001; Table 3). To distinguish between hardness bread assortments the post-hoc test Conover was used (Table 4)

Table 4. Post-hoc analysis (Conover) for hardness during first compression

Factor	n	Average Rank	Different (P<0.05) from factor nr
CF	37	80.24	FT, P2, P3, P4, SV
FT	36	96.22	CF, P2, P3, P4, SV
P2	16	59.19	CF, FT, P3, P4, SV
P3	15	13.33	CF, FT, P2, SV
P4	16	28.56	CF, FT, P2, SV
SV	34	114.65	CF, FT, P2, P3, P4

The Conover post-hoc test for hardness during compression (Table 4) shows that all commercially available assortments are significantly different from the original breads (P2, P3, P4). Wirkijowska et al, (2020) reported that were Flaxseed flower and marc added to bread (10% and 15%) significantly increased bread hardness, however the original bread assortments presented in this study however showed a significant decrease of hardness compared to commercially available assortments of rye bread.

Table 5. Testing residuals normality for ANOVA for Cohesiveness data

Cohesiveness - Shapiro-Wilk test for Normal distribution (residuals)	W=0.9677 reject Normality (P=0.0011)

In order to accept the results of the ANOVA analysis for cohesiveness we have tested the residuals normality (Table 5).
The Shapiro-Wilk test for residuals of cohesiveness showed that Normality is rejected, therefore the nonparametric test Kruskal-Wallis is used (Table 6).

Table 6. Kruskal-Wallis test for Cohesiveness

Data	Cohesiveness
Factor codes	Type_of_bread
Sample size	154
Test statistic	88.6170
Corrected for ties Ht	88.6170
Degrees of Freedom (DF)	5
Significance level	P < 0.000001

The Kruskal-Wallis test showed that cohesiveness is significantly different for the bread assortments (P < 0.000001; table 6).
The Conover posthoc test for chewiness (Table 7) shows that CF assortment is not significantly different from SV assortment, however it is significantly different of the original breads (P2, P3, P4) and FT.
The original bread assortments cohesiveness is significantly different from the commercial assortment's cohesiveness (Table 7).
The ANOVA for chewiness showed that the normality of the residuals is rejected (Table 8).
The Nonparametric Kruskal-Wallis test is used to differentiate between bread assortments (Table 9).
The Kruskal-Wallis test showed that chewiness is significantly different for the bread assortments (P < 0.000001; Table 9).

Table 7. Post-hoc analysis (Conover) for cohesiveness

Factor	n	Average Rank	Different (P<0.05) from factor nr
CF	37	61.68	FT, P2, P3, P4
FT	36	41.47	CF, P2, P3, P4, SV
P2	16	116.75	CF, FT, SV
P3	15	129.40	CF, FT, SV
P4	16	133.44	CF, FT, SV
SV	34	65.18	FT, P2, P3, P4

Table 8. Testing residuals normality for ANOVA of chewiness data

Chewiness- Shapiro-Wilk test for Normal distribution (Residuals)	W=0.8686 reject Normality (P<0.0001)

Table 9. The Kruskal-Wallis test for chewiness (J)

Data	Chewiness
Factor codes	Type_of_bread
Sample size	154
Test statistic	100.3872
Corrected for ties Ht	100.3872
Degrees of Freedom (DF)	5
Significance level	P < 0.000001

The Conover posthoc test for chewiness (Table 10) shows that CF assortment is not significantly different from FT assortment, however it is significantly different of the original breads (P2, P3, P4) and SV.

The original bread assortments chewiness is significantly different from the commercially available bread assortment's chewiness (Table 10).

The addition of rosehip and hawthorn fruits lyophilized powders and grape seeds powder significantly decreased the bread chewiness which is a encouraging result compared with the results of Wirkijowska et al. (2020) who reported that the adition of flaxseed flour significantly increased the chewiness of bread.

ANOVA (table 12) was used to analyse the springiness index data because the Shapiro-Wilk test for Normal distribution of residuals showed that normality can be accepted (Table 11). No significant differences were observed between all bread assortments tested (P = 0.198; Table 12); therefore, the perception of freshness by hand compression may be considered similar among all the bread assortments tested.

Table 10. Post-hoc analysis (Conover) for Chewiness

Factor	n	Average Rank	Different (P<0.05) from factor:
CF	37	89.08	P2; P3; P4; SV
FT	36	82.67	P2; P3; P4; SV
P2	16	46.56	CF; FT; P3; SV
P3	15	12.47	CF, FT, P2, SV
P4	16	29.31	CF, FT, SV
SV	34	125.35	CF, FT, P2, P3, P4

Table 11. Testing data normality and equality of variances for springiness index

Data	Springiness_Index
Factor codes	Type_of_bread
Sample size	154
Levene's test for equality of error variances Levene statistic	6.490
DF 1	5
DF 2	148
Significance level	P < 0.001
Residuals Shapiro-Wilk test for Normal distribution	W=0.9877 accept Normality (P=0.1953)

Table 12. ANOVA for springiness index considering as factor the bread assortments. Data are normally distributed and the variances are not equal. ANOVA is corrected for unequal variances

Data		Springiness_Index	
Factor codes		Type_of_bread	
Sample size		154	
ANOVA Source of variation	Sum of Squares	DF	Mean Square
Between groups (influence factor)	0.1422	5	0.02844
Within groups (other fluctuations)	2.8351	148	0.01916
Total	2.9773	153	
-ratio			1.485
Significance level			P = 0.198

CONCLUSIONS

The hardness, chewiness and cohesiveness of original assortments of bread containing lyophilized hawthorn fruit powder (P2), lyophilized rosehip fruit powder (P3) and grape seeds powder (P4) are significantly different of the same parameters measured for the commercially available rye bread assortments.

The hardness of all original assortments is significantly lower than the hardness of commercially available rye bread assortments.

The cohesiveness of original assortments of bread is significantly higher than the cohesiveness of commercially available rye bread assortments, meaning that these original assortments of bread will crumble less. The chewiness of original assortments of bread is significantly lower than the chewiness of the commercially available rye bread assortments, for this reason the original assortments of breads will be perceived by consumers to be more tender, soft or fluffy compared to the assortments of rye bread. The original bread assortments chewiness is significantly different from the commercially available rye bread assortment's chewiness, suggesting that during mastication the original assortments of bread will be perceived as being more soft.

The springiness index for the original assortments of bread is not significantly different from the commercially assortments of rye bread, showing that the consumers will not see any difference when testing their freshness by hand compression. Therefore it can be considered that the consumer's expectation (Sajdakowska et al., 2021) will be satisfied from the point of view of the way in which they perceive the freshness of the original proposed bread assortments.

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