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Nutritional, Sensory, Texture Properties and Volatile Compounds Profile of Biscuits with Roasted Flaxseed Flour Partially Substituting for Wheat Flour

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Abstract: The study aimed at assessing effects of partial replacement (0–40%) of wheat flour with roasted flaxseed flour (RFSF) on the quality attributes of biscuits. Nutritional, antioxidative, volatile and sensory properties, as well as texture analysis and the contents of macroelements and microelement were studied. Increasing RFSF content in biscuits resulted in a significant increase ($p < 0.05$) in protein (from 8.35% to 10.77%), fat (from 15.19% to 28.34%) and ash (from 1.23% to 2.60%) while the hardness and spread factor of the biscuits decreased with the increased level of roasted flaxseed flour. Moreover, the addition of 40% RFSF registered a positive influence on the fibre content of the final baked biscuits, increasing its value about 6.7-fold than in the control sample. Total phenolic content, antioxidant activity and biscuits' aroma volatile profile increased their amounts with RFSF addition. The nutritional, textural and sensorial results of the present study demonstrated that 25% RFSF could be added in the biscuits manufacturing without affecting the biscuits aftertaste, offering promising healthy and nutritious alternative to consumers.

Keywords: roasted flaxseed flour; GC/MS; aroma; antioxidant activity; sensory evaluation; fiber; macro and microelements; biscuits

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1. Introduction

Bakery and pastry products are consumed worldwide in large quantities on a daily basis and play an important role in human nutrition. Among bakery products, biscuits are the most popular amongst consumers as a rich source of carbohydrates and fats, but low in proteins and dietary fibers along with quite a good shelf life [1]. Generally, biscuits are made with refined wheat flour which is deficient in some essential amino acids (lysine, tryptophan, threonine, methionine and histidine) and other nutrients (fiber, minerals and vitamins) [2–4]. Nowadays there is a high demand for high nutritional value foods. In the current Western society's diet, the intake of ω -6 fatty acids is generally higher compared to the intake of ω -3 fatty acids and this leads to unfavorable nutritional consequences. Therefore, there is a need on the market for innovative products that meet the nutritional requirements of consumers. Some authors suggest that diet supplementation with flaxseed (*Linum usitatissimum*) offers potential health benefits in cases like cardiovascular risk, severe hyperlipidemia, certain types of cancers and other metabolic disorders [5–9]. Flaxseed contain protein (20 g/100 g), dietary fiber (28 g/100 g), fat (41 g/100 g), moisture (6.5 g/100 g), minerals (2.4 g/100 g) and carbohydrates (28.9%), being recognized as an important oilseed and fiber crop [10–12]. It ought to be emphasized that the linseed chemical composition

may vary depending on the genetic characteristics, growing conditions and crop management practices. Furthermore, flaxseed has a unique fatty acid profile. It is high in polyunsaturated fatty acids (73 g/100 g of total fatty acids), moderate in monounsaturated fatty acids (18 g/100 g), and low in saturated fatty acids (9 g/100 g). The content of linoleic acid is about 16 g/100 g of total fatty acids while α -linolenic acid (ALA) reaches about 57 g/100 g [13]. Tocopherols (20–70 mg/100 g) and carotenoids (~5.7 mg/100 g) are also found in flaxseed oil, therefore flaxseed is considered an important ancient medicine and functional food ingredient [14].

Flaxseed is one of the most important oilseed crops for industrial as well as for food and feed purposes, being part of the human diet for thousands of years, and more recently it has been used as a source of nutraceuticals [10,11,15]. The bioactive components in flaxseed that provide health benefits include α -linolenic acid, lignans and dietary fiber [16,17], proteins and soluble mucilage [8,11,16,18–21]. The flaxseed mucilage may be considered a food hydrocolloid due to its composition, which consists of a mixture of neutral arabinoxylans and acidic rhamnose-containing polysaccharides [22]. Evenmore, antioxidant activity of the lignans and the presence of different types of phenolic compounds such as phenolic acids, flavonoids, phenylpropanoids and tannins [23] may reduce the risk of cardiovascular diseases and contribute to the anticancer activity [12,24–26], particularly hormone-dependent cancers such as prostate and breast [27].

The behavior of proteins in a food system is affected by their techno-functional properties which are mainly dependent on the following factors: the structure of the protein, their hydration mechanisms for solubility and water or oil retention capacity, rheological characteristics for viscosity and gelation, and their interfacial properties for emulsions and foams [28]. Flaxseed proteins have real potential to be used as techno-functional food ingredient in several food products particularly in breads, meat emulsions, and sauces [26]. Thus, flaxseed can be incorporated into diet as ground flaxseed or flaxseed oil. Flaxseed was previously incorporated in various bakery products such as cookies and biscuits [26,29–33] bread [13,22,34,35] and cakes [15,36]. The results of these studies showed that a substitution levels up to 20% led to good product acceptability [29].

Consumers' trend to seek nutritional foods with remarkable value in the diet is highly directed toward the use of flaxseed as a potential ingredient in foods. The nutrient profile of flaxseed biscuits is a valued option, especially for consumers interested in healthy snack diversification.

The aim of this study was to examine the effects of partial replacement of wheat flour with roasted flaxseed flour on the quality attributes of biscuits, with special attention on their nutritional proprieties and volatile profile. Wheat flour substitution with flaxseed flour in biscuits formulation proposed in this study can be an example of successful collaboration between research and food industry and are in agreement with the confectionery products trends.

2. Materials and Methods

2.1. Materials

All the ingredients used in the biscuit formulations were bought from the local market in Cluj-Napoca, România. The wheat flour (WF) sample was produced by a local mill (Boromir, Deva, Romania) and sold as type 000 according to its ash content following the Romanian classification [37] (0.48% ash content and 29.57% wet gluten). Flaxseeds originating from Ukraine were used to prepare the flaxseed flour as described further. Initially, flaxseeds were roasted at 180 °C for 15 min, then cooled and ground on a GM200 laboratory mill (Grindomix, Retsch GmbH, Haan, Germany) at 10,000 rotations/min for 50 s. To ensure the uniformity of particles, the roasted flaxseed flour (RFSF) was sieved through a 0.8 mm sieve. Four blends of various ratios of both flours were used to prepare the biscuits, as presented in Section 2.2.2.

2.2. Methods

2.2.1. Proximate Composition Analysis

The chemical characteristics were determined using the AACC (2000) methods [38]. Wheat flour (WF), roasted flaxseed flour (RFSF), control biscuits and RFSF incorporated biscuits were analysed for moisture (AACC 44-15.02, 2000), ash (AACC 08-01.01, 2000), fat (AACC 30-25.01, 2000), crude fiber (AACC 32-07.01, 2000). The proteins were measured using the Kjeldahl method (AACC 46-11.02, 2000) using the nitrogen to protein conversion factor of 5.7. Total carbohydrate (%) content was calculated according to Equation (1) according to methods reported by Man et al. [39]:

$$\text{Total carbohydrates}(\%) = 100 - [\text{moisture}(\%) + \text{ash}(\%) + \text{proteins}(\%) + \text{lipids}(\%) + \text{crude fiber}(\%)] \quad (1)$$

All determinations were made in triplicate.

2.2.2. Preparation of Biscuits

First step was to formulate the four flour blends (100:0, 90:10, 75:25 and 60:40 WF:RFSF, w:w). The flour blends were stored in air-tight containers until further use. The second step was premixing margarine (60% fat) with powdered sugar into a cream base and then mixing that with the flours, instant whole milk powder (26% fat and 26% protein), sodium bicarbonate, vanilla essence and water. The doughs were mixed for seven min in a mixer (KitchenAid® Precise Heat Mixing Bowl, Greenville, OH, USA), at medium speed. Mixing, resting and baking technological parameters are listed in Table 1. The control sample was prepared using the same procedure, but omitting the flaxseed. The dough was rolled out into circular shapes of 0.4 cm thickness and then the biscuits were shaped by stamping with cylindrical shapes into 5.5 cm diameter. After baking (Zanolli oven, Verona, Italy) all biscuits samples were removed from the trays for cooling, then packed in polypropylene bags and sealed until further analysis. Biscuit samples were coded as B0, B10, B25 and B40, respectively, taking into consideration the amount of RFSF (0%, 10%, 25%, 40%) as shown in Table 1. Each batch of biscuits was made the day before the sensory, texture and volatile analysis.

Table 1. Ingredients and technological parameters used in the preparation of biscuits.

Ingredients (g)	Biscuits Samples *			
	B0	B10	B25	B40
Wheat flour (WF)	100	90	75	60
Roasted flaxseed flour (RFSF)	-	10	25	40
Powder milk **	20	20	20	20
Margarine **	40	40	40	40
Sugar powdered **	40	40	40	40
Sodium bicarbonate **	2.5	2.5	2.5	2.5
Vanilla essence **	0.5	0.5	0.5	0.5
Water **	25	25	25	25
Technological parameters				
Mixing time (min)	7	7	7	7
Dough temperature (°C)	22	22.4	23	23.5
Resting time (min)	60	60	60	60
Temperature (°C)	3–4	3–4	3–4	3–4
Baking time (min)	10	10	10	10
Temperature (°C)	200	200	200	200

Note: * B0 = 0% biscuits with 100% wheat flour (control sample); B10 = biscuits with 10% RFSF; B25 = 25% biscuits with 25% RFSF; B40 = biscuits with 40% RFSF. ** The auxiliary materials are reported to 100% of flour blends.

2.2.3. Macro- and Microelements

Macro- and microelements were determined by atomic absorption spectrophotometry (AAS), according to the methods described by Păucean et al. [40] and Chiş et al. [41]. Briefly, 3 g of biscuits were burned at 550 °C in the furnace for 10 h (Nabertherm B150, Lilienthal, Germany). The ash was dissolved in HCl 20% and made up to a final volume of 20 mL in a volumetric flask. The macroelements (K, Ca, Mg) and microelements (Fe, Cu, Zn and Mn) were determined by AAS (Varian 220 FAA instrument, Mulgrave, Victoria, Australia). Mixed standard solutions with P, K, Cu, Zn, Fe, Mn, Ca, Mg (ICP Multielement Standard solution IV CertiPUR) were purchased from Merck (Merck KGaA, Darmstadt, Germany). All chemicals and solvents used in this study were of analytical grade. The results were expressed related to the weight of the fresh biscuits.

2.2.4. Physical Evaluation of Biscuits

The diameter of six biscuits placed edge to edge was measured with a Vernier caliper (0.01 mm accuracy). The average diameter in centimetres was calculated by dividing [42] the value by six [4]. Similarly, the mean thickness of the biscuits was measured by stacking 6 biscuits on top of each other and dividing the value by six. For the spread factor the diameter was divided by thickness. The weight of the biscuits was measured on an analytical balance and calculated as the mean value of the weight of four individual biscuits.

2.2.5. Total Phenolics Content

Total polyphenols content and antioxidant activity were determined as described by Bunea et al. [43] with slight modifications as proposed by Chiş et al. [44]. Briefly, one gram of biscuit sample was extracted three times with 100 mL acidified methanol (85:15 *v/v*, MeOH:HCl) by maceration under continuous stirring (magnetic stirrer, Velp Scientifica, Usmate Velate, Italy) for 24 h. Total phenolics content of the extracts was determined spectrophotometrically (Folin–Ciocalteu method). Thus, in a 100 mL volumetric flask, 10 mL of methanolic extract was mixed with 5 mL of Folin–Ciocalteu's reagent; 5 mL of 7.5% sodium carbonate solution was added. Distilled water was used to fill up the flask until the graduation marking. Samples were kept in the dark for 90 min, and then, absorbance was read at 760 nm on a model 1700UV/VIS spectrophotometer (Shimadzu Scientific Instruments, Kyoto, Japan).

2.2.6. DPPH Radical Scavenging Activity Assay

The radical scavenging activity was determined spectrophotometrically by the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method as described by Păucean et al. [40]. The phenolic extracts (0.1 mL) were mixed with DPPH solution (3.9 mL), kept in the dark at ambient temperature for 30 min. The absorbance of the mixtures was recorded at 515 nm (1700 UV/VIS spectrophotometer Shimadzu) against a methanol blank. Negative control was prepared using 0.1 mL methanol and 3.90 mL of DPPH. The radical scavenging activity was calculated according to the following Equation (2):

$$RSA[\%] = \frac{Abs_{DPPH} - Abs_{sample}}{Abs_{DPPH}} \times 100 \quad (2)$$

where Abs_{DPPH} = absorbance of DPPH solution and Abs_{sample} = absorbance of the sample.

2.2.7. Volatile Compounds

Qualitative analyses of the volatile compounds were achieved using “in-tube extraction” coupled with gas-chromatography mass spectrometry (ITEX/GC-MS, Shimadzu GC-MS model QP-2010) [45]. Three grams of each sample were weighed into a 20 mL sealed-cap headspace vial and incubated for 30 min at 70 °C with continuous agitation. The volatile compounds from the gaseous headspace of the sample were repeatedly adsorbed onto a microtrap (ITEX-2TrapTXTA, TA 80/100 mesh, Tenax, Zwingen, Switzerland) using

a CombiPAL AOC-5000 autosampler (CTC Analytics, Zwingen, Switzerland). The volatile compounds were further thermally desorbed into the injection port of the GC-MS QP2010 system and separated on a ZB-5 ms column of 30 m $\times$ 0.25 mm i.d. and 0.25 μ m film thickness (Phenomenex, Torrance, CA, USA). The column oven temperature program was set initially at 40 °C (kept at this temperature for 6 min) and then increased to 50 °C at 2 °C/min, followed by an increase to 240 °C at 7 °C/min (kept at this temperature for 5 min). The temperatures of the ion source, injector, and interface were set at 250 °C. The carrier gas was helium at a flow rate of 1 mL/min. The split ratio was 1:2. The MS detector was operated in the EI mode, using a scan acquisition mode in the range of 40–400 *m/z*. Mass spectra was identified by comparison with a series of standard alkanes—alkane standard solution.

The identification of volatile compounds was performed by comparing their mass spectra with those in the NIST27 and NIST147 libraries and by retention indices drawn from [46,47] (for columns with a similar stationary phase to ZB-5 ms). Afterwards, the mass spectra values were compared and verified with the retention indices drawn from Pherobase [46] and Flavornet [47] databases. The results were expressed as relative percentage of the total peaks area.

2.2.8. Instrumental Analysis of Texture

The textural properties of the biscuits were measured with a CT 3 Texture Analyzer (Brookfield Engineering Labs, Middleboro, MA, USA), equipped with a 10 kg load cell and the 6 mm cylindrical probe (TA41). The textural properties were determined as described by Pop et al. [48] with slight modifications. A compression test was applied to all samples (5 mm target distance, 3 mm/s test and post-test speed, trigger load 5 g). The Brookfield Engineering Labs Texture Pro CT V1.6 software was used to calculate the specific texture parameters.

2.2.9. Sensory Analysis

The sensory evaluation of the biscuits took place in the Laboratory for Sensory Analysis from the authors' faculty, under normal daylight conditions. All samples were evaluated for acceptability using a nine-point hedonic scale. A total number of 52 evaluators (40 females and 12 males) between 19–52 years old participated at the study. The evaluators were students and staff members from the Faculty of Food Science and Technology, selected on basis of their interest, availability and regular consumption of biscuits (at least once per week). Samples were coded anonymously with a three digit code and presented on plastic odour-free plates, in random order. Two replications of each sample were evaluated by each participant. Plain mineral water was provided to clean the palate between samples. Five sensory characteristics were rated on the nine-point hedonic scale: "appearance" (1 = extremely irregular surface, 9 = extremely regular surface), "hardness" and "crispiness" (1 = extremely weak, 9 = extremely strong), "chewiness" (1 = extremely difficult to chew, 9 = extremely easy to chew) and finally, "taste and aroma" (1 = no flaxseed taste and aroma, 9 = extremely strong flaxseed taste and aroma). The attributes of hardness were explained to the evaluators and their definitions were also inserted in the evaluation forms. The evaluators were trained with the scale and the sensory attributes used for the evaluation of biscuit samples (2 sessions $\times$ 2 h). As already published by Park et al. [49] the hardness was considered the force needed to bite through the sample by using the front teeth. Crispiness was evaluated as the force and the noise with which the sample breaks down between the molar teeth. Finally, the chewiness was evaluated as the energy necessary to masticate solid foods so that they can be easily swallowed.

2.2.10. Statistical Analysis

The results of three independent ($n = 3$) replicates were expressed as means $\pm$ standard deviations (SD). Data of proximate composition, sensory data and instrumental textural analysis were analyzed using Duncan multiple comparison test ($p < 0.05$) using the SPSS

version 19 software (IBM Corp., Armonk, NY, USA). Correlation among means of the sensory data was determined using a two-tailed Pearson Correlation test ($p < 0.05$) using Microsoft Office—Excel.

3. Results and Discussions

3.1. Proximate Composition of Flours

The proximate composition of WF and RFSF is reported in Table 2. The data show that the two flours have complementary nutritional profiles. The moisture content of any flour is an important quality criterion for its preservation, packaging and transport as well. WF had eight times more humidity than RFSF (14.55% compared to 1.64%, respectively). The low moisture content for RFSF can be explained by the prior roasting process which removed most of the sample's water content. Comparison of the carbohydrate content of the two samples presented a similar pattern: WF presented high levels of carbohydrates (74.45%), whereas RFSF contained 21.76% of total carbohydrate. However, RFSF presented higher levels of protein (21.40%), fiber (8.75%) and fat content (42.50%) compared to WF.

Table 2. Proximate composition of raw materials.

Parameters	Wheat Flour Type 000 (WF) *	Roasted Flaxseed Flour (RFSF) *
Moisture (% fw)	14.55 ± 1.20 ^b	1.64 ± 0.04 ^a
Protein (% fw)	9.12 ± 1.03 ^a	21.40 ± 1.50 ^b
Ash (% fw)	0.48 ± 0.01 ^a	3.95 ± 0.04 ^b
Fat (% fw)	1.03 ± 0.20 ^a	42.50 ± 1.50 ^b
Crude fiber (% fw)	0.37 ± 0.23 ^a	8.75 ± 1.45 ^b
Total carbohydrate (% fw)	74.45 ± 0.9 ^b	21.76 ± 0.76 ^a

* Values represent mean of three independent determinations ± SD; Mean values followed by the same superscript alphabet in the row are not significantly different at $p < 0.05$ according to Duncan comparison test; fw-fresh weight.

Therefore, a composite flour can be successfully used to obtain biscuits with improved nutritional value. These results are in agreement with those obtained by Kaur et al. [26] and Kelapure [50] who found the fat content of flaxseed flour was 38.2 and 40.5%. The protein, crude fiber, and ash content of RFSF, in our study, was observed to be 21.40%, 8.75%, and 3.95%, respectively. These values correlated well with the values reported earlier by Hussain et al. [19], Kaur et al. [26], Masoodi [29] and Kelapure [50].

The valuable chemical composition of RFSF along with the high carbohydrate content of WF, especially starch, led to a composite flour with good characteristics for biscuit manufacturing. Mamat and Hill [51] showed that flour with high carbohydrate content and low in gluten is highly recommended for biscuit manufacturing. Therefore, we considered that the composite flours with 25% RFSF could be successfully used for further processing. WF contributes to the final characteristics of biscuits with the pasting properties of the starch and with the gluten content. Moreover, the high protein content of RFSF could contribute also to the pasting property on the finished product and to the dough viscosity, as it was reported previously in the development of protein-enriched composite flour for biscuits production [52].

3.2. Volatile Compounds of Raw and Roasted Flaxseed

The purpose of the analysis was to compare the volatile compounds profile of both raw and roasted flaxseed, to explain, based on the identified volatile compounds, consumers' acceptability of roasted seeds. As a result, a total number of 18 aroma compounds were identified by using ITEX/GS-MS and are presented in Table 3 group in six classes of compounds: alcohols, aldehydes, ketones, terpenes, and terpenoids, acids and others.

Table 3. Volatile compounds of raw flaxseeds and roasted flaxseed.

Volatile Compounds	RT (Retention Time, min)	Raw Flaxseeds (%) *	Roasted Flaxseed (%) *	Aroma Characteristics **
Alcohols				
3-Methylbutan-1-ol	3.904	2.75 ± 0.05 ^a	4.48 ± 0.03 ^b	Whiskey, malt, burnt
2-Methylbutan-1-ol	3.983	3.81 ± 0.21 ^a	3.64 ± 0.032 ^a	Malt
Pentan-1-ol	4.843	3.97 ± 0.11 ^b	1.38 ± 0.21 ^a	Fruit, balsamic
Hexan-1-ol	9.943	23.06 ± 0.03 ^b	3.74 ± 0.11 ^a	Resin, flower, green
Phenol	15.682	3.63 ± 0.03 ^a	2.99 ± 0.61 ^a	Whiskey, malt, burnt
Aldehydes				
Hexanal	6.059	N.D.	24.24 ± 0.21	Grass, tallow, fat, fruity, sweaty
Benzaldehyde	14.758	5.76 ± 0.11 ^a	10.42 ± 0.32 ^b	Almond, burnt sugar
Nonanal	19.753	1.55 ± 0.08 ^a	2.85 ± 0.11 ^b	Fat, citrus, green
Decanal	22.41	1.82 ± 0.03 ^a	1.25 ± 0.04 ^a	Orange peel, tallow
Ketones				
Acetophenone	18.532	13.22 ± 0.21 ^a	17.28 ± 0.21 ^b	Must, flower, almond
Benzophenone	31.22	3.18 ± 0.03 ^b	1.85 ± 0.11 ^a	Balsamic
Terpenes and terpenoids				
α-Pinene	13.358	12.70 ± 0.21 ^b	6.81 ± 0.30 ^a	Pine
β-Pinene	15.343	4.80 ± 0.21 ^b	1.99 ± 0.03 ^a	Pine, resin
D-limonene	17.32	10.72 ± 0.10 ^b	9.85 ± 0.03 ^a	Citrus, mint
Camphene	14.117	2.48 ± 0.21	N.D.	Camphor
Acids				
Benzoic acid	21.15	1.19 ± 0.21	N.D.	Balsamic
Others				
2-Methyloctane	9.503	4.51 ± 0.02 ^b	2.80 ± 0.02 ^a	Alkane
2-Pentylfuran	15.97	N.D.	2.95	Fruity

* Each value was the mean of triplicate measurements; N.D.—not detected. ** drawn from [46,47]; Note: ^{a,b} different superscripts in a row indicate significant differences within samples ($p < 0.05$) according to Duncan comparison test.

It was found that the main volatile compounds of raw flaxseed were hexan-1-ol (23.06%), acetophenone (13.22%), α-pinene (12.70%), D-limonene (10.72%) and on the other hand, the major volatile compounds in the roasted flaxseed were hexanal (24.24%), acetophenone (17.28%), benzaldehyde (10.42%), D-limonene (9.85%), α-pinene (6.81%), 3-methylbutan-1-ol (4.48%) and hexan-1-ol (3.74%), respectively (Table 3).

Compounds with fresh and balsamic aroma characteristics, for example hexan-1-ol, benzophenone, β-pinene, D-limonene, camphene and benzoic acid, were present in significantly higher ($p < 0.05$) amounts in raw flaxseed compared to roasted flaxseed. With respect to hexan-1-ol, a lipid oxidation volatile compound with a significant value in raw flaxseed, its amount could be justified by the activity of dehydrogenase enzyme during storage [53].

In the roasted flaxseed compounds with aromas like malt, burned sugar and almond were found in significantly higher amounts ($p < 0.05$) than in raw flaxseed. Hexanal is the primary oxidation product of linoleic acid [52]. The increase of hexanal in roasted flaxseed reaching a final value of 24.24% may be due to lipid oxidation during thermal treatment [54]. Roasted flaxseeds are a rich source of lipids and in the present study, a total amount of 42.50% total fat was previously mentioned. Furthermore, Wei et al. [53] reported a higher content of α-linolenic acid, the precursor of docosaheptaenoic and eicosapentaenoic acids, in flaxseeds, thus explaining the formation of hexanal during the roasting process. Furthermore, acetophenone (17.28%) was the major volatile compound from the ketone group, while the main alcohol identified was 3-methylbutan-1-ol (4.48%). The presence of aldehydes, ketones and alcohols in the roasted flaxseeds could be justified by thermal reactions during roasting such as non-enzymatic Maillard reactions and sugar caramelization. Likewise, the aforementioned compounds could also be formed as a result of lipid oxidation [54].

3.3. Proximate Composition for Biscuits with RFSF

The proximate composition of the biscuits with RFSF (B0, B10, B25, B40) is summarized in Table 4. Incorporation of the RFSF in biscuits has a significant influence on the major components ($p < 0.05$) and a decrease of the moisture content was observed while fat, ash, protein and fiber content of composite flour mixes increased. RFSF had a significant ($p < 0.05$) effect on the moisture content of the biscuits compared to the control with a decrease in moisture content from 7.34% to 4.92%. Similar patterns were previously noticed by Khouryieh and Aramouni [55] and Kaur et al. [26] who found that as the flaxseed flour concentration increased in the blend, the moisture content of cookies decreased. These results may be due to low moisture content (1.64%) of RFSF. Moreover, a high amount of fat (42.50%) was recorded in RFSF, which also contributed to the hydration of the dough, thus reducing the moisture of the biscuits. Furthermore, the low moisture content of the biscuits allows a longer preservation period, due to minimal microbial or chemical activity.

Table 4. Proximate characteristics of the biscuits samples.

Parameters	Biscuit Samples *			
	B0	B10	B25	B40
Proximate Composition (% fw)				
Moisture (%)	7.34 ± 0.10 ^d	6.50 ± 0.20 ^c	5.7 ± 0.15 ^b	4.92 ± 0.14 ^a
Protein (%)	8.35 ± 0.50 ^a	9.12 ± 0.20 ^b	9.89 ± 0.40 ^c	10.77 ± 0.90 ^d
Ash (%)	1.23 ± 0.02 ^a	1.61 ± 0.05 ^b	2.13 ± 0.07 ^c	2.60 ± 0.02 ^d
Fat (%)	15.19 ± 0.90 ^a	19.06 ± 1.01 ^b	23.88 ± 1.20 ^c	28.34 ± 1.50 ^d
Crude fiber (%)	0.75 ± 0.92 ^a	1.95 ± 0.04 ^b	3.20 ± 0.14 ^c	5.05 ± 0.45 ^d
Total carbohydrate (%)	67.14 ± 0.70 ^d	61.76 ± 0.06 ^c	55.19 ± 0.21 ^b	48.32 ± 0.32 ^a
TPC (mg GAE/100 g, fw)	63.06 ± 0.07 ^a	69.95 ± 0.03 ^b	74.23 ± 0.12 ^c	78.82 ± 0.26 ^d
DPPH (%RSA)	13.57 ± 0.14 ^a	18.89 ± 0.09 ^b	26.41 ± 0.29 ^c	32.03 ± 0.71 ^d

* Values represent mean of three independent determinations ± SD; fw-fresh weight; Mean values followed by the same superscript alphabet in the row are not significantly different at $p < 0.05$ according to Duncan comparison test.

Ash content increased from 1.23% (control biscuits) to 2.60% (sample B40). This might be due to the higher mineral content of flaxseed flour [56,57]. Also, the protein content increased significantly ($p < 0.05$) from 8.35 g/100 g in B0 to 10.77 g/100 g in B40 and fat from 15.19 g/100 g in B0 to 28.34 g/100 g in B40. Moreover, the addition of 40% RFSF registered a positive influence on the fibre content of the final baked biscuits, increasing its value about 6.7-fold compared to the control sample. Improving the nutritional value of pastry products by substituting wheat flour with other fiber-rich sources was also recommended by others [58,59]. This increase could be explained by the fact that roasted flaxseed flour is far higher in fat, protein and crude fiber content compared with wheat flour as mentioned in the proximate analysis section of this article.

The total carbohydrate content was significantly decreased ($p < 0.05$) in biscuits substituted with flaxseed from 61.76% to 48.32% compared to control biscuits (67.14%). These results are similar with the results obtained by Ahmed et al. [60] El-Demery et al. [61] mentioned that as the level of substitution with flaxseed flour increased, all compounds increased except total carbohydrate. Other authors also revealed that the substitution of wheat flour with flaxseed flour resulted in a considerable improvement in protein, crude fiber and ash of biscuit samples [12,16,24,26,50,59,62].

TPC and DPPH of biscuit samples increased with the substitution level of RFSF to WF in the blends. The highest increase in DPPH activity and TPC was exhibited by sample B40 (32.03% RSA and 78.82 mg GAE/100 g) and the lowest (13.67% RSA and 63.06 mg GAE/100 g) was shown by the control sample. Similar results have been obtained by Kaur, et al. [26,33]. This increase can be explained by the fact that flaxseed possesses a very powerful antioxidant system, being particularly rich in lignans, e.g., secoisolariciresinol diglucoside (SDG), which are also present in flaxseed oil. [63]. Besides

lignans, flaxseed contains high amounts of phenolic compounds, such as ferulic acid, syringic acid, cinnamic acid, vanillic acid, *p*-coumaric acid and gallic acid [64]. However, although flaxseed enriches the material basis for exerting its antioxidant activity, previous studies have observed differences in the quality characteristics of flaxseed varieties from different regions of the world, indicating some geographical and varietal specificity [64]. Deng et al. [64] reported that the total phenolic contents in studied flaxseed varieties ranged from 109.93 mg GAE/100 g to 246.88 mg GAE/100 g, and the DPPH values ranged from 32.56 mg TE/100 g to 46.22 mg TE/100 g. Even if the roasting process of flaxseeds could produce a slight decrease in the antioxidant activity, the baking process resulted in a significant increase in antioxidative activity due to the Maillard pigments recognized as having a high antioxidative capacity [59].

3.4. Mineral Content of Biscuits

The results of the evaluation of the mineral content of biscuits are displayed in Table 5. The addition of RFSF increased the P, K, Zn, Fe, Ca and Mg contents, meanwhile Cu and Mn could not be identified in the biscuit samples.

Table 5. The concentration of macro and microelements in biscuit samples.

Mineral Content (mg/100 g, fw)	Biscuit Samples *			
	B0	B10	B25	B40
P	27.83 ± 0.03 ^a	35.64 ± 0.39 ^b	43.20 ± 0.67 ^c	49.78 ± 0.03 ^d
K	240.46 ± 0.89 ^a	275.38 ± 0.76 ^b	313.08 ± 0.55 ^c	356.99 ± 0.99 ^d
Cu	N.D.	N.D.	N.D.	N.D.
Zn	0.71 ± 0.09 ^a	1.12 ± 0.03 ^b	1.54 ± 0.05 ^c	1.97 ± 0.02 ^d
Fe	1.40 ± 0.03 ^a	1.87 ± 0.05 ^b	2.27 ± 0.07 ^c	2.76 ± 0.11 ^d
Mn	N.D.	N.D.	N.D.	N.D.
Ca	164.46 ± 0.83 ^a	195.43 ± 0.79 ^b	223.05 ± 0.85 ^c	256.09 ± 0.533 ^d
Mg	41.36 ± 0.55 ^a	90.16 ± 0.59 ^b	141.47 ± 0.88 ^c	191.33 ± 0.39 ^d

* Values represent mean of three independent determinations ± SD; fw—fresh weight; Mean values followed by the same superscript alphabet in the row are not significantly different at $p < 0.05$ according to Duncan comparison test. N.D.—not determined.

The significant increase of minerals ($p < 0.05$) in biscuits could be justified by the rich minerals content of RFSF. A large body of literature highlighted that flaxseeds are a valuable source of minerals. For instance, Bernacchia et al. [65] showed that P, K, Ca, Mg flaxseed content reached values of 622, 831, 236 and 431 mg/100 g, respectively. Furthermore, Kaur et al. [57] mentioned that flaxseed is rich in Mg which is the second most abundant element in human body, as well as in K, which is the most common macro-mineral with positive effect in reduction of stroke incidence and blood platelets aggregation.

It is important to note that mineral content could vary between flaxseed cultivars and could be influenced by external factors such as soil conditions, fertilizers, water availability, climatic conditions and genetic factors [57].

3.5. Analysis of Volatile Compounds of Biscuit Samples

A total number of 21 volatile compounds were identified in the RFSF enriched biscuits, by means of ITEX/GC-MS technique as shown in Table 6. In all biscuit samples, the main volatile compound from the aldehydes group was hexanal, ranging from 14.76% to 18.39%, meanwhile β -myrcene and D-limonene were the main volatile compounds from terpenes and terpenoids group, ranging from 8.99% to 15.65% and 2.47% to 8.48%, respectively. Acetophenone was the major volatile compound from the ketones group with values between 2.50% to 10.98%, meanwhile, 4-methyloctane reached a final value of 6.92% in the B40 sample. The presence of 4-methyloctane could be justified by the addition of vanilla essence during the biscuit manufacturing [66]. The amount of D-limonene in RFSF increased linearly with increasing levels of RFSF in the final baked products. D-Limonene is responsible for odour perceptions like citrus and mint. Furthermore, flaxseed represent

a high source of carotenoids [67] which could be correlated with higher amounts of D-limonene, as reported by Chiş et al. [68]. From the terpenes and terpenoids group apart from D-limonene, β -myrcene enhanced the final odour perception through its balsamic, musty and spice perceptions.

Table 6. Volatile compounds content of the biscuits with roasted flaxseed flour.

Volatile Compounds	RT (Retention Time, min)	Biscuit Samples *				Aroma Characteristics **
		B0	B10	B25	B40	
Alcohols						
Phenol	15.65	1.83 ± 0.03 ^b	1.8 ± 0.02 ^b	1.13 ± 0.03 ^a	3.63 ± 0.04 ^c	Phenol
Aldehydes						
Hexanal	6.07	18.39 ± 0.05 ^c	14.76 ± 0.12 ^a	15.35 ± 0.22 ^a	16.36 ± 0.03 ^b	Grass, tallow, fat
Heptanal	11.926	0.63 ± 0.02 ^b	0.19 ± 0.02 ^a	0.98 ± 0.04 ^c	1.12 ± 0.07 ^c	Fat, citrus
Octanal	16.506	0.97 ± 0.03 ^a	0.87 ± 0.06 ^a	1.20 ± 0.05 ^b	1.46 ± 0.04 ^c	Lemon, green
Nonanal	19.74	5.13 ± 0.22 ^c	3.12 ± 0.11 ^b	1.69 ± 0.05 ^a	2.99 ± 0.03 ^b	Fat, citrus, green
Benzaldehyde	14.744	2.40 ± 0.03 ^a	5.08 ± 0.21 ^b	7.18 ± 0.33 ^c	8.82 ± 0.03 ^c	Almond, burnt sugar
Decanal	22.412	0.59 ± 0.04 ^b	0.45 ± 0.02 ^a	0.62 ± 0.03 ^b	0.90 ± 0.02 ^c	Orange peel, tallow
Ketones						
Heptan-2-one	11.167	0.89 ± 0.04 ^a	1.13 ± 0.02 ^a	3.82 ± 0.06 ^b	4.22 ± 0.08 ^b	Cheese, fruity, ketonic, green banana, with a creamy nuance
Acetophenone	18.524	2.50 ± 0.03 ^a	5.02 ± 0.02 ^b	8.69 ± 0.06 ^c	10.98 ± 0.02 ^d	Must, flower, almond
Nonan-2-one	19.341	1.59 ± 0.02 ^b	1.44 ± 0.03 ^b	0.53 ± 0.05 ^a	1.70 ± 0.04 ^b	Fruity, sweet, waxy, green herbaceous
Benzophenone	31.223	1.26 ± 0.04 ^c	0.72 ± 0.06 ^b	0.91 ± 0.03 ^b	0.44 ± 0.05 ^a	Balsamic
Terpenes and terpenoids						
β-Myrcene	15.951	8.99 ± 0.17 ^a	10.77 ± 0.23 ^a	12.79 ± 0.31 ^b	15.65 ± 0.22 ^c	Balsamic, must, spice
D-Limonene	17.323	2.47 ± 0.03 ^a	4.28 ± 0.04 ^b	6.14 ± 0.07 ^c	8.48 ± 0.03 ^d	Citrus, mint
Acids						
Benzoic acid	21.232	9.62 ± 0.02 ^c	5.91 ± 0.03 ^b	7.15 ± 0.07 ^b	3.02 ± 0.03 ^a	Balsamic
Dodecanoic acid	29.711	2.47 ± 0.03 ^a	4.28 ± 0.04 ^b	6.14 ± 0.07 ^c	8.48 ± 0.03 ^d	Mild fatty, coconut bay oil
Others						
Dimethyl disulfide	4.067	7.29 ± 0.05 ^b	6.67 ± 0.03 ^b	4.06 ± 0.12 ^a	4.27 ± 0.34 ^a	Sulfurous
2,4-Dimethylheptane	7.008	8.18 ± 0.22 ^c	6.86 ± 0.31 ^b	6.81 ± 0.02 ^b	3.16 ± 0.12 ^a	Alkane
4-Methyloctane	9.388	6.55 ± 0.12 ^b	6.05 ± 0.05 ^a	6.75 ± 0.03 ^{bc}	6.92 ± 0.02 ^c	Alkane
3,7-Dimethyldecane	18.213	8.79 ± 0.15 ^b	14.51 ± 0.21 ^c	5.27 ± 0.23 ^a	2.95 ± 0.08 ^a	Alkane
3,4-Dimethylundecane	18.388	2.60 ± 0.07 ^b	2.52 ± 0.09 ^b	1.20 ± 0.02 ^a	0.68 ± 0.03 ^a	Alkane
Ethyl 2,4-dioxohexanoate	16.369	0.94 ± 0.04 ^a	1.20 ± 0.03 ^{ab}	1.66 ± 0.05 ^b	N.D.	Apple peel, fruit

* Each value was the mean of triplicate measurements; N.D.—not detected. ** drawn from [46,47]. Note: ^{a-d} different superscripts in a row indicate significant difference within samples ($p < 0.05$) according to Duncan comparison test.

Acetophenone, from the ketone group, was previously pinpointed as a volatile compound with implication in the overall flavor of flour products which could be formed during Maillard reactions [69]. Its odour perception is pleasant, having musty, flowery and almond characteristics.

The increased amount of heptan-2-one from the ketone group with increasing yield of RFSF could be explained by the chemical composition of flaxseed, rich in tocopherol and ascorbic acid [65]. In this line, Starowicz et al. [70] showed that tocopherol and ascorbic acid significantly increased the peak area of heptan-2-one.

Furthermore, a recent study of Hidalgo and Zamora [71] highlighted that benzaldehyde could be formed through chemical reactions such as lipid oxidation. The reaction involved in the first step is a carbonyl-amine reaction followed by a free radical amino-acid degradation, mainly phenylalanine. It was previously shown that flaxseed is a rich source of 6 essential amino-acids, from which phenylalanine amount could vary in the range from 1.44 mg/100 g up to 66.6 mg/100 g, depending on the flaxseed cultivars [57]. Therefore, the

significant differences ($p < 0.05$) between benzaldehyde sample amounts, could be justified by the chemical composition of flaxseed and by lipid oxidation.

It is worth nothing that non-enzymatic Maillard reactions such as the Strecker degradation process could lead to the formation of aldehydes as a result of the reaction of aminoacids with dehydroreductones [54].

Overall, the increased RFSF percentages during biscuits manufacturing, led to significant differences ($p < 0.05$) between aroma volatile compounds, mainly due to the rich chemical composition in lipids, protein, aminoacids, phenols and chemical reactions such as Maillard and lipid oxidation.

3.6. Physical Characteristics of the Biscuits

The evaluation results of the physical characteristics of the biscuits indicate that there was a significant difference ($p < 0.05$) between the control sample and B40 in thickness, diameter and spread factor (Table 7). However, there was no significant difference in the weight of any type of biscuit although it was lower than the control biscuits.

Table 7. Physical characteristics of biscuits.

Biscuits Samples	Physical Parameters *			
	Weight (g)	Thickness (cm)	Diameter (cm)	Spread Factor
B0	12.9 ± 1.09 ^a	0.75 ± 0.30 ^a	5.93 ± 1.20 ^a	7.90 ± 1.90 ^c
B10	12.8 ± 1.10 ^a	0.79 ± 1.00 ^{ab}	6.08 ± 1.04 ^b	7.70 ± 1.50 ^{bc}
B25	12.7 ± 1.40 ^a	0.83 ± 0.50 ^b	6.17 ± 1.09 ^{bc}	7.43 ± 2.10 ^b
B40	12.6 ± 1.25 ^a	0.89 ± 0.90 ^c	6.26 ± 1.30 ^c	7.03 ± 2.90 ^a

* Values represent mean of three independent determinations ± SD. Mean values followed by the same superscript alphabet in the column are not significantly different at $p < 0.05$ according to Duncan comparison test.

The diameter and thickness of biscuit samples (B10, B25 and B40) increased slightly with increasing substitution percentage of RFSF compared with control biscuit (B0). Sample B40 presented the maximum diameter and thickness (6.26 and 0.89 cm). The spread factor is the ratio that depends on the values of the thickness and diameter of the cookies and it is used to determine the quality of flour for producing cookies [26]. The results of the spread ratio of biscuits revealed a significant reduction ($p < 0.05$) in spread ratio from 7.90 to 7.03 cm for B40. With the increase in the concentration of RFSF, the spread factor of biscuits gradually decreased. These results are in the line with the findings of other authors [16,32] who stated that proteins and dietary fibers have more water-binding power. Ganorkar and Jain [16], argue that the presence of more water in the dough, leads to higher dissolution of sugar during mixing and this lowers the initial dough viscosity and the cookie is able to spread at a faster rate during cooking. Moreover, in the opinion of the same authors, an inverse correlation is obtained when the flour components absorb large quantities of water and, as a consequence, reduce the amount of water that is available to dissolve the sugars in the formula. Therefore, the initial viscosity is higher and the biscuits spread less during baking.

3.7. Instrumental Analysis of Texture

The results of the instrumental analysis of texture are presented in Table 8. Instrumental analysis of hardness showed statistically significant differences ($p < 0.05$) between control (B0) and B40. Hardness decreased as the amount of RFSF increased, mean values of 10,655 g (control sample) and 5714 g (B40), respectively. Similar patterns were noticed for the load required to reach the hardness work value. The values of hardness work (mJ) decreased with increasing RFSF from 262.73 mJ to 122.30 mJ. These results are similar to those obtained by Ganorkar and Jain [16] and Omran et al. [32] who reported that the textural parameters were found to decrease with increasing flaxseed flour incorporation. This might be due to an increase in dietary fiber and protein, high water absorbing capacity components as well as due to the high level of fat (42.50%) found in RFSF. These factors

contributed to a sticky dough which reduced the extensibility of dough. Previous studies claim that with an increase in fat content, the gluten network gets interrupted thus the physical properties of biscuits are changed and become less hard. At very high fat content the lubricating function is high and a soft texture is obtained. Hence the hardness gradually decreases forming softer biscuits with an increased level of flaxseed flour [16,32,72].

Table 8. Instrumental analysis of texture.

Sample	B0	B10	B25	B40
Hardness cycle 1 (g)	10,655 ± 21 ^d	8801 ± 80 ^c	7136 ± 69 ^b	5714 ± 34 ^a
Hardness Work cycle 1 (mJ)	262.73 ± 34.22 ^d	200.05 ± 11.33 ^c	150.8 ± 35.10 ^b	122.30 ± 25.82 ^a

Values represent mean of three independent determinations ± SD. Mean values followed by the same superscript alphabet in the row are not significantly different at $p < 0.05$ according to Duncan comparison test.

3.8. Sensory Analysis

Before a product becomes commercially available, many tests are conducted with consumers to evaluate the product acceptability. Nowadays, consumers are more health conscious than before and functional foods have an ascending trend on the market. This context brings new challenges upon sensory analysis, transforming it into a more proactive role in producing unique, innovative and functional products. Austria et al. [73] hypothesised that foods that contain significant quantities of flaxseed will be well tolerated by the public.

The mean of hedonic scores and their standard deviation are presented in Table 9. The control sample scored the highest for appearance, hardness, chewiness and aftertaste.

Table 9. Sensory evaluation of the biscuits.

Sample	Appearance	Hardness	Crispiness	Chewiness	Taste and Aroma	Aftertaste	Overall Appreciation
B0	5.83 ± 1.34 ^c	3.58 ± 1.07 ^b	5.38 ± 1.48 ^a	6.15 ± 1.32 ^b	5.77 ± 0.83 ^a	5.02 ± 1.79 ^c	6.88 ± 1.15 ^{ab}
B10	5.62 ± 1.39 ^c	2.37 ± 0.84 ^a	6.79 ± 1.75 ^b	5.33 ± 1.46 ^a	6.10 ± 0.72 ^b	4.42 ± 1.35 ^b	6.92 ± 1.20 ^{ab}
B25	4.94 ± 1.38 ^b	2.88 ± 0.92 ^{ab}	6.56 ± 1.64 ^b	5.50 ± 1.42 ^a	6.42 ± 1.05 ^c	4.23 ± 1.65 ^b	6.75 ± 1.37 ^a
B40	4.35 ± 1.69 ^a	2.65 ± 1.25 ^a	7.12 ± 1.96 ^c	5.40 ± 1.65 ^a	6.87 ± 1.47 ^d	3.90 ± 2.04 ^a	6.94 ± 1.49 ^b

Values represent hedonic scores calculated as mean ± SD ($n = 52$). Mean values followed by the same superscript alphabet in the column are not significantly different at $p < 0.05$ according to Duncan comparison test.

For the attribute of appearance no significant difference was encountered between the control sample and the B10. However, all tested samples which contained flaxseed flour (B10, B25 and B40) scored progressively lower than the control (B0). This can be explained by the fact that evaluators were able to visually discriminate the samples solely based on their color and degree of irregularities which could be seen on the surface of the biscuit. The decrease of the hedonic appearance values may be due to the progressive decrease amount of moisture and total carbohydrates in the biscuit samples ($B0 > B10 > B25 > B40$) as can be seen in Table 4) which caused the depreciation of biscuits' surface and darker color during baking. There was a positive correlation between appearance and moisture ($0.97, p < 0.05$), and between appearance and total carbohydrates ($0.99, p < 0.05$). Moreover, the appearance negatively correlated with ash ($-0.99, p < 0.05$), fat ($-0.99, p < 0.05$) and crude fiber ($-0.98, p < 0.05$). The decrease of appearance perception with the increase of the flaxseed content was also recorded previously in studies performed on biscuits [29,32,74] as well as on other bakery products, like cookies [19,75] muffins [76,77] and bread [13].

The texture plays a key role in assessing consumers' acceptance of a food product. The complex changes of the texture during the process of eating (mouth behaviour) can influence the acceptance or rejection of the product. Although most of the times it is

unconscious, the consumer's preference toward a product is often due to the texture. The biscuits were evaluated by three different textural attributes: hardness, crispiness and chewiness. Each attribute was clearly explained to the participants and a brief description of them was inserted in the evaluation sheet next to the hedonic scale as stated in the method section. The participants were instructed to evaluate the crispiness as the force and noise created when the sample breaks during chewing the sample between the molar teeth. It was noted that the biscuits with higher amount of RFSF presented lower amount of moisture (Table 4). Negative correlation ($p < 0.05$) was found between the consumer's perception of crispiness and the amount of moisture and total carbohydrates of the biscuits (-0.85 and -0.82 , respectively). Similar findings were published by Hussain et al. [19] and Marpalle et al. [13]. This result can be explained by flaxseed's capacity to bind water, which influences the textural properties of the final product [76].

Taste and aroma improved with the increasing amount of the flaxseed in the biscuits. The flaxseed has a unique nutty flavour (Tables 3 and 7) which was found pleasant by the consumers, therefore the taste and aroma characteristics of samples with RFSF scored higher than the control ($B0 > B10 > B25 > B40$). Moreover, the taste and aroma of the samples was positively correlated with the biscuits' content in protein (0.99 , $p < 0.005$), ash (0.99 , $p < 0.005$), fat (0.99 , $p < 0.005$) and crude fiber (0.99 , $p < 0.001$) and negatively correlated with moisture (-0.99 , $p < 0.005$) and total carbohydrates (-0.99 , $p < 0.01$). Some authors mention a bitter taste in samples prepared with high amounts of flaxseed flour [78]. However, in this study, the nutty flavour was appreciated by the consumers which are accustomed to the taste and flavor of different types of traditional biscuits and cookies prepared with various amounts of nuts.

The aftertaste correlated negatively with the biscuit's content in protein (-0.97 , $p < 0.05$), ash (-0.95 , $p < 0.05$), fat (-0.96 , $p < 0.05$) and crude fiber (-0.95 , $p < 0.05$) and correlated positively with moisture (0.97 , $p < 0.05$) and total carbohydrates (0.96 , $p < 0.05$).

Although the sensory attributes of the samples with RFSF were decreased compared to the control, the aroma and crispiness increased and the significant differences between samples in appearance, hardness, chewiness and aftertaste did not reflect on the overall appreciation of the biscuits.

4. Conclusions

The results of this study reveal the effect of roasted flaxseed flour addition on the physico-chemical parameters, volatile profile, and sensory acceptability of biscuits. The high incorporation of RFSF advantageously influenced the nutritional properties of biscuits as evidenced by significant increases in the fibre contents (about 6.7-fold higher than in control biscuits), proteins and minerals. Furthermore, the addition of RFSF increased the total phenolic content and radical scavenging activity amount, reaching final values for biscuits manufactured with 40% RFSF such as 78.82 mg GAE/100 g and 32.03%, respectively. With respect to the volatile profile of biscuits, the addition of RFSF leads to the formation of aroma compounds such as hexanal, β -myrcene, D-limonene, acetophenone and 4-methyloctane, having odor perceptions such as grass, balsamic, must, citrus mint and alkane. Sensory evaluation indicated that the overall biscuits appreciation was not affected in a significant way ($p < 0.05$) by RFSF addition, meanwhile the aftertaste intensity decreased. Considering the nutritional, textural and sensorial analysis of the final baked goods, we can conclude that 25% RFSF could be successfully used in biscuit manufacturing.

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