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Rheological, Textural, and Sensorial Characterization of Walnut Butter

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Abstract: The rheological properties of six formulated walnut semi-solid pastes with 0.5, 1.5, and 2.0% *w*/*w* xanthan gum, maple syrup, and Jerusalem artichoke powder were characterized using the Mars 40 rheometer (Thermo Haake, Karlsruhe, Germany). The butter samples' textural behavior and color parameters (CIE L*, a*, and b*) were analyzed. Sensory evaluation and consumer acceptance were also analyzed. Walnut kernels were roasted at an optimized temperature (120 °C) and time (30 min) and subsequently made into walnut butter (WB). Maple syrup has an appreciable influence on the rheological properties of walnut butter. The prepared butter exhibited non-Newtonian shear thinning behavior and showed excellent stability. The results showed that sample S3 (3% maple syrup and 2% xanthan gum) had a bright color with the highest L* values (47.31 ± 0.32), the lowest a* values (2.72 ± 0.04) and the highest b* values (20.54 ± 0.08). In comparison, sample S6 (5% Jerusalem artichoke powder and 2.0% xanthan gum) had a darker color, with the following mean values obtained: 44.67 ± 0.05 for L*, 6.70 ± 0.09 for a* and 18.34 ± 0.07 for b*. The addition of maple syrup even in combination with xanthan gum (2%) S3 to the walnut butter led to a decrease in the viscosity of the butter samples. The hardness and firmness of the walnut butter samples were affected by the type of sweetener used; thus, the nut butter with xanthan gum and Jerusalem artichoke powder had significantly higher hardness values than the samples with added maple syrup. Therefore, based on consumer preferences, we obtained new formulations of walnut butter with a high sensory quality, suitable for those with allergies to peanut butter.

Keywords: consumer; rheology; texture; walnuts butter; xanthan gum

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1. Introduction

Today, consumer awareness of unhealthy eating habits, especially the lack of natural foods, or the consumption of foods rich in saturated fats, food additives, salt, and/or sugars is observed in most societies [1]. In recent years, herbal-based butter (nut and seed butter) has been widely consumed by people around the world. Peanut butter is the most widely consumed plant-based butter [2,3], but countless varieties of butter have been developed (soybean butter, almond butter, pistachio butter, cashew butter, sunflower seed butter, pumpkin seed butter, and sesame butter, etc.) from various types of nuts and seeds, which are a good source of protein, fiber, essential fatty acids and other nutrients [4]. The development of new walnut spreads could make a significant contribution to the daily diet and present a healthier snack to consumers as they become more interested in the health, taste, and quality of food ingredients. Undoubtedly, the interest in healthy foods that meet the nutritional requirements of consumers has also brought awareness of the need for new functional products on the market.

Walnut (*Juglans regia* L.) is one of the main nut crops in the world, which grows in large areas in northern Bukovina (Suceava Romania). Walnuts have been harvested since prehistoric times [5], and are an important part of regular diet; the use of walnuts in bakeries and pastries is a part of cultural identity [6,7]. The use of walnuts, as an important part of our daily food, has its roots in food traditions [6]. Walnuts can be eaten raw, fried, and salted, added to dairy products, or can be sprinkled on salads, and desserts, especially walnut ice cream. Walnut desserts have been appreciated for thousands of years. One of the widespread applications of walnuts is their use in the confectionery industry by adding them to biscuits, cakes, and desserts.

Walnuts are rich sources of polyunsaturated lipids (a perfect balance of polyunsaturated fatty acids (PUFA) n-6:n-3 (4:1)), proteins, dietary fiber, carbohydrates, minerals, especially potassium, magnesium, calcium, and other micronutrients; therefore, they are ingredients in different diets recommended for the prevention of aging and age-related diseases [7–9]. Nowadays, walnuts are one of the most important sources of polyphenols; the main polyphenol in nuts is pedunculagin, an ellagitannins. Ellagitannins possess antioxidant and anti-inflammatory bioactivity with a role against the onset of disease, including cancer, cardiovascular and neurodegenerative diseases [10]. Walnuts roasted with hot air to improve the sensory properties, develop the characteristic taste and aromas as well as improve the texture, have become popular snacks, and are a valuable raw material in the food industry [11]. For example, studies have revealed that the optimum roasting conditions for walnuts are 130–150 °C for 15–20 min [12], or in other research taking into account the variations of the nutritional qualities, the heat drying of 105 °C was recommended as an optimal process for walnut drying, in which protein, soluble sugar, carbohydrate, and minerals showed the highest values [13]. Walnuts can be used as spreadable pasta by people who suffer from peanut allergy. Walnut-based pasta is obtained by roasting and grinding the kernels.

Walnut butter is one of the best alternatives to milk butter; it is one of the most sustainable foods; and it is environmentally friendly, with health-promoting effects; therefore, many studies have reported its role in preventing many diseases, such as diabetes 2 [14,15], hypercholesterolemia [14], obesity [16] and coronary heart disease [17]. The effects of different levels of emulsifying agents (mono-diglyceride and lecithin at 0, 0.5, and 1.5% *w*/*w* levels) on the rheological texture homogeneity (GLCMs and fractal dimension) and stability of walnut butter have been studied by Shahidi-Noghabi et al. [18]. They found that the oil droplet's size of butter decreased considerably by adding an emulsifier, which was more considerable in 1.5% lecithin. Walnuts are an important food in the vegetarian diet, due to their digestible proteins and low lysine/arginine ratio, and numerous studies state that most of the necessary amino acids could be provided when nuts are eaten with legumes [19]. Previously published reports on the rheological properties of soy-butter [20], low-calorie pistachio butter [21], sesame butter [22], peanut butter [23] has been the subject of various studies primarily directed to improve its rheological and textural properties. The effects of microwave processing conditions at different roasting powers (400 W, 800 W, and 1200 W) and times (4, 4.5, 5, and 5.5 min) have already been described for peanut butter produced from four peanut cultivars, compared to those of commercial peanut butter (CPB). Peanut butter color showed the lowest brightness L* value and the highest a* values compared to the CPB [24].

Inulin, a polymer of fructose, is widely used in functional foods. The so-called prebiotic agent or undigested food supplement, and artichoke tuber contains a large amount of inulin, approx. 20%, 2% protein, a low-fat content, and significant amounts of mineral salts [25]. According to Ropciuc et al. [26], using Jerusalem artichoke as a sweetener increases the fiber content of the products and has various health benefits.

Maple syrup is a natural vegetable product that is consumed worldwide and is made entirely from tree sap. It is a natural sweetener, contains approximately 67% solids, mostly sugars, but is also rich in minerals, amino and organic acids, and a phenolic substance produced by concentrating colorless aqueous sap (*Xilem* sap) collected from certain maple species (genus *Acer*) [27].

Products that contain at least 90% nut/seed ingredients are classified as a herbal butter (nuts/seeds), and spreads refer to a spread that has at least 40% nut ingredients that can be added in different forms [4].

The current demand for natural products requires continuous development by small producers who process walnut in various forms, including kernels, for cakes or to be added to breakfast cereals, or to produce oil by cold pressing for dressings and salads.

The present study had the following three main objectives: (1) to obtain a healthy and appreciated product, (2) to obtain information about consumer perceptions of walnut butter, and (3) to identify the main constraints in purchasing walnut butter in the North-East Region of Romania taking into account the consumers' interest in different natural products.

Therefore, the present study was conducted to determine the stability and acceptability of walnut butter as well as the factors that influence the choice to consume this category of products. In this paper, the effect of different levels of Xanthan gum (at 0, 0.5, and 1.5, 2% *w*/*w* levels) and different edulcorants (Jerusalem artichoke powder and maple syrup) concentrations on the rheological, textural, and color attributes, and stability of walnut butter were studied.

2. Materials and Methods

2.1. Plant Material and Sample Preparation

Walnut kernels were obtained from walnuts harvested in Suceava plateau, Northeast Romania, in the fall of 2020. Walnuts were cracked and shelled manually, and raw walnut kernels were dried at 75 °C for 45 min in an air oven (Gorenje, electric, Bucharest Romania); they were then roasted at 120 °C for 30 min [18].

Jerusalem artichoke tubers were harvested at optimal ripeness at the end of October 2020, in Suceava County, Romania. Jerusalem artichoke tubers were cleaned, washed with tap water to eliminate soil, and then were longitudinally sliced and dried at 60 °C for 10 h in a dehydrator (Gorenje, electric). The tubers were ground and sieved through an 850 µm sieve; the obtained powder, with approximately 5.43% moisture content, was stored for a short period of time in an ambient atmosphere in desiccators until use.

Maple syrup used for walnut butter preparation was purchased from a specialized store. Eight samples of butter with different concentrations of xanthan gum and sweeteners (Table 1) were prepared, as shown in Figure 1.

Table 1. The content of components used in walnut butter mix.

Samples	Maple Syrup, mL %	Jerusalem Artichoke Powder, g %	Xanthan Gum %
M1	3	0	0
S1	3	0	0.5
S2	3	0	1.5
S3	3	0	2
M2	0	5	0
S4	0	5	0.5
S5	0	5	1.5
S6	0	5	2

The amount of walnuts used for each butter sample was constant (50 g of walnut kernels). Walnuts and the other ingredients were mixed with a laboratory blender at a speed of 20,000 rpm for 1 min to form walnut butter. Control samples consisted of walnut butter without xanthan gum and Jerusalem artichoke powder (M1) and M2 butter without xanthan gum and maple syrup.

2.2. Methods

The nutritional composition (moisture, protein, fat, ash) of walnut kernels was analyzed using standard Association of Official Analytical Chemists (AOAC) procedures [28]. Protein content was calculated by multiplying the nitrogen content by 6.25.

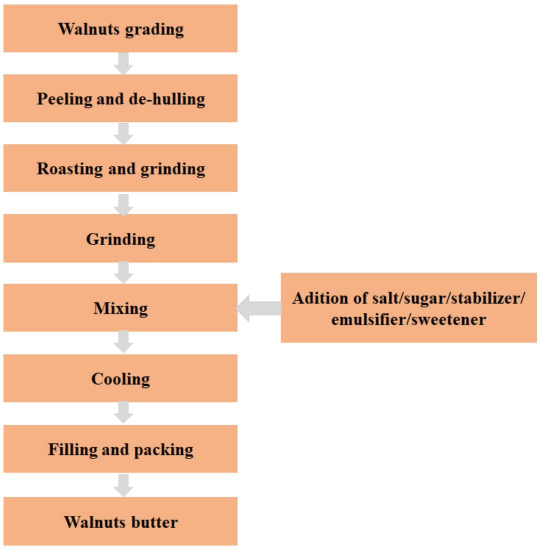


Figure 1. Flow diagram of walnuts butter production.

The carbohydrate content was calculated according to the difference, by applying Equation (1) [28]:

$$\text{Carbohydrates (\%)} = 100 - (\text{protein} + \text{fat} + \text{ash} + \text{moisture}), \quad (1)$$

2.2.1. Rheological Analysis of Walnuts Butter

The dynamic rheometer, model Haake Mars 40, was used for the determination of walnut butter viscosity. Viscosity as a function of time (10 min) at a constant shear rate of 100 s^{-1} and a frequency of 1–100 Hz and graphical representations of viscosity curves were determined using Haake Rheo Win Data Manager 4 Software for Haake Mars 40 Rheometer (Thermo Fisher Scientific, Karlsruhe, Germany).

2.2.2. Walnuts Butter Texture Profile Analysis

The Perten TVT 6700 texturometer (Perten Instruments, Hägersten, Sweden) was used to determine the texture. A 20 mm ball was formed from the analysis samples, which was placed on the determination table after the device had been calibrated.

The probe that measures the texture characteristics of the sample has a descent speed of 1.2 mm/s and penetrates the sample to a depth of 7 mm. After compression, the probe returns to the starting point with a retraction speed of 1 mm/s.

A double compression rate was applied to butter balls of 20 g weight, at 50% height, a speed of 2.0 mm/s and a trigger force of 20 g, and a recovery period between compressions of 12 s was applies. Firmness, adhesiveness, and hardness were analyzed in triplicate [29].

2.2.3. Color Measurement

The surface color of the individual products was determined according to Leahu et al. [30] with slight modifications, using a hand-held colorimeter (Minolta Chroma Meter CR-200, Tokyo, Japan) calibrated with a white tile. The results were expressed using the CIELAB-system (L*, a*, and b*) color space parameters. For each batch of walnut butter, three samples were taken with two readings each.

2.2.4. Sensory Evaluation

An untrained group of 47 consumers (20–45 years), young adult students, and university staff volunteers (who regularly consume peanuts and nut kernel) selected at the university campus (Suceava Romania) were trained on how to perform sensory evaluation [31], and assessed the butter samples using a defined sensory language (taste, flavor, texture, color, odor, spreadability (least spreadable to most spreadable)) and overall acceptability on a 9-point hedonic scale, where 9 was extremely like and 1 extremely dislike, to understand consumer acceptance of butter-based plants [32]. Different studies used a varied number of evaluators to perform the sensory analysis. For example, Rognlien et al. [33] investigated the effects of different oils (butter, fish, and oxidized fish) on the sensory characteristics of a savory low-fat yogurt and they only used 31 untrained panelists in the preliminary study, while 41 untrained panelists evaluated a new product (cream cheese with Chia seeds) [34]. Fifty untrained panelists assessed the coded cashew spread samples from a sensory point of view, according to Amevor et al. [35]. A panel of 40 untrained individuals were trained by Kim et al. [31] to test a new food product (yogurt). The sensory characteristics of new vegetable ice creams were evaluated by 30 panelist members [36]. Additionally, there are studies which state that there is a possibility that the results obtained using trained and untrained evaluators do not differ much or even at all. For example, Lelièvre et al. [37] stated that trained and untrained assessors (group A consisted of 19 assessors and group B consisted of 18 assessors) categorized nine commercial beers in the same way.

2.2.5. Consumers Questionnaire

A structured questionnaire (in Romanian) was developed to investigate the market acceptability of a new variety of vegetable butter. It was uploaded to an online platform [38] and shared on various groups and social networks. Overall, 170 responses were recorded. The questionnaire included basic questions regarding personal data (sex, age, etc.), and the following questions: *Do you eat peanut butter? How often do you eat peanut butter? What other types of butter do you prefer? Would you prefer a new range of butter to the market? Would you be tempted to eat nut butter? What qualities would you like nut butter to have? How much would you be willing to pay for 250 g of nut butter?* The questions were selected based on other studies [39,40] and the questionnaire will be developed further in future studies.

2.2.6. Statistical Analysis

The obtained data were analyzed using Minitab 17 statistical software (Minitab, LLC, State College, Pennsylvania, USA). Data were reported as means ± standard deviation. An analysis of variance (ANOVA) with a 95% confidence interval ($p < 0.05$) with Tukey's test was used to compare the results obtained for textural characteristics, color parameters, and sensory quality attributes. Pearson correlations between parameters were determined.

3. Results

Walnut butter is made from roasted and ground walnuts with the addition of sweetener, and to improve the texture and consistency, xanthan gum was added in various quantities.

3.1. Proximate Analysis

The composition of the walnut kernels is shown in Table 2. According to Table 2, the moisture content of the walnut kernels was 3.98%. Previous research states that the values obtained from walnut kernel in nine areas of Suceava County varied between 3.77 and 4.58% [7]. The ash content of walnut kernels used to make butter was 1.8 g/100 g. The walnut kernels have a protein content of 13.81 g/100 g; conversely, Jaćimović et al. [41] reported a protein content of between 13.91 and 19.04% from walnut varieties in Montenegro [41].

Previous studies have illustrated that, depending on the variety, for four different walnut cultivars originating from China, the kernel protein content is from 14.08 to 19.23%, the kernel fat content is from 64.33 to 72.10% and moisture content ranges from 3.08 to 4.08% [42]. Iordănescu et al. [43] state that walnut kernel contains 52.0–77.5% fats, 11.0–25.0% proteins and 5.0–24.0% carbohydrates. Patraş and Dorobanţu [44] determined the chemical composition of walnut kernel from North East Romania and obtained an average of 3.93 ± 0.40% moisture, 62.12 ± 3.87 oil content and a protein content of 16.42 ± 1.36%.

The values presented in this study (Table 2) fall within the values presented in previous studies [42–44].

Table 2. Proximate analysis of walnut kernels used in this study.

Parameter	Content
Moisture %	3.98 ± 0.15
Ash %	1.80 ± 0.02
Crude Protein %	13.81 ± 0.40
Total oil %	60.07 ± 0.42
Carbohydrate content (CHO) %	20.34 ± 0.9
Total phenols mg GAE/kg D.W	19.26 ± 0.08

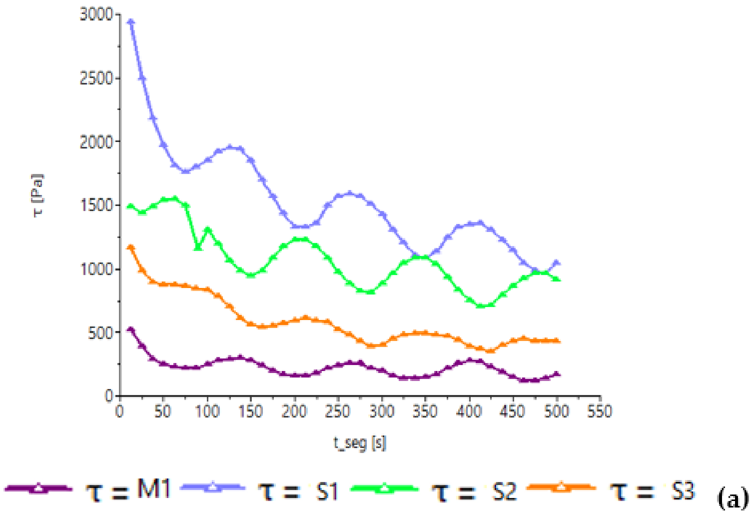
3.2. Rheological Parameters

The rheological properties of the two types of walnut butter were studied. Both types are concentrated suspensions and differ depending on the type of sweetener used and the amount of emulsifier used. The first type of walnut butter is a stabilized suspension consisting of solid walnut particles in maple syrup (non-Newtonian fluid), and the second type of walnut butter is an unstabilized suspension consisting of walnut particles and Jerusalem artichoke powder. The emulsifier (xanthan gum) is used as a gelling agent and stabilizer and the modification of the rheological characteristics is essential for the modification of the sensory properties of the food [45]. Xanthan gum is mainly effective due to its ability to be absorbed by various interferences. Figure 2 shows the data of the flow curves obtained for shearing the walnut butter samples from 0 to 500 s^{-1}. It is possible to observe a decrease in shear stress from M1 to S3, suggesting a decrease in shear stress with a gradual increase in the proportion of xanthan gum cow in the formulation. However, all the analyzed samples showed a similar behavior of thinning by shearing (pseudoplastic), in which a decrease in viscosity with the shear rate is observed. Adding maple syrup to walnut butter reduces the viscosity of the butter and the stress of production. Its use as a sweetener in walnut butter made it more mobile and led to greater liquidity. In the case of walnut butter with Jerusalem artichoke powder, the highest viscosity was registered for S6, which is the sample with 2% xanthan gum as a stabilizer (Figure 2b). It is observed that as the emulsifier (xanthan gum) concentration increased, there was no significant difference between the samples. Lissajous curves were obtained, sinusoidal in shape, with increases and decreases in viscosity due to the fact that no oil was added to the walnut butter in addition to the oils present in the walnut kernel.

According to Agrahar-Murugkar, et al. [20], the shear thinning behavior is usually associated with the presence of any structure that was totally or partially broken down with an increasing shear rate [20]. The thinning behavior of shear was also observed by Shahidi Noghabi et al. [18] who studied the effect of different levels (0, 0.5, and 1.5%) of emulsifying agents (mono-diglycerides and lecithin) on the rheological properties of walnut butter. It was previously reported that the presence of high-molecular-weight substances, nut proteins, and polysaccharides is also responsible for their high shear-thinning behavior [18].

3.3. Texture Profile Analysis

The soft texture is the most important characteristic of walnut butter. Walnuts are rich sources of polyunsaturated lipids, and studies show that a higher ratio of saturated fatty acids contributes to the hardness and poor spreadability of butter at refrigeration temperature [46]. The textural attributes of formulated walnut butter were investigated with a texturometer (Perten instruments TVT 6700) and are presented in Table 3. According to the results of textural attributes, the lowest hardness values were obtained for the formula containing only 5% Jerusalem artichoke powder (Table 3).



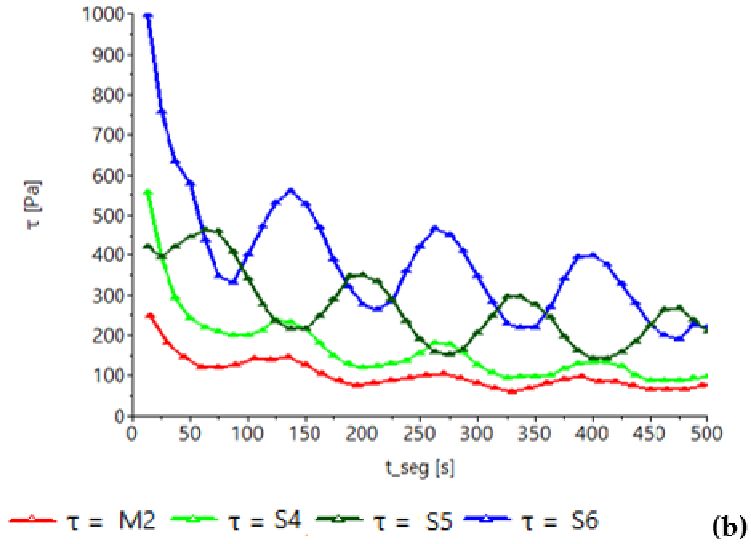


Figure 2. Steady-state flow curves of the walnut butter formulations. (**a**) M1: 3% maple syrup; S1: 3% maple syrup and 0.5% xanthan gum; S2: 3% maple syrup and 1.5% xanthan gum; S3: 3% maple syrup and 2.0% xanthan gum; (**b**) M2: 5% Jerusalem artichoke powder; S4: 5% Jerusalem artichoke powder and 0.5% xanthan gum; S5: 5% Jerusalem artichoke powder and 1.5% xanthan gum; S6: 5% Jerusalem artichoke powder and 2.0% xanthan gum.

Table 3. Textural characteristics of walnuts butter samples.

Samples [1]	Hardness (N)	Firmness	Adhesiveness (J)
M1	575.08 ± 0.42 [a]	−0.02 ± 0.06 [b]	−134.27 ± 0.03 [g]
S1	355.75 ± 0.44 [c]	0.03 ± 0.63 [a]	−39.48 ± 0.01 [c]
S2	352.00 ± 0.01 [d]	−0.01 ± 0.07 [b]	−68.36 ± 0.03 [e]
S3	340.51 ± 0.54 [f]	0.04 ± 0.58 [a]	−31.67 ± 0.04 [a]
M2	261.03 ± 0.49 [h]	−0.04 ± 0.48 [b]	−69.64 ± 0.34 [f]
S4	284.43 ± 0.72 [g]	0.03 ± 0.34 [a]	−37.42 ± 0.06 [b]
S5	346.40 ± 0.64 [e]	0.03 ± 0.95 [a]	−38.11 ± 0.93 [b]
S6	469.38 ± 0.38 [b]	0.02 ± 0.79 [a]	−61.51 ± 0.04 [d]

[1] Means with the same letter within a column are not significantly different at $p < 0.05$.

The hardness and firmness of the nut butter samples were affected by the type of sweetener used. Control M1, walnut butter without xanthan gum and Jerusalem artichoke powder, had significantly greater hardness values than walnut butter with maple syrup, S1–S3, (Table 3). The walnut butter samples' adhesiveness or the amount of work needed to overcome the attractive forces between the butter's surface and the probe ranged from −134.27 ± 0.03 J to −31.67 ± 0.04 J. These results are similar to those of Abd-Elsattar and Abdel-Haleem [47], who found that fried and cooked soybean butter was significantly harder and more adhesive than commercial peanut butter.

3.4. Color Changes

In general, the perception and selection of food is a multifactorial process, and color has a major role in the acceptance or rejection of food [48]. Changes in color were assessed using the CIELab methodology (L*a*b*); CIELAB parameters are currently the most used and recommended to evaluate color in the food industry [49].

CIELab results obtained for all samples are presented in Table 4.

Table 4. Color parameters of walnut butter samples.

Samples [1]	L*	a*	b*
M1	42.49 ± 0.32^{e}	2.78 ± 0.02^{d}	17.68 ± 0.23^{e}
S1	43.56 ± 0.18^{d}	2.74 ± 0.04^{d}	18.70 ± 0.28^{c}
S2	45.85 ± 0.17^{b}	3.17 ± 0.04^{c}	19.49 ± 0.14^{b}
S3	47.31 ± 0.32^{a}	2.72 ± 0.04^{d}	20.54 ± 0.08^{a}
M2	42.68 ± 0.25^{e}	6.42 ± 0.05^{b}	17.24 ± 0.11^{e}
S4	43.61 ± 0.08^{d}	6.76 ± 0.08^{a}	18.21 ± 0.04^{d}
S5	44.15 ± 0.12^{cd}	6.49 ± 0.07^{b}	17.48 ± 0.07^{e}
S6	44.67 ± 0.05^{c}	6.70 ± 0.09^{a}	18.34 ± 0.07^{cd}

[1] Means with the same letter within a column are not significantly different at $p < 0.05$.

The value of L* (whiteness) in the control samples (42.49 ± 0.32 and 42.68 ± 0.25), as expected, was lower, showing less clarity compared to the samples sweetened with maple syrup and the addition of 2% xanthan gum, S3 (47.31 ± 0.32) and with the Jerusalem artichoke powder S6 (44.67 ± 0.05). The positive values of a* (redness/greenness) and b* (yellowness/blueness) and the overall result of an increase in the values of a* and b* indicate a change in the color of the walnut butter samples from pale yellow to yellow-brown; additionally, the color parameter (b*) showed positive values. For example, the highest value was registered for sample S3 (20.54 ± 0.08), as shown in Table 4.

3.5. Sensory Quality Attributes of Walnuts Butter Samples

In general, color and flavor are the most important attributes for consumer acceptance of butter. It was observed that the color scores of the butter samples were not within the acceptable range.

The sensory acceptability of two types of walnut butter with different concentrations of xanthan gum (0.5, 1.5, 3%) (Figure 3) is shown in Figure 4.

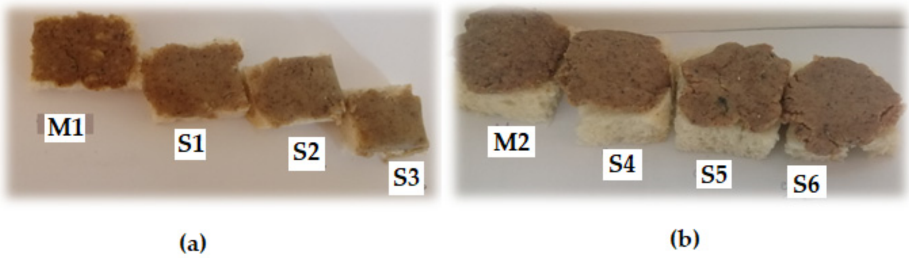


Figure 3. Slices of bread with walnut butter: (**a**) 3% maple syrup and different levels of xanthan gum (0.5, 1.5, 3%); (**b**) 5% Jerusalem artichoke powder and different levels of xanthan gum (0.5, 1.5, 3%).

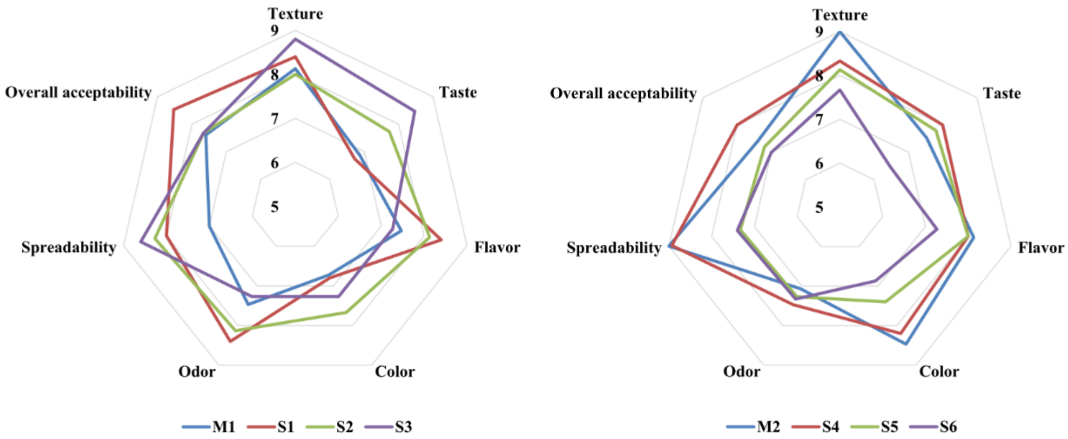


Figure 4. Sensory acceptability of walnuts butter samples.

Overall, the walnut butter with maple syrup had the highest overall texture scores (almost very pleasant), the texture was appreciated as fine and creamy and had an average of 8.13 ± 0.04 for M1 and 8.80 ± 0.10 for S3, and the sensory attribute least appreciated by tasters was the color, with the lowest average of 6.73 ± 0.02 for the M1 test. The taste has received an average score of between 6.87 ± 0.04 and 8.47 ± 0.02; the average increased with the addition of a stabilizer, and the general appearance of this type of walnut butter is 7.67 ± 0.10 for the one that contains a 2% stabilizer. The overall acceptability of the new walnut butter assortment is between 7.67 ± 0.10 and 8.53 ± 0.02. For walnut butter sweetened with Jerusalem artichoke powder (Figure 3b), the most appreciated qualities were texture, spreadability, and flavor (Figure 4). The smell was less appreciated, due to the predominant smell of dried Jerusalem artichoke, and consumers are not accustomed to such an odor, even though Jerusalem artichoke has many benefits for the human body. The average odor score for all four samples of walnut butter with Jerusalem artichoke powder did not differ much, at around 7. The taste and overall acceptability of the walnut butter sweetened with Jerusalem artichoke powder were rated "neither liked nor disliked", which is considered a satisfactory rating considering that this is the first time that Jerusalem artichoke powder has been added to a butter matrix. According to the results of the statistical analysis (ANOVA and Tukey comparisons) of the sensory quality attributes, it turned out that the walnut butter sample (S4) with 5% Jerusalem artichoke powder and without xanthan gum is the most preferred by consumers, followed by the S2 sample with 3% maple syrup and 1.5% xanthan gum, while sample S6 (with 5% Jerusalem artichoke powder and 2% xanthan gum) is the least pleasant.

3.6. Consumers Questionnaire

The respondents of the questionnaire were aged between 18–25 years (44.30%), 25–40 years (32.90%), and >40 years (22.80%). The majority of respondents who desired an assortment renewal were those aged 18–25, but also those aged 25–40; they were also most tempted to try walnut butter. Conversely, people who were more skeptical about assortment renewal were over 40 years. The majority of the surveyed population are from urban areas (over 60%). A total of 42.90% of all respondents are skilled workers, 41.40% are students, and 15.7% did not declare their occupation. The results showed that 70% of the questionnaire population consumes peanut butter at least once a year, while 30% answered that they do not consume this product. Approximately 30% of the interviewed population consume peanut butter once a month, 27% consume it once a year, and 17% consume it at least twice a week. The low frequency of peanut butter consumption is due to the fact that Romanian residents are not used to this food product, like those in the United States of America, who were found to consume peanut butter three times a day [12]. It was found that a considerable percentage of the people interviewed approve of the introduction of a new assortment of butter on the market; however, 10% did not agree with this renewal of assortment in the food industry. Over 90% of respondents would prefer to consume walnut butter. In total, 2.85% of the population surveyed would not be tempted to consume walnut butter, nor would they buy a new type of butter. The people surveyed preferred the butter to not be creamy (34.28% of responses), to have a specific taste (17.14%), to be sweet (17.14%), and for the butter to be spreadable, aromatic, and have a uniform color. The respondents would be willing to spend 20 RON (48.60%). Amounts between 25 and 40 RON (47.10%) were recorded for the purchase of 250 g of walnut butter. Less than 5% would be willing to pay more than 40 RON for 250 g of walnut butter.

Various factors can affect the willingness of consumers to purchase a new food product like walnut butter and a new study focusing only on this aspect is recommended [50,51]. For example, Hong et al. [51] performed an empirical analysis of consumers' willingness to buy nut products and the influencing factors, and indicated taste, nutritional value or price among these factors.

3.7. Correlations of Measured Data

The positive and negative correlations (Pearson correlation) between parameters measured for walnut butter samples with maple syrup and xanthan gum (Table 5) and with Jerusalem artichoke and xanthan gum (Table 6) were determined. A strongly negative correlation was observed between adhesiveness (A) and hardness (H), while strongly positive correlations were noticed for the concentration of xanthan gum (XG) and L*, XG concentration and b*, or L* and b* (Table 5).

Table 5. Correlations between parameters measured for walnut butter samples with maple syrup and xanthan gum (Pearson correlation).

	Xanthan Gum (XG)	L*	a*	b*	H	F
L*	**0.998**					
a*	0.269	0.223				
b*	**0.981**	**0.984**	0.109			
Hardness (H)	−0.764	−0.743	−0.219	−0.818		
Firmness (F)	0.496	0.513	−0.544	0.655	−0.698	
Adhesiveness (A)	0.690	0.683	−0.101	0.797	**−0.949**	0.888

Values in bold show very high positive/negative correlation (according to Mukaka [52]).

Table 6. Correlations between parameters measured for walnut butter samples with Jerusalem artichoke powder and xanthan gum (Pearson correlation).

	Xanthan Gum (XG)	L*	a*	b*	H	F
L*	**0.971**					
a*	0.324	0.526				
b*	0.499	0.661	**0.969**			
Hardness (H)	**0.937**	0.899	0.386	0.593		
Firmness (F)	0.651	0.791	0.666	0.645	0.452	
Adhesiveness (A)	0.173	0.325	0.376	0.234	−0.122	0.819

Values in bold show very high positive/negative correlation (according to Mukaka [52]).

From Table 6, it can be observed that there is a very high positive correlation between XG concentration and L*, as well as between XG concentration and H, or between color parameters a* and b*.

The highest values of hardness (H) for walnut butter samples with maple syrup (MS) and xanthan gum (XG) are presented in the upper left corner of the plot which corresponds with low values of XG (Figure 5a), while the lowest values of hardness (H) for walnut butter samples with Jerusalem artichoke (JA) and xanthan gum (XG) are in the lower right corner of the plot, which corresponds to higher values of XG (Figure 5b).

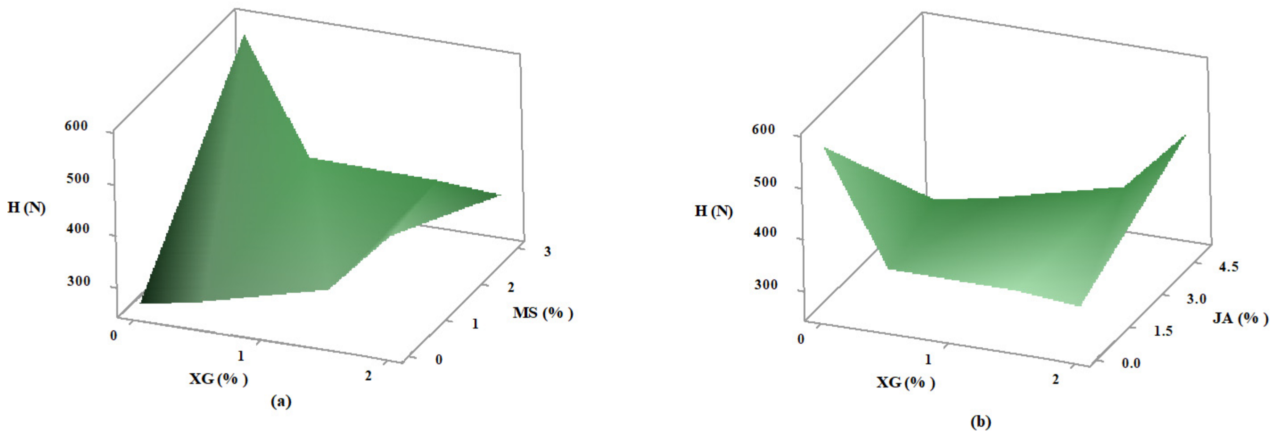


Figure 5. Response surface plot of the correlative effects of (**a**) maple syrup (MS) and xanthan gum (XG); (**b**) Jerusalem artichoke (JA) and XG on the hardness (H) of walnut butter.

The highest values of L* for walnut butter samples with MS and XG are observed in the upper right corner of the plot which correspond with higher values of XG (Figure 6a), while the lowest values of L* for walnut butter samples with JA and XG are found in the lower left corner of the plot, which correspond to lower values for XG (Figure 6b).

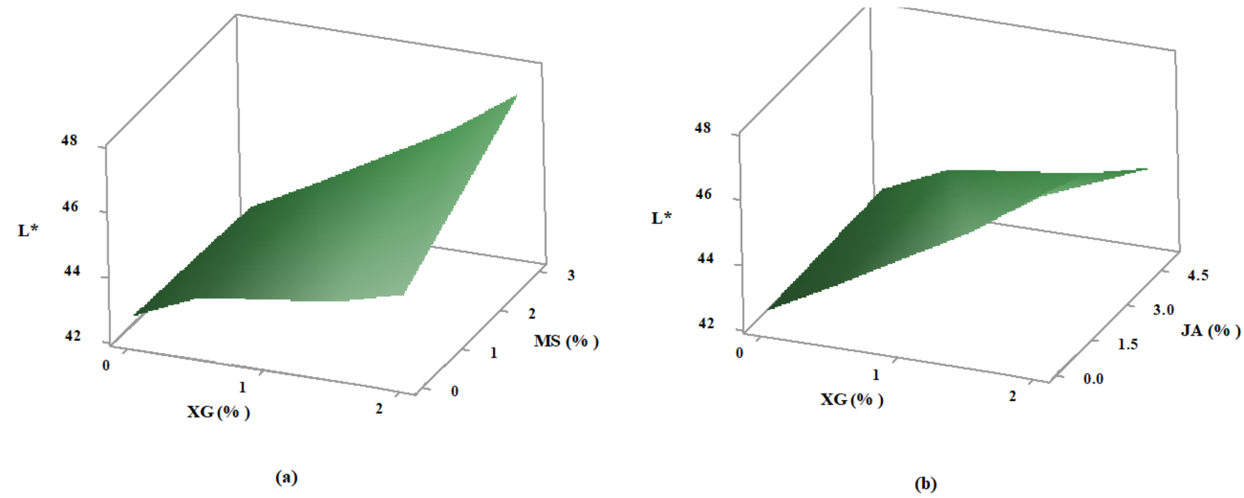


Figure 6. Response surface plot of the correlative effects of (**a**) maple syrup (MS) and xanthan gum (XG); (**b**) Jerusalem artichoke (JA) and XG on the color parameter L* of walnuts butter.

4. Conclusions

Walnut butter samples are fairly well-defined suspensions of small but non-colloidal walnut particles in walnut oil. Based on the obtained results, it can be concluded that:

- The flow properties of walnut butter were influenced by the lipid fraction and the solid particles targeting the sugar as the primary soluble solid.
- Texture and color uniformity influenced consumer preferences; thus, we can conclude that xanthan gum is a significant variable that affects the firmness of the nut butter samples, but did not have a negative effect on the sensory characteristics and adhesiveness of the nut butter.
- The incorporation of maple syrup in walnut butter decreased texture and viscosity when compared to the walnut butter sweetened with Jerusalem artichoke powder.
- Based on the sensory analysis of walnut butter, it can be concluded that the parameters that most influenced the choice and acceptability of butter were the appearance and consistency. The spreadability, as a sensory attribute, was good for walnut butter sweetened with Jerusalem artichoke powder.

Thus, new walnut butter products with special sensory qualities can be developed to meet the requirements of consumers in the face of modern lifestyles.

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