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THE OPTIMIZATION OF TECHNOLOGICAL FACTORS DURING PRODUCTION OF HUMMUS SPREAD

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ABSTRACT

The traditional hummus spread is obtained of cooked and grinded chickpeas, blended with susame paste (tahini), olive oil, lemon juice and spices. Hummus spread is a rich source of dietary fibers, polyunsaturated fatty acids, vitamins A, E and C, folate, minerals Mg, K and Fe. During production of such kind of spreadable food product, many factors can have influence on product behavior trough the all phases of production and to the final product quality. In this work, the influence of different technological factors on rheological, textural and sensory properties of hummus spreads made by certain recipes were examined, in the aim to achieve the maximum quality of final product. The way of preparation of raw materials, the composition of the spreads and the amount of water phase have been varied in the aim to define optimal rheological and textural parameters, to increase the production efficiency and in order to obtain desired sensory properties of final spread product.

Keywords: hummus spreads, technological factors, rheology, texture and sensory properties

1. INTRODUCTION

The Chickpeas (*Cicer arietinum L.)* is one of the oldest and most widespread legumes, usually available in tropical and subtropical areas. Chickpea seeds are round and large, similar to soybean and pea seeds, with light brown color and specific by high amount of carbohydrates (~ 47 %) and proteins (~ 23 %). Starch is the most abundant carbohydrate component in the chickpea seeds, in amount about 83.9 %. Also, in chickpea seed are present vegetable oil (4–5 %), cellulose (3–5 %), vitamins of B–group (pyridoxine, riboflavin, thiamine and niacin), minerals (Na, K, Ca, Mg, P, Mn, Zn, Cu , Fe, Se), essential amino acids (isoleucine, lysine, phenylalanine, tyrosine, tryptophan), carotenoids, flavonoids, phenols and antioxidants [1, 2, 3].

The Chickpea seeds are consumed cooked or baked, alone or in combination with other foods. The most commercial application of chickpea seeds is in the production of the increasingly popular humus spread, which was initially intended primarily for vegetarians. The traditional humus spread, which is originally from the Middle East, is made from cooked and grinded chickpea seeds, and then mixed with tahini paste (sesame paste), olive oil, lemon juice, garlic and spices. Therefore, humus is an excellent source of proteins, fibers, polyunsaturated fatty acids, vitamins, minerals, especially folate, calcium, magnesium and potassium. Four tablespoons (~ 100 kcal) of traditional humus spread daily compensate about 2 cups of legumes a week and about 25 g of dietary fibers. Humus also contains bioactive components such as phytic acid, sterols, tannins, carotenoids, and other polyphenols. Several studies confirm the positive impact of humus consumption on weight control, on glucose control, insulin response, positive effect on cardiovascular disease and cancer [4].

Spread–making process is very demanding process, because good quality of the final product strongly depends on the chosen factors, such as firstly the nature of applied main components and their quantities and certainly the applied technological processes. The aim of this paper is to investigate the influence of different technological parameters on the physical and sensory properties of humus spreads and to adjust these parameters in order to obtain maximum quality of the final product. For that purpose, the rheological, textural and sensory properties of observed humus spreads, depending on the varied technological factors during production, were examined.

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2. MATERIALS AND METHODS

2.1. Materials

In the production of humus spread the certain recipe was used. The applied components in obtained spreads were: chickpea seeds (55.3 %), water, sesame paste (14 %), rapeseed oil (4.9 %), spices and spice extracts (1.5 %), table salt, citric acid, acidity regulator (sodium bicarbonate), a preservative (potassium sorbate). All components were kindly donated by local producer DTD Ribarstvo doo, Bački Jarak, Serbia.

2.2. Methods

Firstly, the chickpea seeds had been soaked in water with sodium bicarbonate for 24 h in the aim to achieve partial softening of otherwise very hard seeds. Then, the seeds had been cooked in fresh water for 20–30 minutes, until they were enough soft. The hummus spreads were prepared in a kitchen blender by grinding and homogenizing the constituent components for 15 minutes.

Varied factors during this production process were the way of preparation of the raw materials, the composition of the spreads and the amount of water phase in the composition of the spreads. In the composition of some spread samples, the cooked and frozen chickpea seeds were used. Cooking and freezing process of chickpea seeds provide constant and greater availability of prepared raw material during the production process, so the effect of the application of frozen cooked seeds on the properties of spreads has been tested with the aim to increase the efficiency of spreads production.

Some of the spreads were prepared with freshly cooked chickpea seeds, some with frozen cooked chickpea seeds, some with bouillon (water remaining after cooking process), some with fresh water and some with combination of water/ice in aqueous phase and with different amount of aqueous phase. The influence of application of the water/ice combination in aqueous phase during spread production was examined in the aim to provide adequate temperature regulation during grinding and homogenization, because the temperature can significantly increase during this phase. Also, the changes of aqueous phase content in the composition of the spreads were examined in order to eliminate the specific property of the spread to crack on the surface after the pasteurization phase and during cooling.

After preparation, the spreads were poured into suitable polypropylene packaging (PP 5) and sealed using a packaging machine. They were then pasteurized in a water bath at 85° C for 20 minutes. The scheme of production process of hummus spreads and the composition of the spreads were presented on Fig. 1 and in Table 1.

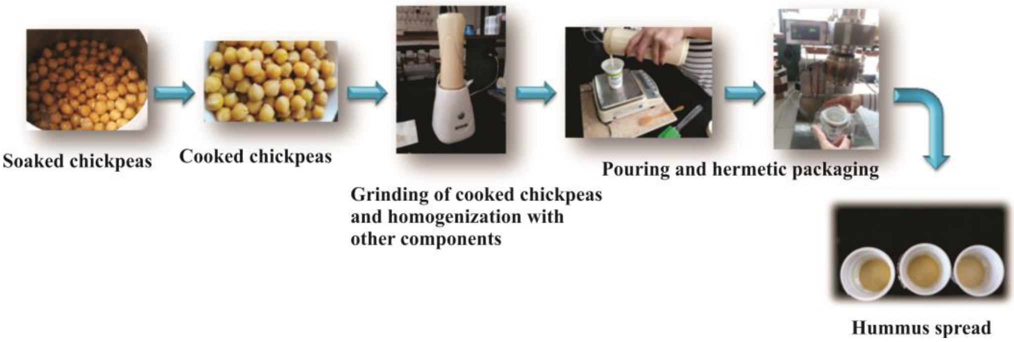

Figure 1. Production scheme of hummus spread

Table 1. Composition of observed humus spreads

Sample	Sample composition
1	Freshly cooked chickpeas / chickpea bouillon / 24 % W
2	Freshly cooked chickpeas / water / 24 % W
3	Frozen cooked chickpeas / water-ice / 24% W
4	Frozen cooked chickpeas / water-ice / 28% W
5	Frozen cooked chickpeas / water-ice / 32% W
6	Frozen cooked chickpeas / water-ice / 36% W

The influences of technological factors and their changes during production on the physical and sensory properties of obtained spreads were examined by adequate rheological, textural and sensory methods of analysis. The rheological measurements defined the flow curves of the spreads and the viscoelastic properties of the spreads. Obtained flow curves of the spreads were defined by rheological parameters: the yield stress τ_0 (Pa) and the hysteresis loop area A_0 (Pa/s). The viscoelastic properties of the spread were defined by the modulus of elasticity G' and the modulus of viscosity G" and their ratio, the value Tan δ = G"/G'. All measurements were performed by a Haake RheoStress RS600 rotary viscometer (Thermo Electron Corporation, Karlsruhe, Germany) with equipment plate-to-plate PP60 Ti (plate diameter is 60 mm and gap between plates 1 mm).
Textural measurements determined the firmness of spreads, the work of shear, the stickiness and the work of adhesion. The texture method *Spreadability/Softness of spread* was applied using the Texture Analyzer TA.HD Plus (Stable Micro Systems, Godalming, UK) with adequate equipment.
The sensory characteristics of the spreads were analyzed by a quantitative descriptive method (QDA method) under adequate determination conditions defined by ISO standards. The coded samples were analyzed under appropriate conditions [5] by a six–member expert panel [6] using a numerical scale with seven rating levels for each sensory characteristic [7]. Also, each sensory property had its factor of significance on a scale from 0 to 1. Sensory parameters for appearance were: *color uniformity (1), lightness (0.5), color intensity (0.5),* and *surface appearance (1)*. The sensory parameters for the texture of the spread were: *hardness (1), spreadability (1), adhesiveness (0,7)* and *graininess*. Also, the *odor (1), taste (1), salinity (0.7)* and *acidity (0.7)* were determined and at the end of the sensory analysis, the *general acceptability (1)* of the spreads was also evaluated.
The applied statistical method for analysis of obtained results was the ANOVA, using 5 % level of significance, and statistically significant differences were determined using the Tukey's post hoc test, also with 5 % level of significance. The approximation of the sensory characteristics of the spreads to the optimum desired values was determined by applying the ranking function, which was formed as equation (1):

$$f(\omega_i, s_i) = \sum_{i=1}^{13} \omega_i \cdot s_i \tag{1}$$

Where ω_i is the relative significance of observed characteristic compared to other characteristics (1 is the maximum and 0 is the minimum). S_i is the mean square deviation of the arithmetic mean compared to the optimal value. Between some individual variables the mutual correlations were determined and expressed by Pearson's correlation coefficient-r, using Statistica 12.0 software package (Statsoft, Tulsa, USA).
Obtained hummus spread with optimal properties was observed by optical microscope (TP-1001C Topica Ccd Camera (Kruss)) at magnification of x 40 and x 100.

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3. RESULTS AND DISCUSSION

The composition of the first three samples of the spreads was different (Table 1). Sample 1 consisted of freshly cooked chickpea seeds, of bouillon (water remaining after cooking process) and of other consisting components of the spread. Sample 2 was made of fresh cooked chickpea seeds and fresh water, while the sample 3 was made of cooked and frozen chickpea seeds and of water/ice combinations in aqueous phase. Frozen chickpea seeds were used in the aim to increase the efficiency of the production, and the water/ice combination was used in the aim to regulate the temperature during homogenization process. For all three samples the amount of aqueous phase was constant, 24 %. During rheological analysis of humus spreads samples, the flow properties of spreads with different composition, samples 1, 2 and 3 were firstly examined. Flow curves of these three observed samples are presented in Fig. 2.

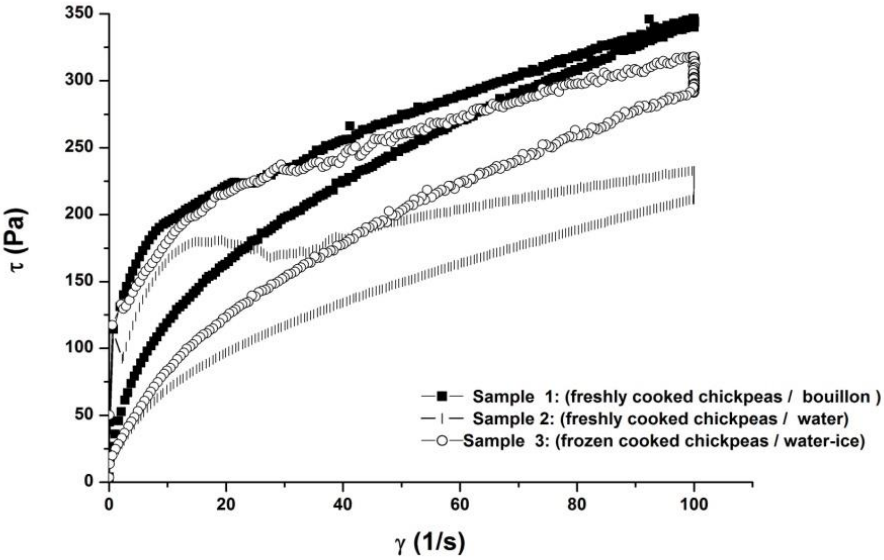

Figure 2. Flow curves of the hummus spreads dependent on composition

All three curves formed a characteristic hysteresis loop which pointed to thixotropic type of flow. This type of flow is specific for spreadable food systems, because their structure is gradually degraded during applied shear stress, but it has an uncommon ability to recover after the stress is removed. The surface of the hysteresis loop A_0 has the dimensions of energy required to break down the structure of the system [8].
On the other hand, the yield stress τ_0 is the minimum stress required for the system to begin to flow [8] (Table 2). For the sample 2, the yield stress is statistically significantly lower than the yield stresses of samples 1 and 3, which means that this spread offers less resistance to the flow than the other two spreads. The statistically significantly larger surface of the hysteresis loop of sample 3, compared to hysteresis loop of samples 1 and 2, indicated a stronger, more arranged structure of the system and higher degree of structure organization.

Table 2. Rheological parameters of hummus spreads with different composition

Sample	Yield stress, τ_0 (Pa) ± SD	Hysteresis loop area, A_0 (Pa/s) ± SD	Tan δ ± SD
1	3.91 ± 0,65[a]	4914 ± 259.91[a]	0.191 ± 0.005[a]
2	2.21 ± 0,26[b]	5513 ± 295.24[a]	0.196 ± 0.003[a]
3	3.65 ± 0,61[a]	9714 ± 162.30[b]	0.201 ± 0.001[a]

[a-b] Different letters in the superscript means statistically significant difference at p=0.05

The viscoelastic nature of the spreads was defined by the rheological parameter Tan δ and represents the contribution of the elastic, G', and viscous, G'', components of the system. For all spreads, the ratio of these system components, namely the value Tan δ was less than 1 and indicated the dominance of the elastic component. Also, statistically significant differences between the values of Tan δ for observed spreads were not registered.

Based on the rheological observation of these three spread samples with different composition, it can be observed that they are spreadable food systems with thixotropic type of flow and with a similar viscoelastic nature in which the elastic component are dominate.

The textural characteristics of these spreads are shown in Table 3. Statistical analysis did not show a pronounced difference between these textural characteristics and most of the observed parameters are close to each other. Accordingly, it can be observed that the preparation phase of chickpea seeds did not have a significant effect on the texture of the spread, as well as the preparation and composition of the aqueous phase within the spread did not influenced to textural properties. This means that the application of cooked and then frozen chickpea seeds in production of hummus spread provide an elastic, developed structure of the spread, confirmed by rheological analysis, without negative influence on textural characteristics of the spreads, which all increase efficiency of production due to the constantly available cooked chickpea seed as raw material.

Table 3. Textural characteristics of hummus spreads with different composition

Sample	Firmness ± SD (g)	Work of shear ± SD (gsec)	Stickiness ± SD (g)	Work of adhesion ± SD (gsec)
1	553.23 ± 65.26[a]	487.72 ± 60.45[ab]	-553.67 ± 59.08[a]	-176.65 ± 18.81[a]
2	451.94 ± 28.04[a]	391.91 ± 25.10[a]	-442.59 ± 23.78[a]	-139.52 ± 8.23[a]
3	562.63 ± 32.26[a]	529.73 ± 20.77[b]	-535.425 ± 23.92[a]	-161.13 ± 11.23[a]

[a-b] Different letters in the superscript means statistically significant difference at p=0.05

The sensory characteristics of observed spreads with different composition (samples 1, 2 and 3) were compared using the optimization function of ranking. Based on sensory properties shown at Figure 3 and based on ranking function, the sample 3 was singled out. The value of the ranking function for this spread is the lowest (f= 0.3167) compared to samples 1 and 2 (f= 1.9889 and f= 1.5792). A smaller function value indicates values closer to the optimum values of sensory properties. Accordingly, a spread made of cooked and frozen chickpea seeds and using the water/ice combination for aqueous phase exhibited the best sensory characteristics comparing these three spreads samples.

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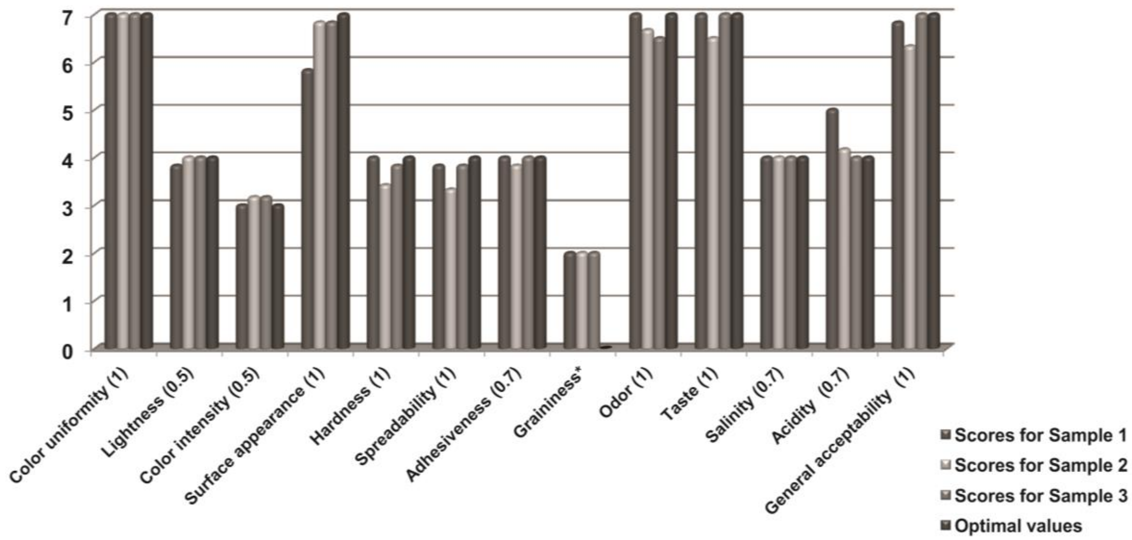

*Figure 3. Sensory properties and their factors of significance for hummus spreads with different composition; *Graininess does not have an optimal value and it was determined on a scale of 1 (smooth) to 7 (grainy)*

Thus, in the further work, the frozen cooked chickpea seeds were used as the main raw material for the production of spreads. Also, for the aqueous phase has been used the combination of water/ice, but the amount of aqueous phase has been varied in the aim to determine the optimal content of the aqueous part in the spread, which will prevent cracking of the spread surface after pasteurization and during time.

The rheological analyzes of these spreads with different water content showed that they were also spreadable viscoelastic systems with thixotropic type of flow and with relatively equal ratio of elastic and viscous components of the system (Fig. 4 and Table 4).

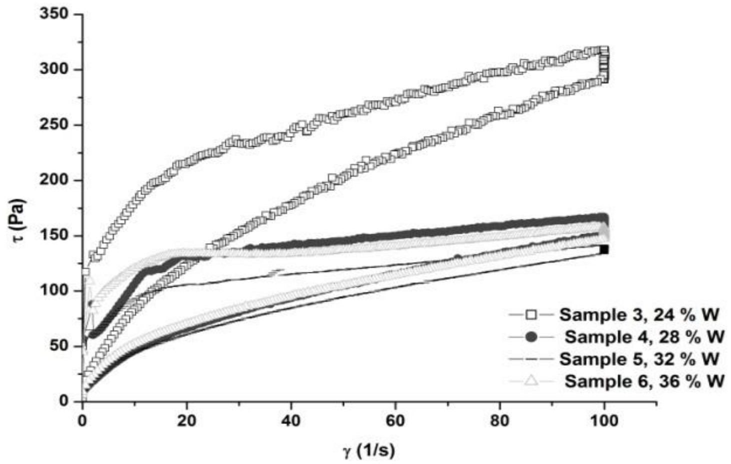

Figure 4. Flow curves of the hummus spreads with different amount of aqueous phase

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Table 4. Rheological parameters of hummus with different amount of aqueous phase

Sample	Yield stress, τ_0 (Pa) ± SD	Hysteresis loop area, A_0 (Pa/s) ± SD	Tan δ ± SD
3 (24 % W)	3.65 ± 0.61[a]	9714 ± 162.30[a]	0.201 ± 0.001[a]
4 (28 % W)	4.06 ± 0.26[b]	4518.33 ± 121.63[c]	0.209 ± 0.011[a]
5 (32 % W)	3.54 ± 0.11[ab]	2961 ± 74.94[d]	0.201 ± 0.005[a]
6 (36 % W)	3.37 ± 0.16[a]	4052 ± 70.08[b]	0.192 ± 0.003[b]

[a-d] Different letters in the superscript means statistically significant difference at p=0.05

The changes in water content affected to the degree of arranging in the system and thus to the consistency of spreads. Thus, the consistency of the spreads tended to decrease during increasing water content and all observed rheological parameters had decreasing tendency (Table 4). However, the increase in the amount of aqueous phase was extremely reflected to the texture properties of the spreads and thus to decrease of texture parameters (Table 5).

Table 5. Textural characteristics of of hummus with different amount of aqueous phase

Sample	Firmness ± SD (g)	Work of shear ± SD (gsec)	Stickiness ± SD (g)	Work of adhesion ± SD (gsec)
3 (24 % W)	562.63±32.26[a]	529.73±20.77[a]	-535.425±23.92[a]	-161.13±11.23[a]
4 (28 % W)	385.50±32.55[c]	356.20±34.06[c]	-354.07±28.26[c]	-115.19±8.68[c]
5 (32 % W)	162.92±10.74[b]	139.05±13.29[b]	-149.19±9.88[b]	-53.36±3.54[b]
6 (36 % W)	147.77±10.52[b]	135.19±14.91[b]	-133.10±8.76[b]	-51.40±3.97[b]

[a-c] Different letters in the superscript means statistically significant difference at p=0.05

Observing the sensory properties of these spreads with different amount of aqueous phase and using the optimization function of ranking, one spread with sensory properties that were closest to the optimal desired properties could be singled out. The ranking functions for the observed samples were: for sample 3 f= 0.2917, for sample 4 f= 0.0694, for sample 5 f= 1.575, and for sample 6 f= 11.9805. Based on that, a sample 4, with 28 % of the aqueous phase was distinguished, because its ranking function was the lowest and its sensory properties were rated with the highest marks (Fig. 5). Beside very good other sensory properties, the hummus spread with this amount of aqueous component did not exhibit cracking of the surface after pasteurization process and during time.

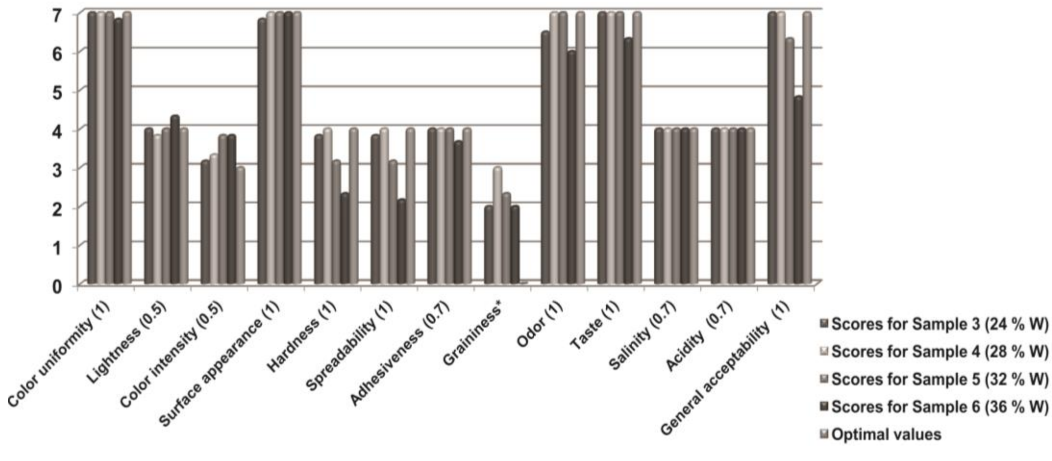

Figure 5. Sensory properties and their factors of significance for hummus spreads with different amount of aqueous phase; *Graininess does not have an optimal value and it was determined on a scale of 1 (smooth) to 7 (grainy)

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Also, a relatively high correlation was noticed between sensory and instrumentally determined texture parameters (Pearson's correlation coefficient r= 0.9252–0.9615). It means that the instrumentally measured texture parameters for sample 4 can be defined as optimal (firmness, work of shear, stickiness and work of adhesion). A similar correlation was obtained with rheological parameters (r= 0.8538–0.8415). Thus, it can be concluded that with these technological parameters of the rheology and texture of the spreads, defined for sample 4, the desired optimal sensory properties of the spreads can be achieved.
The structure of this spread with optimal properties was analyzed by optical microscope and presented at Fig. 6. It can be noticed that solid particles of the spread with dimensions between 140–210 μm were evenly distributed through the continuous liquid phase of oil and water, which provided adequate rheological, textural and sensory properties of such spreadable food system.

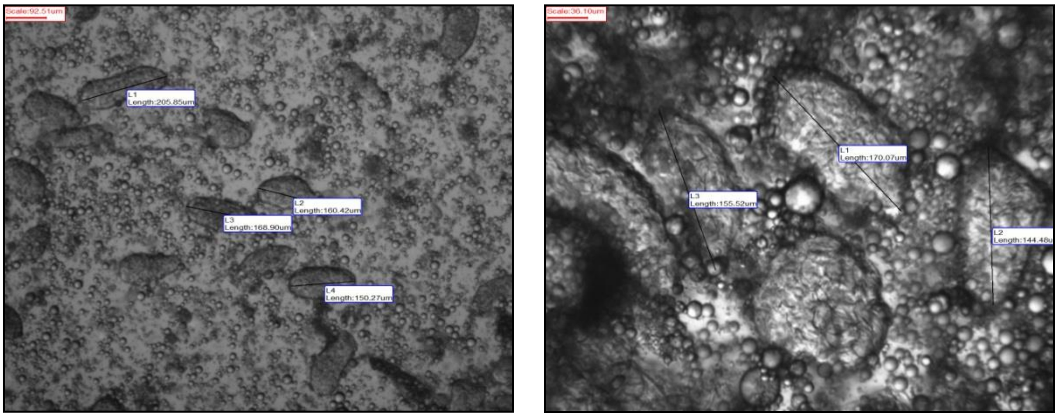

Figure 6. Structure of humus spread with optimal properties and distribution of its constituents

4. CONCLUSIONS

For the production of hummus spread, the frozen cooked chickpea seeds can be used in the aim to provide constant availability of main raw material and to increase the production efficiency. Also, the aqueous phase of the spread can be consisted of combination of water and ice, in the aim to provide constant temperature during homogenization process and to prevent temperature increasing. Application of frozen cooked chickpea seeds and combination of water/ice provides good rheological properties during production and do not disrupt the textural properties of the spread and beside the all mentioned advantages, also provides the desired sensory properties of the spread, which are very close to the optimal properties. The amount of aqueous phase in the spread should be 28 % with the aim of achieve adequate quality of the final product after all stages of production, meaning excellent sensory properties without unwanted cracking of spread surface. All these technological factors can provide production of a nutritional and biologically very valuable functional food product with the desired sensory properties.

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