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Original Research Article

Manufacturing Low-Fat Processed Cheese Using Chickpea Proteins as a Fat Substitute and Studying Its Physicochemical, Rheological, and Sensory Quality Characteristics

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Abstract: ***Background*:** Manufacturing processed cheese has many advantages compared to natural cheese because the cost of refrigeration is lower during storage and transportation, and maintaining improved quality with minimal changes in the characteristics of the cheese during storage. It is possible to produce cheese with different intensity in flavor, functionality, and characteristics for different applications. ***Methods*:** This study was carried out in the laboratories of the College of Food Sciences, department of dairy science and technology at Al-Qasim green university, where full-fat cheddar cheese was mixed with full-fat soft cheese and used in the manufacture of cooked cheese treated with positive control + C, as well as mixing full-fat cheddar cheese with low-fat soft cheese to manufacture low-fat processed cheese, the negative control treatment was treated C-. Full-fat cheddar cheese was mixed with soft, low-fat cheese, with the addition of chickpea proteins as a fat replacers, with addition rates of 1.5, 3, and 4.5%, represented by treatments T3, T2, and T1, respectively. ***Results*:** The chemical tests included estimating the percentage of moisture, protein, fat, ash, carbohydrates, and total acidity, in addition to estimating the pH, while the rheological tests included hardness, adhesion, and springiness. A sensory evaluation of processed cheese parameters was also conducted. The results showed that the replacement treatments were characterized by a lower moisture content and protein percentage than the negative control treatment and close to the positive control treatment. The percentages of carbohydrates, ash, and acidity also increased in the replacement treatments, but the percentage of fats and pH decreased.

Keywords: Fat replacers, processed cheese, quality characteristics, chickpea proteins.

INTRODUCTION

The issue of fat consumption is closely linked to an increased risk of many chronic diseases such as heart disease, high blood pressure, and atherosclerosis, as well as tissue injuries that are linked to fat oxidation. In addition, fat is one of the causes of obesity, the risk of which is growing around the world, and which is considered one of the diseases that cannot be controlled (Astrup *et al.*, 2011). This has led to the growth of health awareness among many consumers about the issue of eating low-fat, fat-free, or low-calorie foods. Due to the high consumption rates of dairy products, it has become one of the popular options that attention is turning to in reducing the percentage of fat, so there has been a significant increase in demand for these types of foods, including types of cheese and yogurt (Katsiar *et al.*, 2002). Some dairy products can be added, such as powdered milk, dried whey, calcium caseinate, and whey proteins. Some other foodstuffs can also be added, such as vegetable proteins, starch, and carbohydrates. Some flavors, such as cheese flavors, can also be added (Kommineni *et al.*, 2012.). Processed cheese manufacturing has many advantages compared to natural cheese because the cost of refrigeration is lower during storage and transportation, and the improvement of quality is maintained with minimal changes in the characteristics of the cheese during storage. It is possible to produce cheese with different intensity in flavor, functionality, and characteristics for different applications. And modifying the packaging for the purpose of different uses and economic needs, (Cari & Kaláb, 1999) and it was proven that cheddar cheese is the most suitable and unprecedented cheese in the manufacture of processed cheese. It contains a lower percentage of calcium content, compared to other hard cheeses, due to the occurrence of the acidification process during production Cheddar has ideal melting properties and the ability to retain fat. Cheddar is the first choice in making recipes for sliced processed cheese (Guinee, 2009). Processed cheese is produced by cutting mature cheese and immature cheese under heat treatment conditions until a homogeneous mass is obtained (Hladká *et al.*, 2014). Emulsifying salts are used to obtain a product. Homogeneous and stable and can be satisfactorily included in 2 to 3% of the initial cheese mixture. (Weiserová *et al*., 2011). In recent decades, there has been an increasing interest in developing low-fat or fat-free products. People are motivated to consume low-fat dairy products from In order to ensure overall good health and reduce the risk of many types of diseases, such as obesity, high blood pressure, stroke, coronary heart disease (Sandoval-Castilla *et al*., 2007; Yoo *et al*., 2007). Dietary interventions should encourage people to consume low-fat dairy products as part of a healthy lifestyle. However, the functions of fats in dairy products are very important as explained previously, and removing the fats will deteriorate the quality. Therefore, fat substitutes are used in low-fat dairy formulations to mimic some of the physicochemical properties and sensory qualities of fat. The most common fat substitutes come from whey proteins and hydrocolloids whose functions, such as thickness, textural capacity, and water retention, allow them to mimic the physical properties of fat in dairy products. (Razavi & Behrouzian, 2018). Hydrocolloids applied for fat substitutes are generally divided into polysaccharide and protein, which can be used alone or as a mixture in low-fat dairy formulations (Akbari, *et al*., 2019; Peng & Yao, 2017; Yashini *et al*., 2019). The vegan lifestyle is becoming increasingly popular, and people are switching from an animal diet to a vegetarian diet (Fehér *et al.*, 2020), this has led to enhanced investments in the plant-based food sector to become a mainstream trend. One of the main focuses is to create a wide range of alternative products as healthier and more sustainable options than animal products. Therefore, the demand for a variety of vegetarian alternatives to cheese and yogurt, among others, is gradually gaining importance in the market Markets and Boukid *et al*., 2021). There is little information available about the functional properties of chickpea proteins, and given the importance of these proteins in food processing, it is necessary to study their functional properties (Jimoh & Aroyehum, 2011). Most plant proteins, with the exception of wheat protein and soybean protein (chemical concerns), are considered food safe. Among these plant proteins is chickpea protein, which is considered one of the most promising proteins due to its great functional properties in food processing (Singhal *et al*., 2016). This study aimed to determine the effect of partial fat neutralization in mixtures for manufacturing low-fat processed cheese with chickpea proteins on the product quality characteristics.

MATERIALS AND METHODS

Raw milk was obtained from fields near Al-Qasim Green University. The rennet used was imported from the Danish Chris Hanson Company, while chickpea proteins were obtained by extracting them in the laboratories of the College of Food Sciences, Al-Qassim Green University. As for the emulsifying salts, they were purchased from CAS Company. Chinese.

Manufacture of Soft Cheese

Soft cheese was made according to the method mentioned by (Al-Zarfy, & Al-Bedrani, 2023). A quantity of raw cow's milk was received from the fields near Al-Qasim Green University in Al-Qasim city, Babylon Governorate, and then it was divided into two parts: The first part was full-fat and was used in the manufacture of soft, full-fat cheese. As for the second part, the skiming process was carried out by reducing the percentage of fat in the milk by 0.5%, after which the pasteurization process was carried out at a temperature of 63°C for 30 minutes, then it was cooled to 37°C, after which microbial rennet was added (Chymosin enzyme) prepared by the Danish Chris Hanson Company after dissolving it with distilled water according to the instructions of the producing company and leaving it for half an hour until clotting occurs. The clot was cut horizontally and longitudinally and left for 5 minutes without stirring. Then the clot was stirred to drain the whey, then salt was added to it in a 2-3 ratio. % of the weight of the clot. After that, the clot is packed in plastic boxes in the molds. The molds are inverted twice within an hour, then they are stored in the refrigerator at a temperature of (5 + 1) C, and a portion of them is taken to conduct the necessary tests.

Manufacture of Processed Cheese

Processed cheese was manufactured according to the method mentioned by Al-Zarfi, 2022) whereby mixing full-fat cheddar cheese with full-fat soft cheese in the manufacture of positive control treatment cheese was mixed with an amount of 100 gm of cheddar cheese and 300 gm of full-fat soft cheese, while 100 gm of cheese were mixed Full-fat cheddar with 300 gm of soft, low-fat cheese to form the negative treatment. Also, 100 gm of full-fat cheddar cheese were mixed with 300 gm of soft, low-fat cheese, and chickpea proteins were added to the treatments at concentrations of 1.5, 3, and 4.5% for T1, T2, and T3 treatments respectevely. The emulsifying salts and water were added and the cooking process was carried out at 85°C for 15 minutes, after which the filling process was completed, then stored and preserved in the refrigerator at (5+1)°C, and a portion of it was taken to conduct the necessary tests.

Chemical Analysis

The moisture percentage was estimated according to the method mentioned in Ling (2008), the fat percentage was estimated according to the method mentioned by Min & Ellefson, (2010) while the ash percentage was estimated using the direct burning method according to William *et al*., 2006). The percentage of carbohydrates was estimated according to the method mentioned by Ihekoronye & Ngoddy, (1985). The pH of the cheese was estimated according to the method mentioned by (Ling, 2008). The total acidity percentage was estimated according to the method mentioned by William *et al*., (2006).

Texture Analysis

The texture of the cheese treatments was estimated using a texture measuring device (BrookfieId engineering Iab CT3, 4500) with a 5 kg load cell, according to (Joon, 2017).

Sensory Evaluation

Sensory evaluation tests were conducted by a group of panelists specialized in food sciences at the College of Food Sciences according to what was stated in the sensory evaluation form created by Afnor (1993).

Statistical Analysis: The statistical program Statistical Analysis System -SAS (2018) was used.

RESULTS AND DISCUSSION

The results shown in Table 1, show the percentage of moisture for each of the processed cheese treatments, the positive control treatments C+ and the negative control treatments C+, and the different processed cheese treatments to which chickpea proteins T3, T2, and T1 were added in the proportions of 1.5, 3, and 4.5%, respectively, where their value was for the positive control treatment + C for the negative control treatment - C is 63.8 and 66.33%, respectively, and this is consistent with what was found by (Chatziantoniou, 2015)... for processed cheese, which is 63.35%. It is also consistent with what El-Aidie, (2023). For cooked cheese, the amount is 62.53%, and it agrees with what was found by Al-Zurfi, (2022), who indicated that the moisture percentage for full-fat cooked cheese reached 64%, while the moisture percentage for low-fat cooked cheese reached 66.33%. It is also noted from the results that the moisture content of the low-fat processed cheese treatment was higher compared to the full-fat positive control treatment. The reason for this may be due to the decrease in the percentage of total solids due to the reduction of fat in it because it was made from separated milk., who indicated that Fat separation leads to a higher moisture content in soft, low-fat cheese. This also agrees with what was stated by Visser (1991), who indicated that the fat reduction process leads to a higher moisture content in low-fat cheddar cheese made from sorted milk. Increasing the moisture content of low-fat cheese is one of the important strategies for improving its properties, which results in the moisture in the non-fat solid being equal to or higher than that in full-fat cheese (Oberg and Welker, 2001).

Table 1: Chemical analysis, pH values, and normalized acidity of cooked cheese for the positive and negative control treatments

% Components								
Treatment		**Moisture**	**Protein**	**Fat**	**Carbohydrates**	**Ash**	**Acidity**	
C^{+}		63.8	13.28	17.5	3.52	1.90	1.24	5.90
C^{-}		66.33	17.87	5.75	7.49	2.56	1.25	5.88
Processed cheese treatments with chickpea proteins added	T1 1.5%	64.3	19.01	4.90	8.2	3.5	1.28	5.82
	T2 3%	63.3	20.3	4.5	8.3	3.6	128	5.81
	T3 4.5%	62.1	21.6	4	8.7	3.6	1.81	5.72
L.S.D value		3.502	2.711. *	3.926 *	*1.874	0.966 *	0.479	0.381NS *
)P≤0.05(*								

The moisture content of the chickpea protein addition treatments reached 64.3 and 63.3. And 62.1%, respectively, and this is consistent with what was found by Zalazar, (2002) for low-fat cooked cheese, which was 62.03%. It is noted from the results that the moisture percentage for the addition treatments was lower compared to the positive and negative control treatments, and it is directly proportional to the increase in the addition percentage. The reason for this may be due to the increase in the percentage of total solids in it is due to the addition of chickpea protein compared to the negative control treatment that is devoid of any addition, and this is consistent with what was found by (Al-Zurfi & Al-bedrani, (2022). From the results, we notice a higher moisture content in the cheese of treatment -C compared to treatment C+, and the reason for this may be due to the lower percentage of total solids in it.

The results of the statistical analysis indicate that there are no significant differences (P≤0.05) in the percentage of moisture for the positive control treatment compared to the negative control treatment. While they indicated that there are significant differences (P≤0.05) between the negative control and the T3 treatment. As for the protein percentage, it reached 13.28 and 17.87% for the treatments C+ and C, respectively. It is noted from the results that the percentage of protein in the negative control treatment was higher compared to the positive control treatment. The reason for this may be due to the fact that the fat reduction process made the sample volume occupied by a large portion of Protein from the screening model (Guinee, 2013) for cooked cheese, amounting to 13.9%. It agrees with what was found by El-Aidiel, (2023) for cooked cheese, amounting to 12.20%. As for the protein percentage for fat replacement treatments with chickpea protein in the percentages mentioned previously, it amounted to 19.1, 20.3, and 21.6%, respectively. This it agrees with what was found by Zalazar, (2002) for low-fat processed cheese, amounting to 19.55%. It is noted from the results that the protein percentage in the replacement treatments increased in direct proportion to the increase in the addition percentage. The reason may be due to the addition of chickpea proteins (with a protein percentage of 80%) compared to the positive control treatment. This is consistent with what Al-Saadi *et al*., (2019) found, this is consistent with (Rahi, *et al*., 2023) who indicated that adding protein ingredients to the cooked cheese mixture leads to an increase in the percentage of total solids, especially the protein content. The results of the statistical analysis showed that there were significant differences ($P\leq 0.05$) between the two positive control treatments compared to the negative ones, and there were significant differences ($P\leq 0.05$) between the positive control treatment.

The percentage of fat for processed cheese treated with C+ is 17.5%, and this is close to what Chatziantoniou, (2015) found for cooked cheese, which is 18.67. It is also consistent with what Guinee, (2013) found for processed cheese, which is 18.0%, and it was 5.75% for treatment C, which is 5.75%. This result is lower than what EI-Assar al-el (2019) found for processed cheese, which is 7.00%. It is also lower than what (Zalazar, 2002) found for low-fat processed cheese, which is 7.96. % and similar to what (Al-Zurfi & Al-bedrani, (2022) found for low-fat cooked cheese, which was 4.80%. We note from the results that the percentage of fat in the negative control treatment was lower compared to the positive control treatment, and the reason for this is that the cooked cheese in this treatment was made from low-fat cheese.

The percentage of fat in the replacement treatments was 4.90, 4.5, and 4%, respectively. It is noted from the results that the percentage of fat in the processed cheese treatments, the cheese with chickpea proteins added to them, was lower compared to the C+ treatment. The reason for this may be due to the fact that it was made from low-fat cheese on the one hand, and the increase in the concentration of solids by adding fat substitutes of a protein nature to the cooked cheese, which led to a reduction The percentage of fat in cheese, on the other hand, is consistent with what Abd El-Salam, (2015) found when adding fat replacers.

The results of the statistical analysis showed that there were significant differences ($P \leq 0.05$) between the positive control treatment compared to the negative control treatment, and between the negative control treatment and the treatments to which chickpea proteins were added.

As for the percentage of carbohydrates, their percentage for treatment C+ was 3.52%, and this result is consistent with what was found by Guinee, (2013). For Ras cheese, the amount is 3.52% and agrees with what ((Al-Zurfi & Al-bedrani, (2022) found for cooked cheese, amounting to 3.34%, while for treatment C it was 7.49%, while for the replacement treatments it amounted to 8.2, 8.3, and 8.7%. Respectively, it is noted from the results that the percentage of carbohydrates in the cheese of the treatments added to chickpea proteins is higher compared to the positive and negative control treatments, due to the addition of chickpea proteins.

The results of the statistical analysis showed that there were significant differences ($P \leq 0.05$) between the positive control treatment compared to the negative control treatment, and the presence of significant differences between all treatments to which chickpea proteins were added compared to the positive control treatment. As for the ash percentage for each of the different cooked cheese treatments, this percentage was for treatment C + It is 1.90%, and this result is consistent with what was found by Khudair, (2010), who indicated that the percentage of ash in samples of imported and local cooked cheeses and samples of laboratory-manufactured processed cheeses ranged between 1.08 -4.55%. It is also consistent with what was found by Chatziantoniou, (2015). For cheese, which amounted to 2.29%, and also consist with Al-Bedrani *et al*., (2022) finding, while for the treatment C-, it was 56.2%. As for the replacement treatments, it amounted to 3.5, 3.6, and 3.6%, respectively) and is consistent with what he found by El-Aidie, (2023). From the addition of alonine to processed cheese, amounting to 3.72%, the results showed a higher percentage of ash for the cheese of the treatments with chickpea proteins added compared to the positive and negative control treatments. The reason for this is due to the effect of adding chickpea proteins as a fat substitute, which leads to a higher ash content of the cheese (El- Baz, & Azza, 2013).

The results of the statistical analysis showed that there were no significant differences (($P\leq 0.05$) between the positive control treatment compared to the negative control, and the presence of significant differences between the treatments added to chickpea proteins compared to the positive control treatment. And the presence of significant differences between the negative control and the treatments T2 and T3.

As for the pH values for the C+ treatment, it is 5.90, and this is consistent with what Zalazar (2002) found for low-fat cooked cheese, which is 5.3, and is close to what Al-Khalayla and Tayfour (2011) found for cooked cheese, which is 5.75, and it agrees with what Guinee (2013) found... for cooked cheese. The amount was 5.48%, while for treatment C it was 5.88. This result is consistent with what Ibrahim (2016) found for spreadable cooked cheese in the negative control treatment, which amounted to 5.54, while for the replacement treatments, it amounted to 5.82, 5.81, and 5.72, respectively. It is noted from the results that the pH values of all processed cheese treatments were lower compared to the soft cheese and cheddar cheese from which it was made. The reason for this may be due to the addition of emulsifying salts that work to lower the pH, and this is consistent with what was mentioned by Battistotti and Mariani (1999), who indicated the adoption of the resulting pH and acidity of processed cheese depends on the pH, acidity and quality of the milk from which the processed cheese is made, as well as the manufacturing method. He also indicated that the pH value of processed cheese ranges between 5.8 - 6.3.

The results of the statistical analysis showed that there were no significant differences ($P \leq 0.05$) between all treatments in the pH values. As for the percentage values of leptic acidity (calculated on the basis of lactic acid), this percentage for the C+ treatment was 1.24%, and this agrees with what Al-Saadi, (2019) found for processed cheese amounted to 1.26%, while for treatment C it amounted to 1.25%, and this result is also consistent with what Al-Saadi, (2019) found for spreadable cooked cheese amounted to 1.26%, while for the substitution treatments it amounted to 1.28, 1.28, and 1.81%, respectively. It is noted Among the results was an increase in the acidity of all low-fat cheese treatments compared to the positive control treatment, and this is consistent with what was approved by the Iraqi standard specification for cooked cheeses for 1990, which stipulated that the normal acidity percentage of cooked cheese should range between 0.3 - 1.9%.

The results of the statistical analysis showed that there were no significant differences ($P \leq 0.05$) between the positive control treatments compared to the negative one. There were significant differences ($P \leq 0.05$) between the two control treatments compared to T3treatment.

Rheological Tests

Hardness: The results shown in Figure (1) show the hardness examination of the cheese of the positive control treatment C+, the cheese of the negative control C⁻ treatment, and the cheese of the treatments to which chickpea proteins T1, T2, and T3 were added respectively.

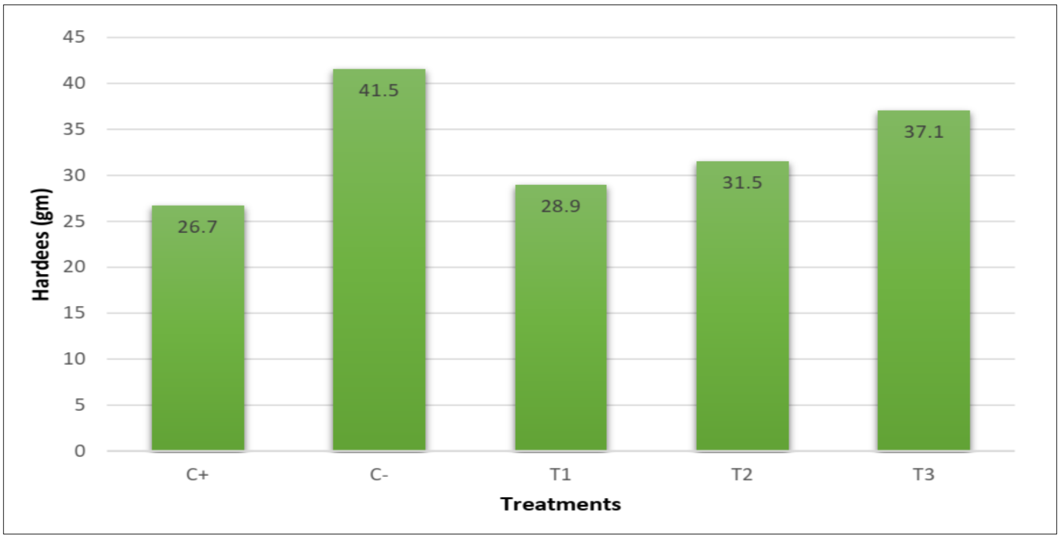

Figure 1: Hardness values for of full-fat positive processed cheese treatment C+ and low-fat negative control treatment C⁻ and treatments of low-fat processed cheese added to chickpea proteins at rates of 1.5, 3 and 4.5%, L.S.D. value is 7.02*

The hardness value of the positive control treatment C+ was 26.7 g and that of the negative control treatment was 41.5 g, while the hardness values of the partial fat replacement treatments of chickpea protiens were 28.9, 31.5 and 37.1 g, respectively. It is noted from the results that the hardness values of the replacement treatments are higher and are directly proportional to the increase in the added percentage of chickpea protein compared to the negative control treatment. The reason for this may be due to the high percentage of total solids, which leads to a decrease in their moisture and thus an increase in hardness. This is consistent with what Akalin *et al*., mentioned (2012) and it is also consist with (Al-Bedrani *et al*., 2021). It is also noted from the results that the hardness values of the replacement coefficients are lower compared to the negative control treatment. The reason for the higher hardness of low-fat cheese (negative control treatment) may be due to its high casein content. (Zisu & Shah, 2005) indicated that the use of fat substitutes works to reduce the hardness of the cheese. Al-Zurfi & Al-Bedrani (2022) also pointed out the role of these additives in improving the texture of cheese by binding it to water and thus reducing hardness.

The results of the statistical analysis showed that there were significant differences (P≤ 0.05) between the positive control treatments compared to the negative treatment. There were significant differences between the positive control treatments compared to the addition treatment T3.

Cohesiveness Tests

The quality of cohesion is one of the important characteristics of the texture of cheese and shows its acceptance from the consumer's point of view. Cohesion is defined as the strength of the internal bonds that maintain the ideality of the product for the consumer. It is expressed by the extent to which the material deforms when it confronts the cause of the deformation (Mousavi *et al.*, 2019). Examining the consistency standard of the processed cheese treatments for the positive control treatment, the negative control treatment, and the replacement treatments, it was 0.95 for the positive control treatment, C+, and for the negative control treatment, it was 0.94, and for the addition treatments, it was 0.95, 0.97, and 1.02, respectively.

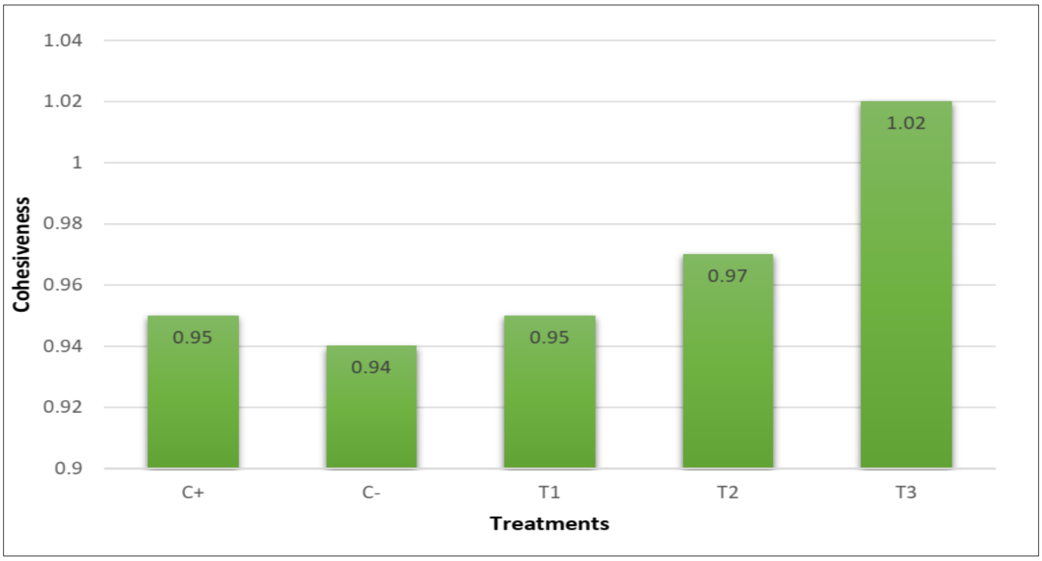

Figure 2: Cohesiveness for of full-fat positive processed cheese treatment C+ and low-fat negative control treatment C- and treatments of low-fat processed cheese added to chickpea proteins at rates of 1.5, 3 and 4.5%, L.S.D. value is 0.081

Springiness Tests

It is clear from Figure 2 that the treatments to which chickpea proteins were added have higher cohesion than the negative control treatment and are close to the positive control treatment. Yilmaz-Ersan and *et al*., (2014) indicated that the less cohesion there is in semi-solid dairy products, the smoother their texture. Texture and previous studies have shown that protein is the most effective component in increasing the consistency of dairy products (semi-solid) and that the effect of fat is of secondary importance (Okenne & Keogh, 1998). From this we conclude that as the percentage of protein increases, the strength of cohesion increases. The results of the statistical analysis showed that there were no significant differences (P≤0.05) for all treatments.

Figure 3, shows the results of the springiness test for the cheese treatments C+ and C and the processed cheese treatments with chickpea proteins added as fat substitutes. It is clear from it that there is a clear difference in the time it takes for the different cheese samples to return to their original position after the effect of the weight applied to them has disappeared, and thus their difference in the degree of springiness that It possesses it, which is naturally affected by its chemical composition and the type and quantity of the alternative substance (added proteins). It is noted that the negative control treatment - C, took a longer time to return to its normal state compared to the positive control treatment, which took a shorter time to return to its original state. This is consistent with what was found by Koca and Metin (2004) of high elasticity cheese treatment

Springiness depends on various factors, such as heat treatment, protein content, interaction and bonding between components, and the degree of protein dissociation Delikanli, Ozcan (2014).

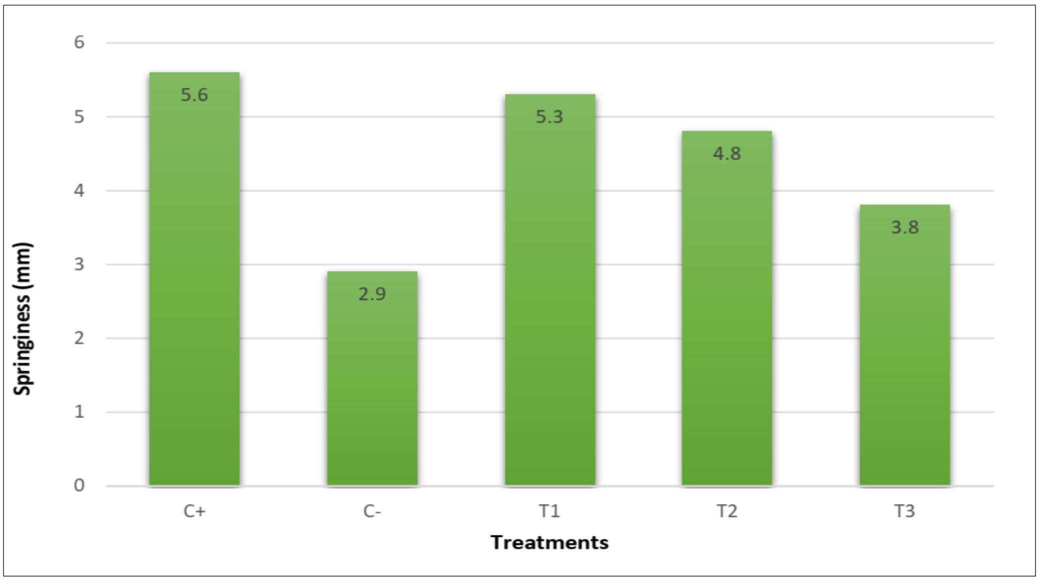

Figure 3: Springiness values for of full-fat positive processed cheese treatment C+ and low-fat negative control treatment C- and treatments of low-fat processed cheese added to chickpea proteins at rates of 1.5, 3 and 4.5%, L.S.D. value is 1.77*

Processed cheese made from whole, full-fat milk compared to low-fat processed cheese made from sorted milk. The reason for this is due to the high protein content of this treatment because it is made from sorted milk, which gives it a compact and rough protein matrix and reduces the spongy nature imparted by the presence of fat interspersed in the protein matrix, as is the case in the C+ treatment cheese, which made it easy for the cheese matrix to return to its position. It is also noted from the results that the cheese treatments supplemented with fat substitutes were more elastic compared to the negative control treatment, and this is consistent with what was found by Korish & Abeer, (2012), who indicated a higher elasticity of cheese to which fat substitutes were added than the negative control treatment.

The results of the statistical analysis showed that there were significant differences (P≤0.05) between the positive control treatment compared to the negative control treatment. There were significant differences between the positive control treatment and the T3 treatment to which chickpea proteins were added. There were also significant differences between the negative control treatment compared to the addition treatments T1 and T1.

Sensory Evaluation

The results shown in Table 4 show the sensory evaluation of the positive and negative processed cheese treatments and the replacement treatments with chickpea proteins T1, 2T, and T3.

Table 2: Sensory evaluation of positive and negative control treatments and low-fat processed cheese treatments with chickpea proteins added

Treatment	color 10	body 10	Flavor 10	Fat separation 10	Texture 10	Bitterness 10	Appearance 10	Cohesiveness 10	Total 80
C+	9.5	9	9.5	9.8	9.0	10	9.4	9.5	75.7
C-	9.2	8.5	8.8	9.0	8.5	9.4	9.1	8.7	71.2
T1	9.4	8.8	8.7	9.2	9.3	9.6	9.5	9.3	73.8
T2	9.2	8.5	9.2	9.1	8.7	9.5	9.0	9.1	72.3
T3	9.0	7.4	8.0	9.1	7.7	9.5	8.8	7.8	67.3
L.S.D	0.605 NS	1.28 *	1.167 *	0.833 NS	1.059 *	0.726 NS	0.651NS	1.277 *	6.208 *
.) P≤0.05(*									

It is clear from the results of the sensory evaluation of the cheese samples of the control treatment C+ and the fat is effective in imparting the desired color, texture, and flavor characteristics from the consumer's point of view, as its color is characterized by a yellowish white color that satisfies the consumer's desire and knowledge of the color of the natural cheese that is familiar to him compared to the sensory characteristics of the cheese of the negative control treatment. This is consistent with what Alnemr *et al.*, (2013) found regarding the deterioration of the sensory characteristics. For low-fat cottage cheese without fatty substitutes. The results also showed that cooked cheese with 1.5% chickpea protein added received the highest sensory rating score with regard to texture, amounting to 8.8, which is almost identical to the characteristics of the cheese of the positive control treatment compared to the cheese of the negative control treatment. As for the color characteristic, the processed cheese treatments with chickpea proteins added had a color that was very close to the natural color of the cheese of the positive control treatment, and in inverse proportion to the increase in the addition percentage, as this increase led to giving a more yellow color, and this is consistent with what was found by Ahmed, (2009) who indicated The color of the processed cheese treatments was less white and more yellow, and closer to the positive control treatment made from whole milk, as the small protein molecules act as centers to scatter light and thus reduce the whiteness. It can be said that it is possible to manufacture low-fat processed cheese with good characteristics that do not differ greatly from the characteristics of cheese made from whole milk, by adding chickpea proteins as an alternative to fat, as the protein improves its sensory properties, and this is consistent with what Abou-Zeid, (1992) found. It was also noted that chickpea proteins do not negatively affect the natural flavor of cheese that comes from milk, but rather preserve it as it is, and this is consistent with what was found by Dave, (2012) that chickpea protein does not affect the flavor, that is, it does not lead to what is known as (off- flavour), but rather improves the flavor. Cheese makes it firm and closer to the natural creamy flavor of milk fat. As for flavour, the cheese treatment with a 3% addition rate, treatment T2, received high evaluation scores and was very close to the evaluation scores of the positive control treatment. El-Sayed, (2006) stated that the sensory evaluation of cooked cheese in the overall result gradually declines with increasing levels of vegetable protein addition up to 15 % but it is still a consumer favorite. This decrease in overall score relates to flavor but not color or texture. The difference in flavor and taste may be due to the influence of some chemical developments. As for the grades awarded for bitterness and fat separation from the overall results of the sensory evaluation of the processed cheese treatments with chickpea proteins added, it can be said that the processed cheese treatment with chickpea proteins added in all proportions obtained the highest grades for the sensory evaluation and acceptability.

CONCLUSION

This study suggested that the additives improved the textural properties and improved the sensory properties of low-fat processed cheese.

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Author Contributions

Conceptualization, methodology, software, and validation by SHA and formal analysis, investigation, and resources by DIA; both authors have read and agreed to the published version of the manuscript.

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