Improving Low-Fat Soft Cheese Quality Properties Made From Reconstituted Skim Milk By Using Whey Protein Concentrate as A fat Replacer

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Abstract

This study was conducted to determine the effect of using whey protein concentrate (WPC) as a fat replacer and its role in improving the physicochemical, rheological, and sensory properties of low-fat soft cheese by adding four different ratios of (WPC) as (1.0,1.5,2.0,2.5) % to reconstituted bovine skim milk in four treatments (W2, W3, W4, W5) respectively, besides control cheese treatment (W1) which was made of whole bovine milk. The chemical tests included the percentage of moisture, protein, fat, lactose, and ash. The physical tests included the percentage of total acidity, pH, springiness, and compression ability besides cheese yield percentage, total energy, and sensory evaluation after cheese making and throughout the 14 days of storage time at (5±1)°C. Results showed that all (WPC) treatments have high moisture percentage compared to the control treatment, though all the treatments had a decrease in moisture values with storage. Results also showed a decrease in fat content for all the skim milk treatments with (WPC) addition. Lactose percentages were converged in all treatments. The results also showed an increase in total acidity and a decrease in pH for the (WPC) addition treatments. Microbiological results showed increased total count for the (WPC) addition treatments compared with the control. Furthermore, the results showed that adding (WPC) led to improving the springiness and compression ability and increased the cheese yield. On the other hand, it decreased the cheese energy compared to control. Sensory properties were improved by added WPC.

Keywords: Low-fat, Soft cheese quality, Whey protein concentrates, Fat replacer.

1.Introduction

Soft cheese is widely consumed around the world, especially in the United States of America and Mexico, for it has a natural milk flavor with a slightly salty taste, and moisture of around 58% [1], even after 15 days of storage, which is originally higher directly after manufacturing [2-4]. Fat is a major source of body energy, essential for growth, and supplying it with essential fatty acids, fat-soluble vitamins, and other compounds [5]. On the other hand, it is a cause for many diseases, generally, the proportion of fat should not exceed 30% of total calories in the daily diet [6].

In recent years, many consumers became increasingly concerned about the relationship between food and health; this made them resort to reduce their consumption of high-fat food products, in that concern, some types of cheese a major source of fat. Reducing this fat is a technological challenge because fat plays a significant role in rheological characteristics, texture properties, and sensory evaluation as well functional characteristics of the product [7]. Since cheese plays a key role in the diet of large segments of communities [8]. So recent studies have tended to add some substances as a fat replacer that work on improving the rheological properties of products, these are called fat mimetics, an example is whey protein concentrates [9]. Whey proteins as fat replacers are used to improve the sensory properties of low-fat cheese [10], to give more protein holes and less protein density in the protein network making it better in texture compared with the full-fat cheese. Adding to that, whey proteins have emulsifying properties [11,12]. In recent years the use of whey proteins in the formation of many food products has increased, this use is not just for their nutritional importance but also their functional and technological properties. β-lactoglobulin and α-lactalbumin being the main proteins in it, counting about 70% of total whey proteins, are the main contributors to the functional properties of whey proteins, they are globular, have high water and oil absorption and binding ability, this with the ability to surround the air to form bubbles helps to increase the stability of the emulsions [13,14]. The functional behavior of whey proteins in foods is very complex, due to the interactions associated with the internal properties of these proteins (chemical composition, amino acid sequence, molecular weight, nature of the formation,
elasticity, net charge, ability to bind to water, and external factors (heat, pH, and other food components) [15]. Reducing the fat content of food results in low moisture to protein ratio (M:P), low protein to water binding, and a high level of interactions between proteins [16]. For example, the (M:P) values for the full fat, low fat, and free fat mozzarella cheese are 2.31, 1.99, and 1.64 respectively (Dave et al. 2003). The best way to produce a low-fat cheese with a soft texture is by increasing its moisture content to reach an (M:P) ratio equal to or more than that of the full-fat [17]. Our study aimed to manufacture low-fat, low-calorie soft cheese from reconstituted skim milk by adding whey protein concentrates as a fat replacer and studying their role in improving the physical, chemical, and sensory properties of low-fat soft cheese.

2.Materials and Methods

Whole bovine milk was used in soft cheese control treatment W1 manufacturing that processor from farm fields near Al Qasim Green University. Reconstituted bovine skim milk (0.5% fat) from Nido company –France was used in W2, W3, W4, and W5 cheese treatments manufacturing. Whey protein concentrates (34%protein) supplied from Iranian Golshad Company, A microbial rennet [18], CaCL₂ was used.

2.1 Cheese manufacturing

Soft cheese manufactured according to [19], with some modifications, control treatment(W1) made from whole bovine milk, while low-fat soft cheese treatments were made from dried skim milk after reconstitution in distilled water at 30°C. Milk was divided into four treatments that represented as (W2, W3, W4, W5) fortified with whey protein concentrates (WPC) at 1.0, 1.5, 2.0, 2.5 % (w/v) respectively. Substitution treatments were mixed by electric blinder to ensure that they are well mixed and are released in the refrigerator until the next day to ensure complete dissolution of fat replacer. The control treatment was heated at 62.8°C for 30 min while all substitution treatments were heated at 85°C for 30 min to denaturation of whey proteins, cooled to 32°C, calcium chloride was added by 0.02% w/v. Microbial rennet was added after dissolved with distilled water according to the instructions of the manufacturer and left 30 min until the clotting gets, then the clot was cutting and left for 5 min without stirring, then stir the clot for 30 min and drain the whey, then add salt by 2-3% of the weight of the clot. Then the clot was packed and kept in the refrigerator at 5 ° C.

2.2 Chemical analysis

Fat percentage was determined according to [20], while pH, the percentage of moisture, ash, and total acidity were determined according to [22]. Lactose was determined according to [21]. Total nitrogen was determined using the Kjeldahl method, digestion, and distillation process was accomplished according to [23], using a German analyzing system of the type Behr model S2.

2.3 Physical tests

2.3.1 Compression test

The compression force was estimated using a special uniaxial compression device according to the method described by [24]. The device is equipped with a cylinder with a diameter of 49 mm. Samples were cut in a cylindrical shape with a diameter of 2.4 cm and a height of 1.6 cm at 6 °C. The sample was put in a sealed container to prevent loss of moisture from the sample, and then taken out and then kept at room temperature for 4h before the test was placed in the device and put pressure down the non-axial compressor at 50 mm / min (speed) until the sample crashed.

2.3.2 Total energy values

Total caloric values were calculated according to( Cengiz and Gokoglu, 2005 ), the following equation was used:

\[ K = (Fp \times P) + (Fl \times L) + (Fc \times C) \]

Where:

K= energy, F=the coefficient for each component where Fp of protein is 4.27, of fat, Fl is 9.02 and of carbohydrates, Fc is 4.10., P = protein percentage g / 100 g. The L = fat percentage g/ 100 g. And C = carbohydrate percentage g / 100 g.

Cheese yield: yield was calculated by the weight of the cheese mass-produced to the weight of the milk used [25], as in the following equation:
2.4 Microbiological Tests

Total count bacteria, coliform count, Psychrophilic, yeasts, and molds count were determined according to [26]. while *Staphylococcus aureus* count was determined according to [27].

2.5 Sensory evaluation

Sensory tests of soft cheese models were conducted in the Department of Dairy Science and Technology – Faculty Food Science - AL - Qasim Green University by 10 trained panelists with competence the sensory evaluation form used is from [28].

2.6 Statistical analysis

The SAS (2012) program was used according to a complete random design (CRD) to study the effect of different factors on the studied characteristics, and the significant differences between the means were compared with the least significant difference (L.S.D) test.

3. Results and Discussion

3.1 Cheese composition

The results in table (1) shows soft cheese composition, pH, and percentage of total acidity, the moisture percentage for the control treatment (W1) directly after manufacturing was 61.79% while for WPC addition treatments (W2, W3, W4, W5) were 69.01, 68.05, 67.43 and 66.71%, respectively. As noted from the table increased moisture content in WPC addition treatments compared to control treatment this is due to differences in protein content, as the high protein content in low-fat cheeses contributed to increased water absorption by the protein network thus increase their moisture content and these results were in line with [29]. Also, the addition of WPC as a fat replacer gives high water.

| Treatment          | Cheese age (day) | % Moisture | % Protein | % Fat  | % Lactose | % Ash | pH  | % Total acidity |
|--------------------|------------------|------------|-----------|--------|-----------|-------|-----|-----------------|
| Control W1         | 0                | 61.79      | 17.01     | 16.00  | 3.50      | 1.70  | 6.75| 0.16            |
|                    | 7                | 61.59      | 17.21     | 16.10  | 3.30      | 1.80  | 6.61| 0.18            |
|                    | 14               | 61.13      | 17.36     | 16.38  | 3.12      | 2.01  | 6.00| 0.38            |
| W2 1.0%            | 0                | 69.01      | 21.53     | 3.79   | 3.77      | 1.90  | 6.70| 0.17            |
|                    | 7                | 68.89      | 21.70     | 3.86   | 3.58      | 1.97  | 5.91| 0.31            |
|                    | 14               | 68.39      | 22.03     | 3.93   | 3.40      | 2.25  | 5.60| 0.41            |
| W3 1.5%            | 0                | 68.05      | 22.20     | 3.76   | 3.74      | 2.25  | 6.54| 0.19            |
|                    | 7                | 67.45      | 22.50     | 3.91   | 3.61      | 2.53  | 6.11| 0.24            |
| Cheese treatments  |                  |            |           |        |           |       |     |                 |
| WPC addition       |                  |            |           |        |           |       |     |                 |
| W4 2.0%            | 0                | 67.43      | 23.08     | 3.58   | 3.60      | 2.31  | 6.50| 0.18            |
|                    | 7                | 66.89      | 23.31     | 3.70   | 3.49      | 2.61  | 6.23| 0.22            |
|                    | 14               | 66.62      | 23.40     | 3.82   | 3.39      | 2.77  | 5.52| 0.42            |
| W5 2.5%            | 0                | 66.71      | 23.30     | 3.60   | 3.79      | 2.60  | 6.47| 0.21            |
|                    | 7                | 66.52      | 23.40     | 3.69   | 3.69      | 2.70  | 6.33| 0.39            |
|                    | 14               | 66.35      | 23.50     | 3.80   | 3.52      | 2.83  | 5.51| 0.43            |
| LSD value          |                  |            |           |        |           |       |     |                 |
|                    | 5.071 *          | 3.188      | 3.552     | 0.409 *| 2.058     | 0.716 | 0.205* | 0.43            |

W1: control treatment, W2: treatment with 1.0% WPC, W3: treatment with 1.5% WPC, W4: treatment with 2.0% WPC, W5: treatment with 2.5% WPC.
Retention which increases the moisture content of low-fat cheese [30]. As noted decreased moisture content also treatments by increasing the added percentage of WPC due to increased percentage of total solids. Low moisture is also observed for all treatments with storage as it was after 14 days of control treatment is 61.13% and for (WPC) addition treatments were 68.39, 67.18, 66.62, and 66.35%, respectively, these results agree with [31], who indicated decreasing the moisture content of tigala soft cheese with storage period. The protein percentage control treatment directly after manufacturing was 17.01%, and for WPC addition treatments were 21.53, 22.20, 23.08, and 23.30% respectively. As noted increased moisture content besides treatments due to that WPC addition WPC increase the protein content in these treatments a similar conclusion reached by [32], who was found that adding WPC to milk prepared for the soft cheese making has increased the protein content of the produced cheese. As noted increased protein content during storage for all soft cheese treatments were after 14 days of storage, the control treatment protein percentage was 17.36%, and for WPC addition treatments were 22.03, 22.88, 23.40 and 23.50%, respectively. This decline is due to the loss of moisture content which increases of total solids percentage. The fat percentage of the control treatment was 16.00%, and for the WPC addition treatments directly after manufacturing reached 3.79, 3.76, 3.58, and 3.60% respectively. As it was observed from the results in Table (1), there was an increase in the percentage of fat for all cheese treatments and all storage periods, it reached 16.38% for the control treatment and for the WPC addition treatments were 3.93, 3.94, 3.82 and 3.80%, respectively, after 14 days of cold storage, these results agree with [33], who attributed the reason to the continuation of Whey separation and moisture decline and thus increases of total solids percentage. Lactose percentage of control treatment was achieved directly after manufacturing 3.50%, and for WPC addition treatments were 3.77, 3.74, 3.60, and 3.79%, respectively. It is also noted that this percentage is increased with storage for all treatments after 14 days, the control treatment was 3.12% and for WPC addition treatments were 3.40, 3.40, 3.39, and 3.52%, respectively. The reason for this decrease is attributed to the transformation of lactose to lactic acid induced by lactic acid bacteria or may be attributable to the loss during whey separation. The ash percentage directly after manufacturing in the control treatment was 1.70% and for the WPC addition treatments were 1.90, 2.25, 2.31, and 2.60% respectively. Our result for very close to what found Abd El- Salam(2015) who indicated the ranged ash content in soft cheese with WPC as fat replacer between (2.26 - 2.92)%. It was observed that the ash content of the WPC addition treatments was higher compared to the control treatment, and this is due to whey protein, which has a high ash content and a similar conclusion reached by [34,35]. It is also noticeable that the ash content for all treatments was increased during storage, It reached for control treatment after 14 days 2.01% and for the WPC addition were 2.25, 2.60, 2.77 and 2.83%, respectively.

3.1.1 pH

The pH value control treatment was 6.75, and for the WPC addition treatments were 6.70, 6.54, 6.50, and 6.47, respectively. A lower pH value of WPC addition treatments was also observed compared to a control treatment because WPC contains additional amounts of lactose, which increases the potential for lactic acid production and thus decreased pH values due to microbial activity [36]. The pH values are also observed to be decreased during storage, which after 14 days for control treatment was 6.00 and for the additional treatments were 5.60, 5.53, 5.52, and 5.51, respectively.

3.1.2 Total acidity

The percentage of total acidity control treatment after manufacturing is 0.16%), and for the WPC addition treatments reached 0.17, 0.19, 0.18 and 0.21%, respectively. As noted increased total acidity values of WPC addition treatments compared to control treatment, these results were in line with [37], who reported The heat treatment of skim milk by 2.0% WPC caused increased viscosity, total acidity, and decreased pH value compared to Heat treated skim milk. It is also observed that the percentage of total acidity is increased with storage which reached for control after 14 days 0.38 and for WPC addition treatments were 0.41, 0.40, 0.42, and 0.43% respectively.

3.2 Physical characteristics

3.2.1 Compression

Figure (1) shows the cheese sample's hardness results, it is illustrated by the presence figure evident differences in the amount of force projected on cheese samples indicating different treatments. Their hardness varies depending on the milk type, chemical composition type, and quantity of fat replacer. As noted from the figure, the high hardness of WPC addition treatments compared to the hardness of control treatment, these results agree with [38], who found when he studied soft cheese that supported with Simpleese R100 and Novagil NC-200 as a fat replacer from having a high hardness of soft cheese made from skim milk compared to soft cheese made from whole milk and fat replacers WPC addition soft cheese because of its high content of casein, these results agree with [39], who reported that fat plays a great role in.
Figure 1. The Compression of different soft cheese treatments after 1 day of refrigerated storage at 5°C. W1: control treatment, W2: treatment with 1.0% WPC, W3: treatment with 1.5% WPC, W4: treatment with 2.0% WPC, W5: treatment with 2.5% WPC.

Full-fat cheeses as a lubricant by its ability to penetrate between the folds of the protein matrix and thus make cheese softer. It also agrees with [40], who reported that the hardness of fresh low-fat soft cheese treatment contain WPC was increased compared to soft cheese treatment containing sunflower oil as a fat replacer. Maybe the reason for this increase is the interactions of whey protein concentrates within the cheese matrix leading to an increased protein/fat ratio makes the cheese matrix more integrated and the protein takes up more space in it [41]. [42], indicated that adding WPC to milk lead to the incorporation of whey protein into the pores of the casein network of cheese matrix-like fat globules, this yielded a higher protein/fat ratio which gave the protein matrix a way to compact and continuous relatively large areas. [43], found that both partial or total substitution of milk fat by WPC and/or canola oil caused significant modification on soft cheese hardness, chewiness, and cohesiveness properties.

3.2.2 Cheese energy

The results regarding the energy values for the different cheese treatments in Table 2 shows that the highest energy value was recorded for the control treatment to be 231.5 Kcal / 100 g cheese, while for the WPC addition

| Treatment                  | Energy from fat | Energy from protein | Energy from carbohydrates | Total energy |
|----------------------------|-----------------|---------------------|---------------------------|--------------|
| Control W1                 | 144.32          | 72.63               | 14.35                     | 231.30       |
| W2 1.0%                    | 34.18           | 91.93               | 15.45                     | 141.56       |
| W3 1.5%                    | 33.91           | 94.79               | 15.33                     | 144.03       |
| W4 2.0%                    | 32.29           | 98.55               | 14.76                     | 145.60       |
| W5 2.5%                    | 32.47           | 99.49               | 15.53                     | 147.49       |
|                            | 15.474 *        | 6.501 *             | 1.776 NS                  | 18.538 *     |

* (P≤0.05).

W1: control treatment, W2:treatment with 1.0% WPC, W3: treatment with 1.5% WPC, W4: treatment with 2.0% WPC, W5: treatment with 2.5% WPC.

Treatments these values were 141.56, 144.03, 145.60, and 147.49 Kcal / 100g cheese respectively, this is of course because the cheese in these treatments is made of skim milk with WPC addition, and these WPC proteins can bind water, hence increasing the water content and decreased total solids percentage of the produced cheese.
3.2.3 Cheese yield

The results in a table (3) shows cheese yield percentage of different cheese treatment, It reached for control treatment after 1 day of cheese manufacturing 12.77 % and for the WPC addition were 13.02, 14.93, 16.09, 18.22% respectively. Similar trends were given by [16], who reported that adding WPC to skim milk prepared to cheese making increased cheese yield by more than 60%. Also, these results agree with [22], who reported that the WPC addition to milk prepared to cheese making contributes to increasing cheese yield According to their quantities due to the increase in total solids. Besides, whey protein precipitate on casein micelles which leads cheese to retains moisture and increased yield, since β-lactoglobulin protein is responsible for increasing cheese yield by binding it to water [12]. Whey protein denaturation temperature causes the protein form to be changed and makes the previously hidden protein - water binding sites exposed to water, thus increases

Table 3. Cheese yield of different soft cheese treatments after manufacturing and during 14 days of storage at 5°C.

| Cheese age (day) | Treatment | 0   | 7   | 14  |
|-----------------|-----------|-----|-----|-----|
| Control W1      | W2 1.0%  | 12.77 | 11.76 | 11.56 |
| Cheese treatments with WPC addition | W3 1.5% | 13.02 | 12.91 | 12.75 |
| W4 2.0%         | W5 2.5%  | 14.93 | 14.34 | 14.00 |
|                 | LSD value | 16.09 | 15.88 | 15.11 |
|                 |           | 18.22 | 17.90 | 17.20 |
|                 | * (P<0.05) | 3.668 | 2.094 * | 3.631 * |

W1: control treatment, W2: treatment with 1.0% WPC, W3: treatment with 1.5% WPC, W4: treatment with 2.0% WPC, W5: treatment with 2.5% WPC.

The volume of the occupied or the water-linked protein [29], and by that, the yield is increased. Furthermore, [11] pointed that the proportion between WPC and the caseins is the key to improve cheese yield.

3.2.4 Microbiological tests

The results in a table (4) showed that bacterial total count of control treatment reached 18×10^3 CFU/gm while for WPC addition treatments were 2.0×10^3, 2.0×10^3, 2.3×10^3, 2.0×10^3 CFU/gm respectively. From the results, it is clear that increased total count of bacteria of WPC addition treatments compared with control treatment, these results were agreement with [23], who reported that remove fat promotes the growth and activity of bacteria. [42], pointed out the importance of whey proteins in stimulating the growth of microorganisms by providing them with its need of amino acids and peptides. Coliform bacteria, Psychrophilic, and yeasts, molds did not notice any growth in all treatments, a similar conclusion reached by [43], Staphylococcus aureus bacteria did not show growth until the seventh day of storage at 5°C it's total count were 10 CFU/gm whereas for WPC addition treatments were 33, 77, 45 and 65 CFU/gm respectively. From the results, it is clear that there was a gradual increase in all microorganisms total counts at all treatments with storage, that is due to the addition of WPC that had helped in boosting the growth and activity of the different microorganisms by providing them with needed, essential, amino acids and peptides [8]. The bacterial total counts reached at the end of storage for control treatment 7.6×10^6 CFU/gm and for WPC addition treatments were 2.6×10^5, 9.0×10^5, 10×10^5 and 3.0×10^6 CFU/gm respectively. And total counts of Staphylococcus aureus of control treatment was 100 CFU/gm and for WPC addition treatments were 85, 150, 100, and 200 CFU/gm respectively. Total counts of Psychrophilic bacteria of control treatment was 5.5×10^4 CFU/gm and for WPC addition treatments were 7.3×10^5, 5.1×10^5, 5.1×10^5, and 6.1×10^5 CFU/gm respectively. Total counts of yeasts and molds of control treatment were 80 CFU/gm and for WPC addition treatments were 82, 83, 81, and 72 CFU/gm respectively.
Table 4. Microbiological tests of different soft cheese treatments after manufacturing and during 14 days of storage at 5°C.

| Treatment                  | Cheese age (day) | Total count CFU/gm | Coliform CFU/gm | Staphylococcus aureus CFU/gm | Psychrophilic bacteria CFU/gm | yeasts and Molds CFU/gm |
|----------------------------|------------------|--------------------|----------------|-------------------------------|-------------------------------|--------------------------|
| Control W1                 | 0                | 18×10³             | ---            | ---                           | ---                           | ---                      |
|                            | 7                | 3.8×10⁴             | ---            | 10                           | 3.1×10⁴                         | 65                       |
|                            | 14               | 7.6×10⁵             | ---            | 100                          | 5.5×10⁴                         | 80                       |
|                            | 0                | 2.0×10³             | ---            | ---                           | ---                           | ---                      |
| W2                         | 7                | 4.1×10⁴             | ---            | 33                           | 2.6×10³                         | 76                       |
| 1.0%                       | 14               | 2.6×10³             | ---            | 85                           | 7.3×10⁴                         | 82                       |
|                            | 0                | 2.0×10³             | ---            | ---                           | ---                           | ---                      |
| W3                         | 7                | 5.5×10⁵             | ---            | 77                           | 4.0×10⁴                         | 64                       |
| 1.5%                       | 14               | 9.0×10⁴             | ---            | 150                          | 5.1×10⁴                         | 83                       |
| Cheese treatments with WPC addition | 0                | 2.3×10³             | ---            | ---                           | ---                           | ---                      |
| W4                         | 7                | 10×10⁴              | ---            | 45                           | 3.0×10⁴                         | 60                       |
| 2.0%                       | 14               | 10×10⁴              | ---            | 100                          | 5.0×10⁴                         | 81                       |
|                            | 0                | 2.0×10⁴             | ---            | ---                           | ---                           | ---                      |
| W5                         | 7                | 2.8×10⁶             | ---            | 65                           | 3.3×10⁴                         | 53                       |
| 2.5%                       | 14               | 3.0×10⁶             | ---            | 200                          | 6.1×10⁴                         | 72                       |
| LSD value                  | 64.39 *          | NS                 | 17.498 *        | 25.07 *                       | 6.441 *                       |

W1: control treatment., W2: treatment with 1.0% WPC , W3: treatment with 1.5% WPC, W4: treatment with 2.0% WPC, W5: treatment with 2.5% WPC

3.2.5 Sensory evaluation

The results of sensory evaluation tests table(5) show convergence of scores granted to WPC addition cheese treatments compared to control treatment scores and directly with increasing of WPC addition ratio. It also notes an improvement in sensory properties by increasing the WPC addition ratio, the best one was in treatment (W5) with 2.5% WPC. These results were in line with [17], who indicated the positive effect of adding WPC to feta cheese production milk on sensory properties of resulting cheese. Also results of the color attribute evaluation show convergence between WPC addition treatments and control, this may be since whey proteins are a natural ingredient of milk and contain riboflavin responsible for the yellowish-green color of the compounds contributing to the color of cheese, so whey protein addition did not negatively affect to cheese color [20]. The addition of WPC also improved cheese body and texture by gave it an elastic texture closer to control treatment. A similar conclusion was reached by [18], who reported that addition WPC may increased cheese moisture content and improve texture. Also, these results agree with [6], who indicated that the positive contribution of WPC in cheese body and texture may be because whey protein concentrates overlap inside the cheese matrix.

As for the flavor, the results showed that WPC addition treatments had good scores compared to control treatment, the obtained results are in agreement with those obtained by Carunchia- Whetstine who reported that WPC flavor was more acceptable and have a desirable fatty taste. [23], revealed that the best body and texture quality properties were obtained in whey proteins WPC addition treatments when he used Dairy-Lo (a component of whey proteins) as a fat replacer. As for the presence of pores, the treatment W4 with 2.5% WPC obtained high scores that were closer to the scores of control treatment this is due to the role of whey proteins in providing a more compact protein matrix. As noted from the results decreased all sensory scores with storage progression, these results were in agreement with [19], who pointed out that all soft cheese sensory quality properties gradually decreased with storage progression.
Table 5. Sensory evaluation of different soft cheese treatments after manufacturing and during 14 days of storage at 5°C.

| Treatment                        | Colour 10° | Flavor 10° | Body 10° | Texture 10° | Pores 10° | Bitterness 10° | Total from 60° |
|----------------------------------|------------|------------|----------|-------------|-----------|----------------|----------------|
| Control W1                       | 10.0       | 9.4        | 9.4      | 9.6         | 10.0      | 10.0           | 58.4           |
| W1                               | 7          | 9.7        | 7.8      | 8.2         | 7.8       | 8.4            | 51.5           |
| W2                               | 0          | 9.6        | 9.7      | 9.4         | 9.6       | 10.0           | 57.8           |
| 1.0%                             | 7          | 8.8        | 8.8      | 8.4         | 8.0       | 9.6            | 51.6           |
| W3                               | 14         | 5.2        | 5.4      | 6.0         | 5.4       | 8.8            | 37.6           |
| 1.5%                             | 7          | 9.8        | 9.6      | 9.6         | 10.0      | 9.0            | 58.0           |
| W4                               | 14         | 6.2        | 6.0      | 5.8         | 6.0       | 8.6            | 39.7           |
| 2.0%                             | 7          | 9.2        | 9.0      | 8.8         | 8.0       | 8.8            | 53.3           |
| W5                               | 14         | 9.5        | 9.8      | 9.5         | 9.3       | 10.0           | 58.1           |
| 2.5%                             | 6          | 8.4        | 9.4      | 8.5         | 8.3       | 9.2            | 53.2           |
|                                  |            |            |          |             |           |                |                |
| Cheese treatments with WPC       |            |            |          |             |           |                |                |
| addition                         |            |            |          |             |           |                |                |
| W2                               | 0          | 9.8        | 9.6      | 9.6         | 10.0      | 9.0            | 58.0           |
| 1.0%                             | 7          | 9.2        | 9.0      | 8.8         | 8.0       | 8.8            | 37.6           |
| W3                               | 14         | 6.2        | 6.0      | 5.8         | 6.0       | 8.6            | 39.7           |
| 1.5%                             | 7          | 9.5        | 9.8      | 9.5         | 9.3       | 10.0           | 58.1           |
| W4                               | 14         | 6.3        | 5.7      | 5.2         | 5.4       | 8.6            | 38.6           |
| 2.0%                             | 7          | 9.7        | 9.6      | 9.8         | 9.7       | 9.8            | 58.2           |
| W5                               | 14         | 7.7        | 7.5      | 8.5         | 6.9       | 9.0            | 48.3           |
| 2.5%                             | 7          | 7.2        | 5.9      | 7.0         | 6.4       | 8.2            | 42.4           |
|                                  | 1.826      | *          | 1.55 *   | 1.893       | 1.668     | 1.421          | 5.769 *        |
| LSD value                        |            | *          | *        | *           | *         | 1.502          |                |

W1: control treatment, W2: treatment with 1.0% WPC, W3: treatment with 1.5% WPC, W4: treatment with 2.0% WPC, W5: treatment with 2.5% WPC

* LSD value * (P≤0.05).

Conclusion

It became possible to produce a low-fat soft cheese by adding whey protein concentrates as a fat replacer to the dried reconstituted milk and subjecting it to high temperature treatment, then cooling it and adding calcium chloride. The effects of this process are to improve the rheological properties such as compressibility and springiness, in addition to increasing the percentage of total solids, especially protein content, reducing the total energy, increasing the cheese yield, and improving the organoleptic properties of the low-fat soft cheese.

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