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**RESEARCH ARTICLE**

# Effect of Spirulina Powder on Physical and Chemical Composition of Yoghurt Produced from Milk of Different Somatic Cell Counts

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## ABSTRACT

Processing of high somatic cell count (SCC) milk can negatively affect dairy product quality. Spirulina has highly nutritive ingredients and has recently been incorporated into the food industry. In this study, yoghurts were produced from two batches of milk [low SCC and high SCC milk using the California Mastitis (CMT)] which were subjected to chemical examination to detect the effect of high SCC on milk composition and fortified with different concentrations (0.25, 0.5, and 1%) of Spirulina powder (SPP). Yoghurt samples were subjected to chemical (using the MilkoscanTMFT1 system), physical, and sensory examination. The results revealed that the addition of SPP decreased the coagulation time, syneresis, and pH values. The compositional parameters (fat, protein, TS, and SNF%) increased with the addition of SPP in both low-SCC and high-SCC-fortified yoghurts. The results of sensory evaluation concluded that 0.25% Spirulina enriched yoghurt received better scores regarding all sensory attributes. In conclusion the enrichment of yoghurt with 0.25% spirulina powder can improve the nutritional quality of yoghurt without interfering with its sensory properties.

***Keywords*****:** Spirulina, somatic cell count, Yoghurt, milk quality, Yoghurt quality.

## Introduction

Milk components biosynthesis takes place in the secretory cell of mammary alveoli and its function and structure are going hand-in-hand therefore, milk production and its components secretion depend on the biochemical and structure of the cell. During a bacterial infection such as mastitis, several changes occur in the alveolar cell. These changes include disruption of cell integrity, induced apoptosis, sloughing of cells, and an increase in poorly differentiated cell [1]. Also, during mastitis, somatic cell count (SCC) increases with increasing inflammation levels because of increasing leukocyte migration from vascular into mammary cells to combat the inflammation as well as increasing sloughed cell level [2]. All these factors will lead to a negative effect on milk yield and composition with SCC elevation in case of subclinical mastitis (SCM) and clinical mastitis (CM).

Reduction in fat content of milk with SCC elevation during SCM can be owed to a reduced secretory and synthetic capacity of the mammary gland that may be due to the alteration of milk globule membrane by leucocyte lipases or by plasmin through the hydrolysis of lipoproteins, both of which may enhance lipolysis [3]. The reduction in lactose content of milk was attributed to the reduction of lactose synthetic ability of the mammary tissue [4]. Moreover, Pessora *et al.* [5]attributed lactose reduction in case of mastitis to changes in the mammary gland homeostasis. Berglund *et al.* [6] also, found a similar reduction in lactose content (from 4.86 to 4.69%) associated with SCC increase.

The use of high SCC milk in the manufacturing of dairy products can affect the dairy products quality. Some pathogens of mastitis enhance the production of urokinase, a plasminogen activator in bovine epithelial cells with subsequent increase in plasmin concentration. The quality of the dairy product is influenced by plasmin through the hydrolysis of casein which affects the coagulation properties of milk. Also, plasmin can survive with heat treatment and 30% to 40% of plasmin activity can be determined in milk even after Ultra-high-temperature pasteurization (UHT) treatment [7,8].

Somatic cells are considered as an imperative source of endogenous proteins including enzymes. A wide variety of enzymes are released into milk after the SCs lysis. These enzymes include lipases, oxidases, glycosidases (e.g. lysozyme), and proteases including elastase, collagenase, and cathepsins B, C, D and G, which contribute to hydrolysis of casein [9,10]. This can clear up the persistence of compositional changes in the dairy products during the storage period leading to the production of low-quality dairy products. The average level of lipolysis [free fatty acids (FFA)] increases, and casein hydrolysis were respectively three and two times faster in high SCC milk than in low SCC milk during refrigerated storage [7].

Spirulina is a filamentous cyanobacterium which is recently incorporated in the food industry, feed additives, medicine, and the pharmaceutical sector. It has highly nutritive ingredients such as proteins, carbohydrates, lipids, polyunsaturated fatty acids, essential amino acids, minerals, vitamins, and raw fibres which makes it an excellent nutritional supplement in food products and feed supplementation [11]. It provides a good resource for natural antioxidants (as phenolic compounds, phycocyanin pigments, and carotenoids) [12].

Spirulina has about 61.57% of protein and high content of essential amino acids (about 38.81%). It is preferable for children because of its great content of iron and calcium (338.76 and 1043.62 mg/100 g, respectively) [13]. Spirulina also has many health benefits because of its chemical composition, and it inhibits several diseases development as high blood pressure, cancer, and renal failure [14]. Spirulina contains bioactive chemicals which enhance the nutritional content of food so, can be used in the production of functional foods.In an effort to enhance the nutritional value of yoghurts and other fermented dairy products, researchers have recently instigated to add spirulina powder to them [11, 15] and it was proved lately that spirulina can improve the growth of lactic acid bacteria not only in synthetic media but also in milk and yogurt [16].

The current research aimed to evaluate the effect of Spirulina powder addition with different concentrations on the quality and composition of yoghurts produced from milk of different SCC levels.

## Materials and methods

### *Milk sampling*

Two batches of milk were collected according to their content of SCC (low SCC and high SCC milk) using CMT. All milk samples were directly transferred under refrigeration and hygienic conditions with minimum delay for production of yoghurt.

### *Detection of chemical parameters of raw milk batches*

The two batches of milk were examined for determination of the chemical parameters of milk including fat, protein, total solids, and solid non-fat content using MilkoscanTMFT1 system (Electromagnetic Company Compatibility (EMC) Directive 2014/30/EU, Low voltage Directive (LVD) 94/62/EU, Packing and Packing waste directive 94/62/EU, WEEE Directive 2012/19/EU, REACH Directive 1907/2006/EC ).

### *Production of yoghurt*

Each batch of the two fresh raw milk batches (low and high SCC milk batches) was firstly divided into four parts to produce four categories of yoghourt after Bchir *et al.* [17]**,** then Spirulina powder (produced by Imtenan Health Shop Plot no. 10 – Block 20015- The Industrial Area – Obour City, Egypt, CRN, 369456) was added with different concentrations of 0%, 0.25% [18,19 ], 0.5% [20] and 1% [15, 21]. The part of the milk without the addition of Spirulina powder (0%) acts as a control. Then, different types of milk were heated at 90°C for 20 min for dissolving of Spirulina powder and pasteurization of the mixture. After that, it was cooled to 45°C for the addition of 2% yoghurt starter culture (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) that were obtained from the Animal Health Research Institute, Cairo. The inoculated milk was mixed thoroughly, placed in 100 mL sterile plastic containers, and then incubated at 40°C until complete coagulation and then was stored at 5 ± 1°C in the refrigerator for 7 days.

### *Examination of produced yoghurt samples*

*a. Chemical analysis*

The prepared yoghurt samples were examined during the period of the experiment at (1 and 7 days) for detection of the fat, protein, total solids, and solid non-fat content using the Milkoscan$^{TM}$FT1 system.

*b. Physical analysis*

The pH of all manufactured yoghurt categories was determined and recorded by using a pH meter.

*C. Syneresis*

Yoghurt (35g) was centrifuged at 1100 rpm for 10 min. The clear supernatant was poured off, weighed, and recorded as syneresis [22].

*d. Setting or Coagulation Time*

The coagulation time of each yoghurt category was calculated by recording the starting time of the coagulation period and the end time when found complete coagulation.

*e. Sensory analysis of yoghurt*

Yoghurt sensorial evaluation was performed by a panel of fifteen judges or members (ten trained members of Animal Health Research Institute and other five people). They evaluated the yoghurt for its overall acceptance, body and texture, colour and appearance, odour, and flavour with a point scale from 0 to 5 (0 means unacceptable for human consumption and 5 means very good) [23].

***Statistical Analysis***

The obtained results were recorded as numbers and percentages, then the average and standard deviation were calculated by SPSS software version 16 (Statistical Package for Social Science).

**Results and discussion**

***Preliminary work on Spirulina enriched yoghurt manufacturing***

Initially, before the processing of the end products for evaluation and assessment, preliminary work was done to reach a suitable method for addition of Spirulina in yoghurt manufacturing. Previous researchers provided two methods for the addition of Spirulina powder during yoghurt production. In the current work both methods were conducted to choose the best. The first method was applied by adding Spirulina powder to the raw milk before pasteurization and then pasteurizing the whole mixture and leaving it to cool (45°C) for the addition of the starter [15, 17, 18, 23, 24 ]. While the second method was conducted by the addition of Spirulina powder to the inoculated pasteurized milk with starter just before the coagulation step after pasteurization and addition of the starter [19, 25].

Based on our findings during the application of the two methods, the first method provided complete dissolving of Spirulina powder with very little sedimentation in high concentrations of Spirulina, pasteurization of the whole mixture, and homogenous colour of the end product, unlike the second method in which there was graininess due to insoluble Spirulina particles leaving much sedimentation and uneven distribution of the colour in the final product. Also, the addition of Spirulina powder after pasteurization may threaten the hygienic standards during production. These findings were also mentioned by Mesbah *et al.* [15], Barkallah *et al.* [18], and Bchir *et al.* [17].

***Chemical composition of raw milk used in yoghurt manufacturing***

Chemical composition of the raw milk (low SCC and high SCC milk) used in yoghurt manufacturing was analysed. Fat, protein, TS, SNF, casein, and lactose percents in low SCC milk were 4.29, 3.65, 13.56, 9.22, 2.69, and 4.59%, respectively which were higher than that in high SCC milk which were 3.27, 3.1, 11.42, 8.36, 2.33, and 4.46%, respectively (Table 1). These results confirm the negative correlation between SCC level and milk compositional parameters which was discussed before.

**Table 1. Chemical composition of raw milk used in yoghurt manufacturing**

| Milk | Fat % | Protein % | TS % | SNF % | Casein % | Lactose % |
|---|---|---|---|---|---|---|
| **Low SCC milk** | 4.29 | 3.65 | 13.56 | 9.22 | 2.69 | 4.59 |
| **High SCC milk** | 3.27 | 3.1 | 11.42 | 8.36 | 2.33 | 4.46 |

SCC: Somatic cell count
TS: Total solid.
SNF: Solid non fat.

Chemical composition of low SCC yoghurts enriched with different concentrations of Spirulina powder at 1 day (fresh) and after seven days of refrigeration storage was recorded in Table (2). Fat, protein, TS, and SNF percents were higher in Spirulina enriched yoghurts of different concentrations than that in the control yoghurt and their values increased by increasing SPP concentration in yoghurt. Fat content increased from 4.62% in the control to 4.78, 4.81, and 4.86 in 0.25, 0.5, and 1% SPP enriched fresh yoghurts, respectively, and reached to 4.72, 4.83, and 4.74% after seven days of storage.

Protein percent also, increased from 3.93% in fresh control sample to reach the highest value (4.51%) in 1% SPP fortified fresh yoghurt, and it was 3.91% and 4.69% in control and 1% SPP yoghurt after seven days of storage. High fat and protein content in SPP enriched yoghurts is due to the natural composition of Spirulina which contain 7.12% fat content [15] and high content of protein (65-70%) [26, 27]

Similarly, TS and SNF percents raised from 14.65 and 9.61%, respectively in the control to be the highest in 1% SPP concentration (14.97 and 10%, respectively) and this may be also imputed to the inherent Spirulina composition. Also, TS and SNF percents after seven days of storage were higher in SPP enriched yoghurt than in control (Table 2).

**Table 2. Chemical composition of low SCC yoghurts enriched with different concentrations of Spirulina powder**

| Yoghurt parameters | Concentrations of Spirulina powder in yoghurts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0% | | 0.25% | | 0.5% | | 1% | |
| | fresh | 7day | fresh | 7day | Fresh | 7day | fresh | 7day |
| **Fat %** | 4.62 | 4.67 | 4.78 | 4.72 | 4.81 | 4.83 | 4.86 | 4.74 |
| **Protein %** | 3.93 | 3.91 | 4.10 | 4.06 | 4.14 | 4.20 | 4.51 | 4.69 |
| **TS %** | 14.65 | 14.09 | 14.78 | 14.13 | 14.81 | 14.45 | 14.97 | 14.50 |
| **SNF %** | 9.61 | 9.33 | 9.63 | 9.50 | 9.66 | 9.53 | 10 | 10.34 |

TS: Total solid SNF: Solid non fat.

The displayed data in Table 3 included the results of the chemical composition of high SCC yoghurts enriched with different concentrations of Spirulina powder at 1day (fresh) and after seven days of refrigeration storage. The values of all chemical composition parameters were higher in fresh SPP enriched yoghurts than the control except for fat content. Whereas fat% in 0.25% SPP enriched yoghurt (fresh) was 3.76% which was nearly the same as the control (3.72%) and decreased in 0.5% SPP enriched yoghurt (3.62%) then increased at 1% SPP concentration (3.96%). After seven days of storage, the fat percent of the control sample decreased from 3.72% in the fresh sample to 3.57% after storage period (Table 3). Also, protein content reduced in the control and 0.5% SPP enriched yoghurt. Çelekli *et al.* [25] recorded the highest levels of TS and protein with 1% of Spirulina throughout the storage period.

The change in yoghurt composition parameters during period of storage in case of high SCC yoghurts could be attributed to the influence of high SCC level which negatively affected the composition of the milk, and the effect of these milk compositional changes will persist during the storage period of the dairy products. The proteolytic activity of yoghurts was significantly affected with high SCC [4, 28] and the decreased amount of TS in yoghurt with SCC elevation was a result of the reduction in the secretion and synthesis ability of udder tissue during mastitis [29, 30]. De Noni *et al.* [31] recorded that milk indigenous proteolytic activity was correlated to plasmin and so to SCC and their activity may remain after heat treatment in dairy products.

**Table 3. Chemical composition of high SCC yoghurts enriched with different concentrations of Spirulina powder.**

| Yoghurt parameters | Concentrations of Spirulina powder in yoghurts | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0**% | | **0.25**% | | **0.5**% | | **1**% | |
| | **Fresh** | **7day** | **fresh** | **7day** | **fresh** | **7day** | **fresh** | **7day** |
| **Fat%** | 3.72 | 3.57 | 3.76 | 3.72 | 3.62 | 3.51 | 3.96 | 3.90 |
| **Protein%** | 3.62 | 3.47 | 3.89 | 3.8 | 3.92 | 3.77 | 4.24 | 4.28 |
| **TS%** | 12.90 | 12.38 | 13.11 | 13.02 | 13.78 | 13.79 | 13.83 | 13.57 |
| **SNF%** | 9.20 | 8.9 | 9.42 | 9.34 | 9.67 | 9.63 | 10.07 | 9.91 |

TS: Total solid SNF: Solid non fat.

### *Physical characterization*

*a. pH value*

The pH value of low SCC yoghurts decreased from 4.5 for control to 4.2 for SPP enriched yoghurt (Table 4). Also, there was a reduction in pH values from 4.7 for the control sample to 4.3 for SPP enriched yoghurt in the case of high SCC yoghurts, (Table 5). In conformity with our results, the reduction of pH value because of Spirulina addition was previously recorded [15, 17, 18, 20, 23, 32].Additives of Cyanobacteria significantly enhanced the proliferation level of certain thermophilic dairy industry cultures leading to an increase in acid production and consequent decrease in pH value [33]. Spirulina addition in yoghurt also caused an increase in protein and TS content hence raising the buffering capacity which demanded additional acid production by starter cultures to achieve a similar pH target [29, 34] and this can induce a reduction of coagulation time [23].

*b. Syneresis*

Syneresis refers to whey separation and it is considered a textural defect in fermented dairy products as yoghurt and one of the most effective factors influencing yoghurt quality [35]. Results in Table 4 defined that the syneresis value decreased from 7 in the control sample to 5.2 in 1% SPP yoghurt in the case of low SCC yoghurts. based on results exposed in Table 5, syneresis in the case of high SCC also decreased from 8.2 in control to 6.5 in 1% SPP enriched yoghurt.

Similar results of syneresis reduction with increasing Spirulina level were previously recorded [17, 18, 32]. While Priyanka *et al.* [23] found that syneresis decreased in yoghurt with Spirulina concentrations up to 0.2 % and then rapidly increased with concentrations higher than 0.2%. Syneresis has a direct relationship with protein and TS content since it is decreased with the elevation of protein and TS content [37]. The reduction of syneresis with increasing Spirulina concentration in yoghurt could be also owed to greater water binding capacity of Spirulina [38].

Syneresis in high SCC yoghurts was higher than that of low SCC yoghurts and this could be illustrated by the effect of SCC variation in the two categories of milk used in the yoghurt production. Syneresis and texture of yoghurt are considerably influenced by the base milk composition, fermentation process, and post fermentation treatment [39]. High SCC level negatively influenced the composition of the base milk (Table 1) and significantly affected the proteolytic activity of yoghurts [28], therefore, it could be responsible for higher syneresis rate in high SCC yoghurt than in low SCC yoghurt.

*c. Setting time*

Regarding Table 4, setting time was higher in control yoghurt which was 4h and 55 min. and tended to decrease in order reaching 3h and 20 min. in 1% SPP enriched yoghurt of low SCC. These results indicated that coagulation time decreased with increasing the concentration of Spirulina in yoghurt.Setting time in case of high SCC yoghurt also decreased from 5h and 35min. for the control to 4h for 1% SPP enriched yoghurt (Table 5). The coagulation time for the control sample was markedly higher in the case of high SCC yoghurt than that of low SCC. It was reported that high SCC increased the clotting time during production [8]. It was stated that the elevation of SCC caused an alteration of the ratio of casein nitrogen to total nitrogen (CN/SP) ratio which increases the clotting time [40].

Spirulina concentration had a direct relation with the coagulation time of yoghurt whereas increasing Spirulina concentration decreased the setting time of Spirulina enriched yoghurts. Setting time was (4h and 5min.), (3h and 40min.), and (3h and 20 min.) in 0.25, 0.5, and 1% SPP enriched yoghurts, respectively in low SCC yoghurt (Table 4). While it was (4h and 45 min.), (4h and 20 min.), and 4h in 0.25, 0.5, and 1% SPP enriched yoghurts, respectively in high SCC yoghurt (Table 5). Similar results of setting time reduction were recorded by Priyanka *et al.* [23] who achieved a decrease in setting time from 250 min. in control sample to 180 min. in 0.5% SPP enriched yoghurt. This was attributed to the alkaline character of Spirulina biomass that enhances the growth of starter bacteria and synchronously the acid production, during fermentation [41, 42]. Barkallah *et al.* [18] indicated that fortification of yoghurt with 0.25% of Spirulina could accelerate the end of fermentation with the maintenance of sensory acceptability of fortified yoghurt. In a close alignment with our results, Abd El-Sattar *et al.* [32] recorded that setting time was longer in the control than in treatments containing SPP and decreased from 147 min. in the control to 126 min. in 2% SPP-yoghurt.

**Table 4. Effect of Spirulina powder concentrations on pH, syneresis, and setting time of low SCC yoghurt**

| Spirulina Concentrations | pH | Syneresis (ml) | Setting Time |
|---|---|---|---|
| **Conc. 0%** | 4.5 | 7 | 4 h and 55 min. |
| **Conc. 0.25%** | 4.3 | 6 | 4 h and 5 min. |
| **Conc. 0.5%** | 4.2 | 5.8 | 3 h and 40 min. |
| **Conc. 1%** | 4.2 | 5.2 | 3 h and 20 min. |

Conc.: concentration of Spirulina powder.

**Table 5. Effect of Spirulina powder concentrations on pH, syneresis, and setting time of high SCC yoghurt.**

| Spirulina Concentrations | pH | Syneresis (ml) | Setting Time |
|---|---|---|---|
| **Conc. 0%** | 4.7 | 8.2 | 5 h and 35 min |
| **Conc. 0.25%** | 4.6 | 7.4 | 4 h and 45 min |
| **Conc. 0.5%** | 4.45 | 6.8 | 4 h and 20 min |
| **Conc. 1%** | 4.3 | 6.5 | 4 h |

Conc.: concentration of Spirulina powder.

*d. Sensory evaluation of Spirulina enriched yoghurt*

Sensory evaluation is the most effective and decisive factor influencing the consumer acceptance level of any product [24]. The sensory examination included evaluation of colour, odour, texture, flavour, and overall acceptance.

The average scores of the sensory examination of SPP enriched yoghurts revealed that the addition of SPP with different concentrations modified all sensory parameter scores (Table 6 and Figure 1). Results in Figure1 revealed that the scores of sensory evaluations were the highest in case of 0.25% Spirulina enriched yoghurts and decreased to reach the lowest scores in case of 1% Spirulina enriched yoghurts.

The colour score varied from 4.93 ± 0.06 for the control to 0.53 ± 0.16 for 1% SPP yoghurt sample but there was no significant difference between the control and 0.25% SPP yoghurt samples. The appearance and colour scores significantly decreased with the increase of SPP concentration. This great alteration in the colour with increasing the concentration of SPP was also, recorded in previous studies [17, 18, 23] who stated that the colour of Spirulina is the cause of the colour modification in the end product, and it changed from green to blue according to the concentration of added microalgae.

Regarding the odour, there was no significance between the control and 0.25% concentration of SPP (4.86 ± 0.09 and 4.66 ± 0.12, respectively) but odour was significantly affected by increasing SPP concentration and was the lowest in 1% SPP concentration. This is owed to the appearance of the algal odour with increasing concentration of added microalgae [18].The texture of SPP enriched yoghurt was affected in 0.5 and 1% SPP concentrations but it was more significant in 1%SPP due to the appearance of undesirable graininess and sedimentation of Spirulina powder in the yoghurt and appeared in mouth fell [17, 18].

The flavour score was the lowest in the case of 1% SPP fortified yoghurt. The undesirable flavour resulting from the addition of a high concentration of SPP may be due to the released compounds from the lipids oxidation and minerals which not only react as pro-oxidant molecules but also might produce metallic off-Flavors [43].

According to the overall acceptance scores in Table 6**,** there was no significant difference between the control sample and 0.25% SPP fortified yoghurt. The acceptability score significantly decreased with 0.5% SPP and was the lowest with the 1% SPP enriched yoghurt because of the intense green colour, graininess, sedimentation of Spirulina powder, and undesirable flavour caused by high SPP concentration.Our result was similar to that obtained by Barkallah *et al.* [18] who concluded that yoghurt of 0.25% Spirulina was significantly sufficient to accelerate the end of fermentation and maintain the sensory acceptability and textural properties of the final milk product. Also, it was nearly the same as recorded by Bchir *et al.* [17] and Malik *et al.* [36] who mentioned that 0.3% fresh Spirulina was appreciated more than other formulations and Debbabi *et al.* [19] who recorded that incorporation of Spirulina up to 0.24% into yoghurt did not affect the sensory quality. Conversely, higher concentrations (1 and 1.2%) of Spirulina recorded by Suzery *et al.* [24] and 1% SPP recorded by Mesbah *et al.* [15], Agustini *et al.* [21], Çelekli *et al.* [25] were accepted by organoleptic, chemical, and microbiological tests. While the addition of Spirulina up to 0.5% in yoghurts was recommended by Guldas and Irkin [20].

**Table 6. Sensory evaluation of Spirulina enriched yoghurt**

| Parameters | 0% conc. (control) | 0.25% conc. | 0.5% conc. | 1% conc. |
|---|---|---|---|---|
| **Colour and appearance** | $4.93 \pm 0.06^{a}$ | $4.46 \pm 0.19^{a}$ | $2.86 \pm 0.25^{b}$ | $0.53 \pm 0.16^{c}$ |
| **Odour** | $4.86 \pm 0.09^{a}$ | $4.66 \pm 0.12^{a}$ | $2.93 \pm 0.24^{b}$ | $0.53 \pm 0.19^{c}$ |
| **Texture** | $4.86 \pm 0.09^{a}$ | $4.53 \pm 0.12^{a}$ | $2.66 \pm 0.24^{b}$ | $0.26 \pm 0.19^{c}$ |
| **Flavour** | $5 \pm 0.00^{a}$ | $5 \pm 0.00^{a}$ | $4.60 \pm 0.13^{a}$ | $1.2 \pm 0.40^{b}$ |
| **Overall acceptance** | $5 \pm 0.00^{a}$ | $4.8 \pm 0.10^{a}$ | $3.4 \pm 0.16^{b}$ | $0.2 \pm 0.10^{c}$ |

Different letters (a, b, c) indicate significant difference.

Conc.: concentration of Spirulina powder.

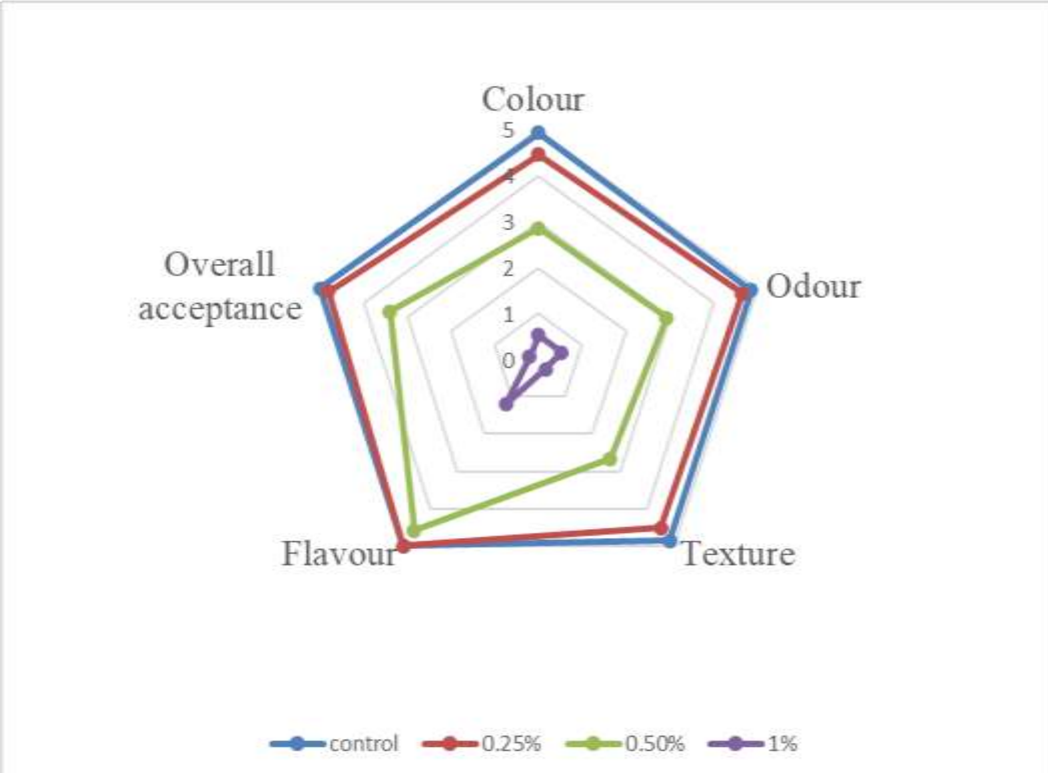


**Figure 1. Sensory examination of Spirulina powder enriched yoghurts.**

## Conclusion

Yogurt that has spirulina supplement has a higher nutritional value because to its enhanced fat, protein, TS, and SNF content as well as a decreased coagulation time and syneresis rate. Yogurt with enriched spirulina (0.25% SPP) scored higher on all sensory evaluations. In order to ensure that SPP dissolves and the mixture is pasteurized, as well as to prevent graininess, powder sedimentation, and uneven color distribution in the finished product, we advise adding Spirulina powder to the raw milk before pasteurization during the yoghurt manufacturing process.

## Conflict of interest

The authors declare that there is no conflict of interest.

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**الملخص العربي**

**تأثير إضافة بودرة الإسبيرولينا على الخواص الفيزيائية والكيميائية للزبادى المصنع من ألبان ذات مستويات مختلفة من الخلايا الجسدية**

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تصنيع الألبان ذات المستويات العالية من الخلايا الجسدية لها تأثير سلبي على جودة المنتج النهائي. تعد الإسبيرولينا من المواد الطبيعية ذات القيمة الغذائية العالية التى بدأ استخدامها مؤخرا لتدعيم بعض المواد الغدائية وإكسابها قيمة غذائية عالية ومنها منتجات الألبان. أجريت هذه الدراسة لتقييم تأثيرإضافة بودرة الإسبيرولينا بتركيزات مختلفة على الخواص الفيزيائية والكيميائية للزبادى المصنع من مستويات مختلفة من العد الكلى للخلايا الجسدية. تم إضافتها بتركيز( 0.25% ، 0.5% ، 1%) إلى الزبادى المصنع من ألبان ذات مستويين مختلفين من الخلايا الجسدية (مستوى منخفض ومرتفع) . وتم تقييم الزبادى المدعم بالإسبيرولينا حسيا وكيميائيا وفيزيائيا وقد تبين من النتائج أن تدعيم الزبادى ببودرة الإسبيرولينا أدى إلى تحسين الخواص الفيزوكيميائية والقيمة الغذائية للزبادى المدعم بالإسبيرولينا من خلال زيادة محتوى الدهون، البروتين، المواد الصلبة والمواد الصلبة اللادهنية والتى تزداد بزيادة تركيز بودرة الاسبيرولينا فى الزبادى المدعم. كما أدت إلى تقليل وقت التجبن وكمية الشرش المنفصلة من الخثرة. أظهرت عينات الزبادى المدعم بنسبة 0.25% قبولا حسيا أعلى مقارنة بالمعاملات الأخرى لذلك يمكن إستخدامه كمنتج نهائى لتحسين القيمة الغذائية للزبادى.