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EXPLORING THE POTENTIAL OF SPROUTED SOYBEAN AND SESAME HULL TO INCREASE NUTRITIONAL VALUE OF ICE CREAM

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KEY WORDS:
sesame hull, sprouted soybean, fiber, nutritious ice cream

ABSTRACT

The study aimed to produce nutritionally enhanced ice cream by adding sprouted soybean (SSB) and sesame hulls (SH) at different concentrations to partially replace skimmed milk powder (SMP). The physicochemical, total phenolic content (TPC), antioxidant activity (AOA), and sensory acceptability of ice cream fortified with SSB or SH were evaluated. The ice cream containing 15% SSB was found to have the best sensory characteristics and was most preferred by the taste panel. The addition of 15% SSB increased the protein and fiber content and improved melting resistance, while the addition of 15% SH resulted in a greater increase in dietary fiber but lower protein content and melting resistance. The highest overrun on the cost was obtained in the sample fortified with 25% SSB compared to the lowest in the sample fortified with 25% SH, but panelists generally did not like these samples in terms of taste-flavor. The study concluded that the addition of SSB and SH to replace SMP in ice cream can create a nutritious and low-cost product with similar physicochemical properties and acceptance to the control.

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ИЗУЧЕНИЕ ПОТЕНЦИАЛА ПРОРОШЕННЫХ СОЕВЫХ БОБОВ И КУНЖУТНОЙ ШЕЛУХИ ДЛЯ ПОВЫШЕНИЯ ПИЩЕВОЙ ЦЕННОСТИ МОРОЖЕНОГО

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КЛЮЧЕВЫЕ СЛОВА:
кунжутная шелуха, пророщенные соевые бобы, клетчатка, питательное мороженое

АННОТАЦИЯ

Целью исследования было производство мороженого с повышенной питательной ценностью путем добавления пророщенных соевых бобов (ПСБ) и кунжутной шелухи (КШ) в различных концентрациях для частичной замены сухого обезжиренного молока (СОМ). Оценивались физико-химические показатели, общее содержание фенолов (ОПП), антиоксидантная активность (АОА) и органолептическая приемлемость мороженого, обогащенного ПСБ или КШ. Было обнаружено, что мороженое, содержащее 15% ПСБ, обладает лучшими органолептическими характеристиками и является наиболее предпочтительным при оценке вкуса дегустационной комиссией. Добавление 15% ПСБ увеличило содержание белка и клетчатки и повысило устойчивость мороженого к таянию, тогда как добавление 15% КШ привело к большему увеличению содержания пищевых волокон, но к снижению содержания белка и понижению устойчивости к таянию. Самое высокое превышение стоимости продукта было получено в образце, обогащенном 25% ПСБ, по сравнению с самой низкой стоимостью продукта, полученном в образце, обогащенном 25% КШ, но членам дегустационной комиссии в целом эти образцы мороженого не понравились с точки зрения вкуса и аромата. Показано, что добавление ПСБ и КШ для замены СОМ в мороженом может создать питательный и недорогой продукт со схожими физико-химическими свойствами и вкусом.

БЛАГОДАРНОСТЬ: Авторы выражают благодарность кафедре пищевой промышленности и кафедре науки о молоке за поддержку данного исследования.

1. Introduction

In recent decades there has been a noticeable increase in public concern for health and quality of life, which concern has led to improved dietary habits and increased consumption of foods with acknowledged health benefits, and innovative nutritious foods. Nutritious foods are the foods that provide specific bioactive components beyond basic nutrition due to their considered health benefits [1].

Ice cream is a product with high acceptability, universal awareness of the product, and has a high probability of business growth due to its numerous varieties and combinations [2].

In reality, ice cream is not only considered a fun food but also a relatively well-balanced, nutritious, easily digestible, and delicious food [3]. So, it is a great model for providing development and innovation products.

On one hand, soybean is one of the oldest food crops in the world and has been studied as a potential ingredient in many foods. It is also a good source of vegetable protein and a healthy source of fat, vitamins, minerals and fiber [4]. Furthermore, plant-derived substances rich in dietary fiber play a significant role in enhancing sensory attributes and exhibiting water-holding properties of ice cream [5]. In addition, soybean has already gained attention as a potential ingredient for various foods due to its numerous health benefits [6]. Sesame, on the other hand, is a plant of the Pedaliaceae family and has been cultivated for its oil since ancient times. Sesame hulls are often removed from the seeds during processing as they can stain the seeds dark [7]. However, the recent research suggests that sesame hulls have potential health benefits and are exceptionally nutritious due to their high content of

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antioxidants, bioactive compounds, and natural preservatives such as sesamolin and sesamin [8]. These hulls can be used for a variety of purposes including animal feed as a source of dietary fiber and in the development of nutritious foods.

Sprouting of seeds is known as a way to improve the nutritional value of the seed due to several metabolic changes that are activated during sprouting, thus, the nutritional content of the sprouted bean is improved while anti-nutritional components such as trypsin inhibitor and phytic acid are reduced as the latter substances inhibit the digestion of some important minerals such as Fe, Zn, Ca, and Mg [9]. Germination, a non-chemical, non-thermal process, is also a better way than cooking to reduce efficiently the levels of anti-nutritional factors without deterioration of the resulting product quality [10]. Examples of the resulting increase in levels of content and bioavailability of many essential nutrients in soybeans include all vitamins, with ascorbic acid levels showing the most noticeable increase during germination, as soybeans contain no or undetectable levels of ascorbic acid in the unsprouted seed, which increases greatly during germination [11]. The reduction and elimination of the three main soy allergens also has several advantages: it is simple, money-saving, and easy to run on an industrial scale compared to technological processes aimed at eliminating or reducing the number of allergenic proteins. Food produced this way (by sprouting) is safe since no microbial enzymes or detergents are used in the process [12]. Also, the content of several bioactive compounds rise during the biological process of germination, such as the levels of folate, which increases during germination and has important biological functions, as it contributes to the prevention of DNA damage; some evidence suggests its preventative effect in some types of cancer, including colon cancer [13].

As a result, there is a growing number of health-conscious consumers of nutritious foods, including, most recently, the production of nutritious ice cream. In addition to nutrient-rich ingredients like fruits, vegetables, legumes, and edible food waste (peels and edible husks), the concept of functional food also includes food fortified with minerals, vitamins, fiber and probiotics [14]. Soybean and sesame hulls for decades have been recognized as inexpensive sources of protein, fat, fiber and minerals [15]. Although ice cream is full of nutrients such as protein, fat, sugars, minerals and vitamins, it still lacks a very important nutrient, which is fiber, and despite the number of papers published on functional ice cream, without mentioning the use of soybean as a source of fiber in addition to vegetable protein which is easier to digest due to the sprouting process [16]. Therefore, the aim of this study was the development of a nutritious ice cream with SSB and SH admixture.

2. Materials and Methods

2.1. Chemicals and materials

All chemicals used in the analyses were purchased from Sigma Chemical Co. (St. Louis, MO, USA). Soybean, skim milk powder (SMP), buffalo cream, sugar, and cocoa powder were purchased from a local supermarket on the 6th of October city, Egypt. Table 1 observed the chemical composition of dairy ingredients (SMP and Cream). Stabilizer and emulsifier (sodium alginate and guar gum) were purchased from MIFAD, the food additives company in New Cairo.

Table 1. **Chemical composition of dairy ingredients**

Таблица 1. **Химический состав молочных ингредиентов**

Ingredients	SMP	Cream
Moisture	4.60±0.24	39.15±0.53
Protein	33.04±0.57	2.30±0.11
Fat	1.22±0.12	54.61±0.40
Ash	7.93±0.04	1.64±0.02
Carb (cal)	53.21±1.58	2.30±0.13

SMP: Skim milk powder; Carb: carbohydrate.

SMP: сухое обезжиренное молоко; Carb: углеводы.

2.2. Soybean sprouting

Rinse the soybeans with cold water and leave them to soak overnight in the refrigerator. Place the cleaned soybeans in a planter with small holes in the bottom and pour more water in the planter every 5 hours to keep the soybeans wet. The water will drain through the small holes in the planter's bottom. A black cloth is also used to cover the planter to keep out the light for 3 days. Rinse and drain the sprouts several times before storing them in the fridge. Using a hot air oven, the sprouted soybeans were dried at 40 °C for 12 hours to remove the moisture without affecting the nutrients naturally contained in the soybeans [16].

2.3. Ice cream processing

Four ice cream mixes were produced according to the recipes shown in Table 2. Buffalo milk was used in the production. The process began by placing the liquid phase, consisting of water and cream, into a benchtop pasteurizer equipped with the mixing blades. Following that, the solid ingredients, which included milled sesame hulls or sprouted soybeans, sugar, and stabilizer, were introduced. At this stage, either SH or SSB substituted 15%, 20%, and 25% of SMP. Subsequently, the temperature of the mixture was gradually raised to 85 °C and held at this temperature for 5 minutes, then cooled to 5 °C. A high-shear homogenizer was used to produce uniformly small fat globules, which improved the whippability and texture of the ice cream mix. The ice cream is then aged at 4 °C for 5 hours to allow the milk proteins and water to interact and the fat to crystallize. The resulting ice cream was then aerated using an ice cream machine and finally stored in suitable conditions (at -18 °C).

Table 2. **Ingredients quantities at the various concentrations of sprouted soybeans and sesame hull as substitutes for skimmed milk powder in ice cream mix (g/kg)**

Таблица 2. **Количество ингредиентов при добавлении пророщенных соевых бобов и кунжутной шелухи в различных концентрациях в качестве заменителей сухого обезжиренного молока в смеси для приготовления мороженого (г/кг)**

Ingredients	Control	T1	T 2	T 3
Water	543	543	543	543
Cream	181.8	181.8	181.8	181.8
Sugar	145.0	145.0	145.0	145.0
SMP	85.20	72.42	68.16	63.90
Cocoa powder	40.0	40.0	40.0	40.0
Stabilizer	5.0	5.0	5.0	5.0
SB, SSB or SH	0.00	12.78	17.04	21.30

T: treatment; SMP: skimmed milk powder; SB: soybean; SSB: sprouted soybean; SH: sesame hull

T: опытный образец; SMP=СОМ: сухое обезжиренное молоко; SB-СБ: соевые бобы; SSB=ПСБ: пророщенные соевые бобы; SH=КШ: кунжутная шелуха.

3. Methods of analysis

2.4.1. Chemical composition

Ash, moisture, protein, fat and fiber contents of all samples were determined according to AOAC [17].

Carbohydrates were determined by the DNS method with some modifications. The samples of 5 g were diluted up to 100 ml with ethanol of 70%, then heated to 90 °C for 1 hour, after that a saturated solution of lead acetate was used to precipitate the impurities, the solution was filtered to get the filtrate, then another precipitation process was run by using sodium oxalate to get the pure filtrate of reducing sugars. The resulting clear solutions were built up to a known volume. 1 ml of both extracts was diluted with 1 ml of DNS in separate test tubes and then boiled for 2 minutes, after that each extract was added to 8 ml of distilled water. The final step involved using a spectrophotometer at 540 nm to measure the amount of absorbed light which indicates the amount of reducing sugars in the samples [18].

2.4.2. Tannin content

Tannin content: quantitative determination of tannins was carried out according to Pulipati et al [19] as follows: One gram of each sample was separately mixed with 10 ml of HCl in methanol 1% (v/v) in a dark bottle and shaken for 20 min at room temperature, then filtered. 1 ml of the supernatant was mixed with 5 ml (vanillin / HCl) mixture (by mixing equal volumes of 2% vanillin in methanol and 8%HCl/methanol) in a test tube and was exposed for 20 min to room temperature. The color formed was measured at 500 nm using a spectrophotometer (Jenway 6300 VIS, Laborned Inc., USA). Catechin was used for the preparation of the standard curve. Tannins were calculated as mg of catechin equivalent (CE)/100 g on dry weight basis.

2.4.3. Total phenolic content

Total phenolic content was determined by the Folin-Ciocalteu method according to Elsayed et al.[20], with some modifications as in described by El-Maksoud et al [21]. Briefly, 1 ml of each sample (extracts before evaporation) was placed in a test tube and 1 ml of Folin reagent was added. After 3 min, 1 ml of sodium carbonate (7.5%) was added. The mixture was left in the dark for 1 h and the absorbance at 740 nm was measured. The total phenolic content was calculated from a standard curve of gallic acid content and expressed as mg of gallic acid/mg of the sample.

2.4.4. Phenolic compounds of sesame hulls

The phenolic composition of sesame hulls was determined by HPLC (Agilent 1260 series, Santa Clara, CA, USA) according to Fathy et al. [22]. The UV detector was used to measure the phenolic chemicals at 280 nm.

2.4.5. Apparent viscosity of mixtures

Following the aging process, all mixtures were subjected to analysis to determine their apparent viscosity. The apparent viscosity was measured in triplicate at 25 °C using a concentric cylinder of the Brookfield Programmable viscometer (Model DV–II; Brookfield Engineering Laboratories, USA) equipped with the UL adaptor. Spindle 2 was run at a rotational speed of 40 revolutions per minute (RPM).

2.4.6. Overrun on the cost estimation

Overrun on the cost were estimated using the weight of the mixture in a fixed volume container (50ml cup) and the weight of the fixed volume of ice cream (50 ml cup). Overrun on the cost was estimated at the end of each collection point, resulting in three estimations of overrun on the cost per the collection point. This was calculated by comparing the weight of a known volume of ice cream (M_2) with the weight of the same volume of unfrozen ice cream mix (M_1) by the formulation as follows [23]:

$$\text{Overrun on the cost\%} = \frac{M_1 - M_2}{M_2} \times 100 \qquad (1)$$

2.4.7. Melting characteristics

The sample, placed on a wire mesh, melted and dripped into the beaker below. The weight of the drip collected in the beaker was measured over time. The rate of weight increase was defined as the melting rate. This experiment was carried out at 25 °C in the laboratory incubator [24].

2.4.7. Sensory characteristics evaluation

The sensory evaluation of the ice cream samples in terms of their color, taste, fat feel, rate of melting, viscosity, aftertaste, grittiness and overall acceptability (OAA) was carried out using a nine-point hedonic scale (1 = disliked very much and 9 = liked very much) according to Ghaderi et al. [25] by a semi-trained panel of ten members, including the laboratory's scientific staff. The samples were randomly drawn from each experimental block, coded and served to the panelists in a sensory laboratory (the samples were tested at room temperature of 25 ± 1 °C). Drinking water was provided for each panelist to rinse the mouth before tasting each next sample.

2.4.8. Statistical analysis

The results obtained in this study were analyzed by analysis of variance (ANOVA) and the mean values were compared using the least significant difference (LSD, 95%) by Duncan's multiple range tests using SPSS software.

3. Results and Discussions

3.1. The chemical composition of SB, SSB and SH

The Table 3 shows the chemical composition of soybean (SB), sprouted soybean (SSB) and sesame hull (SH). It also shows the comparison between the chemical profiles of the sprouted soybean and the unsprouted soybean. Composition is given ~~in~~ as percentage of moisture, ash, fiber, carbohydrate, protein and fat. The moisture content of SB and SSB is different, while SB containing 7.4% moisture and SSB containing 8.31% moisture. SH features the highest moisture content of all three samples reaching 8.86%. The moisture content of the germinated soybean increased significantly. When water enters the seed hull, seed swelling starts and germination is initiated [26].

Table 3. **Chemical composition of SB, SSB and SH**

Таблица 3. **Химический состав СБ, ПСБ и КШ**

	Moisture%	Ash%	Fibers%	Carbo-hydrate%	Protein%	Fat%
SB	7.40 ± 0.10^c	4.00 ± 0.10^c	9.67 ± 0.10^b	25.2 ± 0.2^a	32.29 ± 0.20^b	21.4 ± 0.2^a
SSB	8.31 ± 0.20^b	5.90 ± 0.30^b	10.97 ± 0.10^b	21.0 ± 0.2^b	35.71 ± 0.10^a	17.4 ± 0.1^b
SH	8.86 ± 0.20^a	9.32 ± 0.20^a	20.28 ± 0.10^a	15.9 ± 2.0^c	17.20 ± 0.10^c	17.8 ± 0.3^b

SB: soybean; SSB: sprouted soybean: SH: sesame hull. Different letters (a, b, c) mean statistically significant difference ($p < 0.05$); The data is mean ± SD

SB=СБ: соевые бобы; SSB=ПСБ: пророщенные соевые бобы: SH=КШ: кунжутная шелуха. Различные буквы (a, b, c) обозначают статистически значимую разницу ($p < 0.05$); Показаны средние значения ± стандартное отклонение.

In terms of ash and fiber content, SH had the highest percentage at 9.32 and 20.28% respectively, followed by SSB and SB. The increase in ash content of SSB may be caused by starch loss during germination [27]. Therefore, the inclusion of SH or SSB into the diet may provide additional nutritional benefits by contributing to the support of digestive health. The carbohydrate content of sprouted soybeans was significantly reduced compared to their raw versions. Vidal-Valverde et al. [28] explained that during germination carbohydrate was used as an energy source for germ growth, which could explain the changes in carbohydrate content after germination. In addition, activity of β-amylase was increased, which hydrolyses starch into simple carbohydrates [29]. Starch in the cotyledon was broken down into smaller molecules such as glucose and fructose to provide energy for cell division as the seeds matured and grew [28,30].

SSB has the highest protein content (35.71%), followed by SB (32.29%) and SH (17.20%). The apparent increase in protein content may be attributed to the loss of dry matter, particularly carbohydrates, through respiration during the sprouting [31]. Higher sprouting temperature and longer germination time would result in greater loss of dry matter and an increase in crude protein content. There is a resumption of protein synthesis after imbibition [30], leading to an increase in protein content in sprouted seeds.

Finally, the fat content is highest in SB at 21.4%, followed by SH and SSB. The fat content of sprouted soybeans decreased significantly compared to unsprouted soybeans. The decrease in fat content may be due to the depletion of stored fat, which contributed to the catabolic activities of the seeds during sprouting [32]. Devi et al [26] reported that the degradation of reserve nutrients (lipids and carbohydrates) during sprouting is a process whose main purpose is to provide the energy required for protein synthesis during a plant growth.

The differences in the composition of these three plant-containing foods highlight the importance of including a variety of foods in a balanced diet to ensure an adequate intake of all essential nutrients.

3.2. Phytochemical composition of unsprouted soybean, sprouted soybean and sesame hull

Table 4 displays the phytochemical composition of unsprouted soybean, sprouted soybean and sesame hull, in particular, their total phenolic and tannin content. It also highlights the potential health benefits of consuming the sprouted soybean and sesame hulls due to their high tannin content and total phenolic content. Tannins and phenolics are two types of plant compounds known for their health benefits due to their antioxidant properties, which can help protect against oxidative stress and prevent the development of chronic diseases such as cancer and cardiovascular disease [4].

Table 4. **Phytochemical composition of unsprouted soybean, sprouted soybean, and sesame hull**

Таблица 4. **Фитохимический состав непророщенных соевых бобов, пророщенных соевых бобов и кунжутной шелухи**

Materials	Total phenolics [a]	Tannins [b]
SB	03.46 ± 0.2b	4.73 ± 0.2b
SSB	10.23 ± 0.2a	8.31 ± 0.2a
SH	31.40 ± 0.3	—

[a] Expressed as mg of gallic acid equivalents/g of dry material.
[b] Expressed as mg of mg catechin equivalents/g of dry material
SB: soybean; SSB: sprouted soybean: SH: sesame hull
Different letters (a, b, c) mean statistically significant difference ($p < 0.05$); The data is mean ± SD.

[a] Выражается в мг эквивалентов галлиевой кислоты/г сухого материала.
[b] Выражается в мг эквивалентов катехина/г сухого материала.
SB=СБ: соевые бобы; SSB=ПСБ: пророщенные соевые бобы: SH=КШ: кунжутная шелуха
Различные буквы (a, b, c) обозначают статистически значимую разницу ($p < 0.05$); Показаны средние значения ± стандартное отклонение.

The tannin content of dry soybean and sprouted soybean is given in mg/g dry matter. Sprouted soybean featured significantly higher total phenolic and tannin contents — 10.23 ± 0.2 mg gallic acid eq/g and 8.31 ± 0.2 mg catechin eq/g compared to the dry soybean with 3.46 ± 0.2 mg gallic acid eq/g and 4.73 ± 0.2 catechin eq/g, respectively. In contrast, the phenolic content of sesame hulls was 31.40 ± 0.3 mg/g and it contained no tannins.

The comparison between the phytochemical profiles of the sprouted soybean and the phytochemical profiles of the unsprouted soybean is shown above in the Table 4. The amount of total phenolics in 1 g of soybean sprouts (in terms of dry matter) significantly increased with the number of germination days. The amount of tannins in 1 g of sprouted soybean (in terms of dry matter) increased significantly along with process of germination [33].

The phenolic fractions of sesame hulls were quantified with the help of HPLC, as it was demonstrated in the chromatography diagram presented in Figure 1. Significant amounts of coumaric acid, vanillic acid and resveratrol acids were detected in.

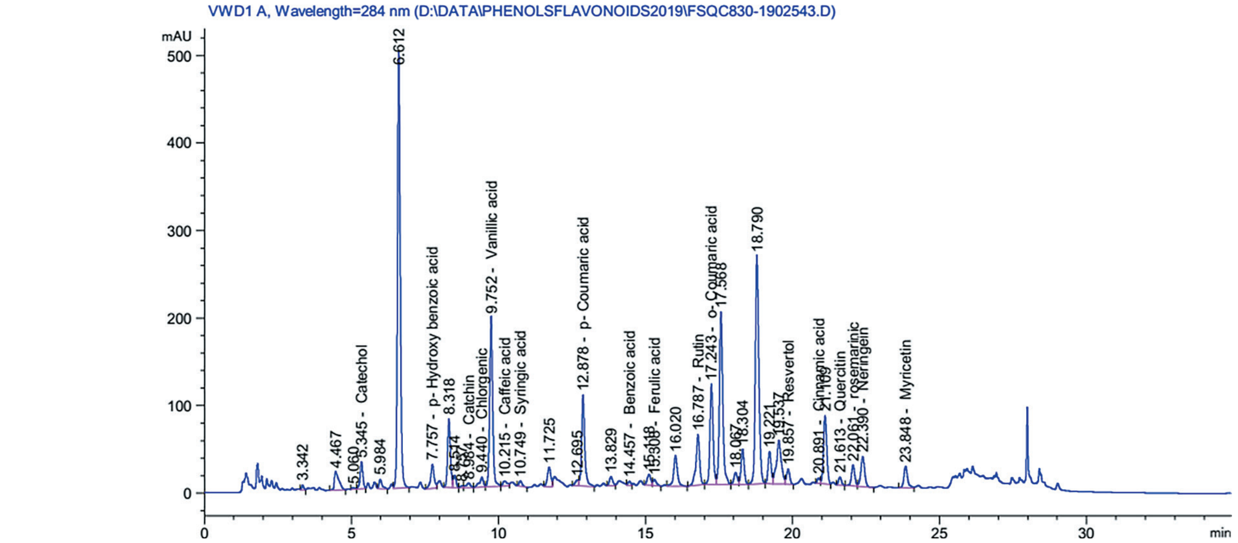

Figure 1. **Phenolic fractions of sesame hull**

Рисунок 1. **Фенольные фракции кунжутной шелухи**

3.3. Effect of sprouted soybean and SH on the nutrition value of Ice-cream

Apparent viscosity values (cP) are plotted as shown in Figure 2. The viscosity behavior is influenced by the addition of plant sources. The samples fortified with sesame hull (SH) showed increased viscosity compared to the control sample or those fortified with sprouted soybean (SSB). This may be due to the higher fiber content in SH (20.28%) compared to SSB (10.97%) as shown above in Table 3[5].

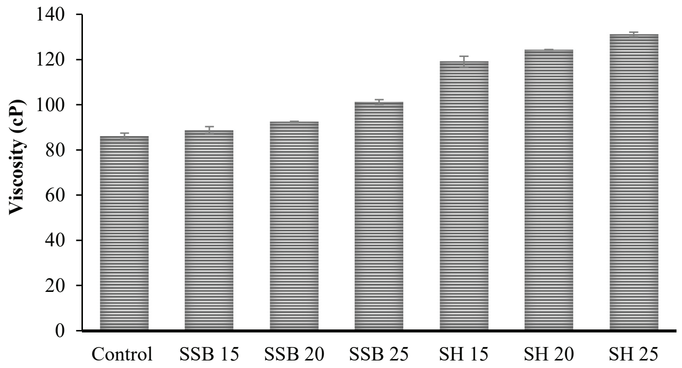

Figure 2. **The average values of apparent viscosity (cP): SSB: sprouted soybean: SH: sesame hull**

Рисунок 2. **Средние значения видимой вязкости (ВВ): SSB = ПСБ: пророщенные соевые бобы: SH — КШ: кунжутная шелуха**

Overrun the cost of ice cream influences the final product's body, texture, and palatability. It is also related to the yield and profit. The average overrun on the cost was the highest in SSB (25%) and the lowest in SH (25%) (Figure 3). The addition of sesame hulls significantly reduced the overrun on the cost. The inclusion of sprouted soybeans (SSB) exhibited a tendency to considerable rising of the overrun on the cost. This effect could potentially be attributed to the supplementary introduction of protein into the product. All samples could be statistically distinguished from each other.

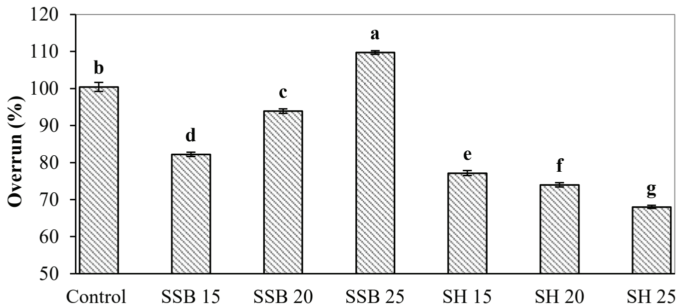

Figure 3. **The average values of overrun on the cost (%): SSB: sprouted soybean: SH: sesame hull**

Рисунок 3. **Средние значения превышения стоимости (%): SSB=ПСБ: пророщенные соевые бобы: SH=КШ: кунжутная шелуха**

Resistance to melting. Meltdown is another essential feature of ice cream that influences its sensory quality (Figure 4). Deviation in the melting parameter from its optimal value might cause the ice cream to be faulty. Melting time was dependent on the ice cream formulation and especially on the nature of the emulsifier. Fat aggregation proved to be the largest contributor to ice cream melting resistance [34] via the presence of bounds formed by the presence of fat, proteins, or other stabilizers, while the melting of the ice cream is also influenced by the ambient temperature and heat transmission rate. Resistance to melting is calculated via the following formulation, where A_1 is the weight of the initial sample (30g) and A_2 is the weight of the melted sample [35].

$$\text{Resistance to melting} = \frac{A_1 - A_2}{A_1} \times 100 \qquad (2)$$

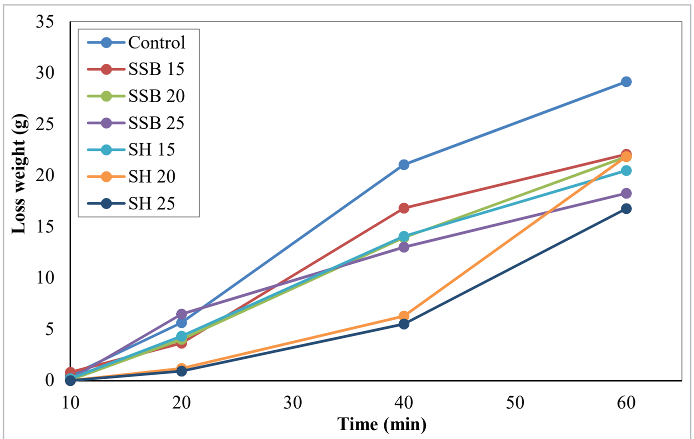

Figure 4. **The average values of melting rate (g/min): SSB: sprouted soybean: SH: sesame hull**

Рисунок 4. **Средние значения скорости таяния продукта (г/мин): SSB=ПСБ: пророщенные соевые бобы: SH=КШ: кунжутная шелуха**

In general, as viscosity increases, so does resistance to melting and texture smoothness [36]. Slow melting is usually attributed to over-stabilization and this condition can be adjusted by reducing the amount of stabilizer and/or emulsifier. The sprouted soybean may be responsible for the increased viscosity and hence the increased resistance to melting (Figure 3). The sample SH (15%) was criticized for " "inability to melt", as it was considered a defect. This sample's properties were often accompanied by texture defects such as soggy, gummy, doughy, and sticky body of the ice cream. This suggests that if such a high resistance to melting is not required, it can be corrected by reducing the amount of stabilizer, emulsifier, or milk solids (not fat) with additional cost benefits. Furthermore, it is noteworthy that in this study, the greatest impact on the resistance to melting was correlated with the ice cream's overrun on the cost.

Protein, fat, and crude fiber percentage in SSB and SH supplemented ice cream were also reviewed. Table 5 presents the protein, fat, and crude fiber percentages in ice cream made with sprouted soybean and sesame hull at different concentrations, as well as a control sample for comparison. As shown in Table 4 there is an increase in protein content in SSB ice cream, unlike the SH ice cream which features protein content decrease. This may be due to the high protein content of SSB (35.71% Table 3). There are no significant differences in the fat ratio throughout all ice cream trials. The crude fiber ratio shows significant differences throughout all trials and the highest fiber concentration was found in the ice cream with the highest SH concentration, due to the high fiber content of SH as shown in the Table 2. In general, this table shows that the addition of sprouted soybeans and sesame hulls to ice cream does not significantly affect the protein content and fat content compared to the control sample. However, the addition of these ingredients increases the crude fiber content, especially at higher concentrations. This may cause implications for the nutritional value and potential health benefits of the ice cream, but further studies are needed to fully understand these effects.

Table 5. **Protein, fat, and crude fiber percentages in ice cream with sprouted soybean and sesame hull**

Таблица 5. **Процент белка, жира и сырой клетчатки в мороженом с добавлением пророщенных соевых бобов и кунжутной шелухой**

Parameter	Protein%	Fat%	Crude Fiber%
Control	4.65±0.10[ab]	10.21±0.10[a]	0.00
SSB15	4.67±0.10[ab]	10.19±0.10[a]	0.44±0.10[e]
SSB20	4.80±0.10[a]	10.21±0.20[a]	0.93±0.10[d]
SSB25	4.81±0.10[a]	10.14±0.10[a]	1.08±0.10[c]
SH 15	4.51±0.10[b]	10.22±0.10[a]	1.07±0.10[c]
SH 20	4.34±0.10[b]	10.30±0.10[a]	1.34±0.10[b]
SH 25	3.96±0.10[c]	10.11±0.10[a]	1.75±0.10[a]

Different letters (a, b, c) mean statistically significant difference ($p < 0.05$); The data is mean±SD/

Различные буквы (a, b, c) обозначают статистически значимую разницу ($p < 0.05$); Показаны средние значения±стандартное отклонение/

3.4. Effect of different concentrations of sprouted soybean and sesame hull on sensory attributes of ice cream

There were two types of admixtures (SSB and SH). Each type was prepared in three concentrations. The parameters of these types and concentrations were tested and assessed, as shown in Figure 5. Among the tests SSB15 seems to have performed relatively well, with scores close to or above 8 for most attributes, except for color and sandy texture, which were slightly lower. SSB20 and SSB25 appear to have generally lower scores, particularly for color, flavor and resistance to melting, resulting in a lower overall acceptability score. The SH ice cream samples (15, 20 and 25) also appear to have varied in their performance, with SH 15 performing quite well, particularly in flavor, and SH 20 and SH 25 performed relatively poorly in most attributes except flavor and fat feel.

The color of the majority of the ice cream samples was very acceptable, except for the sprouted soybean one at 25% concentration. Regarding the flavor score: both SH and SSB ice cream featured an unacceptable flavor at 25% and 20% concentrations, but there is no noticeable flavor at 15% concentration of SH and a nutty flavor at the same concentration of SSB. The viscosity score varied between 5 and 8, with the best viscosity at 20% SSB and the worst one at 25% SSB. None of the trials gave feeling of grittiness. As for the overall scores, the preference was given in the following order: SSP 15%, SH 15%>SP 20%, SH 20%>SSP 25%, SH 25%.

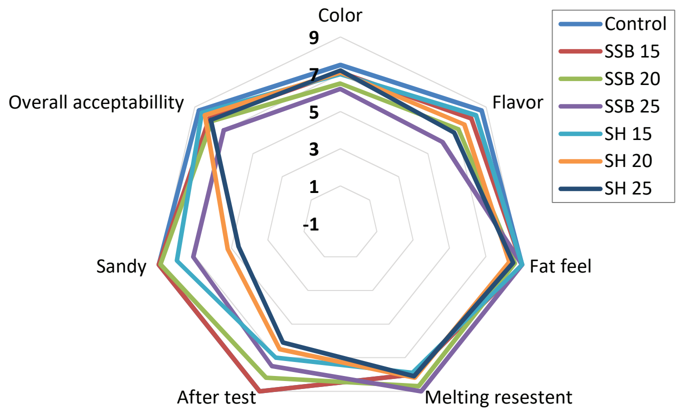

Figure 5. **Effect of levels of sprouted soybean and sesame hull on sensory attributes of ice cream, SSB: sprouted soybean; SH: sesame hull**

Рисунок 5. **Влияние содержания проросшей сои и кунжутной шелухи на органолептические свойства мороженого. SSB=ПСБ: пророщенные соевые бобы; SH=КШ: кунжутная шелуха**

4. Conclusions

Sprouted soybean and sesame hulls improve the nutritional value of ice cream by increasing the protein content and fiber content. According to the sensory evaluation, ice cream with SSB15% was best preferred. The newly developed ice cream features higher protein content and fiber content compared to the commercial ice cream. The results support the assumption that the use of SSB available in Egypt and the technology developed for its admixing to the ice cream increases the nutritional value of ice cream; it now contains more protein and more fiber. On the other hand, SSB admixture reduces the cost of the ice cream as the mild soybean is used as a fiber source without affecting the sensory properties of the ice cream. The protein content in SH ice cream is slightly lower than in the control sample and SSB samples, ranging from 3.96±0.1% at 25% SH to 4.51±0.1% at 15% SH. The fat content in SH ice cream is similar to the control sample and SSB samples, ranging from 10.11±0.1% at 25% SH to 10.30±0.1% at 20% SH. The crude fiber content in SH ice cream increased along with increasing of SH concentrations, ranging from 1.07±0.1% at 15% SH to 1.75±0.1% at 25% SH. In general, although sesame hulls may not be as nutritious as sesame seeds, they may still have potential health benefits and numerous ways of its application in various industries.

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