Effect of Adding Beetroot powder on Chemical, Nutritional, Rheological, and Organoleptic Properties of frozen yogurt.

ABSTRACT

Frozen yogurt is a popular and healthy alternative to traditional ice cream due to its lower fat content and probiotic benefits. In recent years, there has been a growing interest in incorporating various natural ingredients into frozen yogurt to enhance its nutritional value and sensory appeal.

This research paper aims to investigate the effects of beetroot powder on the nutritional and sensory qualities of frozen yogurt, and it will provide an overview of the research problem, define the objectives of the study, and highlight the significance of the results in the context of the frozen yogurt industry, by exploring the effect of these ingredients on frozen yogurt, and the contribution to Developing innovative and nutritious frozen yogurt products that meet the diverse preferences and nutritional needs of consumers.

Beetroot powder was added to frozen yogurt in different proportions (1%, 3%, 5% and 7%). Beetroot powder was chosen based on its potential health benefits, unique flavours, and bright colours.

Overall, the addition of beetroot powder to frozen yogurt has the potential to enhance its nutritional value and sensory appeal, and the results indicate that these powders have the potential to improve the overall quality of frozen yogurt.

Among the main nutritional benefits highlighted in this study is the significant increase in iron content in frozen yogurt, its benefits in improving immune system function, reducing the risk of cardiovascular disease, as well as its high content of dietary fibre. Of beetroot powder. This is an important finding as dietary fibre is known to have various health benefits, including improved digestion and reduced risk of chronic disease. In addition, beetroot powder has been found to have good moisturizing properties, which can be useful in the production of frozen yogurt. These results indicate that adding beetroot powder to frozen yogurt can not only improve its nutritional profile, but also contribute to its sensory properties by enhancing mouth texture and sensation, producing frozen yogurt fortified with nutrients low or absent in dairy products including some Essential dairy, such as vitamins, antioxidants, trace elements, and digestible fibre.

According to the results, beetroot powder 5% is recommended as the best-frozen yogurt additive which can be offered to consumers as a fresh, high quality and marketable product.

Keywords: beetroot, Beta vulgaris, powder, frozen yogurt, Microbiological, and nutritional properties

INTRODUCTION

The increasing demand for healthy food choices with beneficial effects on health has led to increased research on the incorporation of plant raw materials into food products **[1].** These products can improve health or well-being, and when consumed at recommended levels, their benefits include improved immune system function, reduced risk of cardiovascular disease, reduced risk of bone mass loss, and protection against free radical damage **[2- 4]**.Fruits and vegetables in various forms (i.e., fresh, dried, powder, juices, puree, pulp, fiber, and extract) provide a means for producers to optimize the health benefits of food products **[5 - 7]**.

Issar [**8**] reported that yogurt incorporated with up to 3 g of date dietary fiber per 100 g of yogurt had similar sourness, sweetness, firmness, smoothness, and total acceptance ratings as the control yogurt (without added dietary fibre).

Due to the high utilization rate of dairy products, enrichment of these products will successfully decrease or prevent diseases related to nutrition deficiencies [**2**]. Dairy products are rich in protein, fatty acids, calcium, potassium, and B vitamins but are deficient in iron, vitamin C, carotenes, and dietary fibres [**9, 10**]. Thus, the combination of fruits and vegetable products and by-products and cheeses, ice creams, Frozen Yogurt, and yogurts will improve the nutritional and functional food characteristics of these products [**11**].

Vitamins, polyphenols, and carotenoids are considered the most natural antioxidant molecules in fruits and vegetables, These natural compounds can provide better sensory, nutrition, and antioxidant quality compared to the artificial additives in dairy products [**9**].

Fruits and vegetable fibres have better quality due to higher total and soluble fiber and water content and oil holding capacity and colonic ferment ability, in addition to lower phytic acid content and caloric value [**8, 12**]. Also, the primary dietary source of phenolic compounds is present in fruits and vegetable products.

It has been suggested that these products' extracts, juices, and powders have the potential to be applied as functional ingredients in dairy products [**13, 14**].

Most fruits are naturally low in fat, sodium and calories, rich in vitamins, especially vitamins C and A; minerals, especially potassium, and phytochemicals, especially antioxidants. They are generally low in energy density and are a good source of fiber [**15, 16**]. The beetroot is a super food which imparts an important role in the growth and development of the human body. It is naturally consumed as a colourant and as a medicinal plant. It serves as an economic package of health care to cure various diseases. Beetroot is not only blessed with a beautiful natural colour but also packed with nutrients like vitamins, minerals, amino acids, calories, and antioxidants [17-19].

Red beetroot betalain extract, consisting mostly of betanin (E162), is widely used as a natural colourant in many dairy products (e.g. milk, ice creams, yogurt, and kefir), and beverages [20, 21]. The main advantages of beetroot are that it is fat-free, has very few calories, and is an excellent source of fibre. [22].

The beneficial medicinal effects of beetroot are based on bioactive components such as betaine, betaine, betacyanin, auxin, flavonoids, polyphenols, and vitamins (thiamine, riboflavin, pyridoxine, ascorbic acid, bio and folic acid) as well as soluble fibre, pectin, and various metal elements acting on different physiological pathways (e.g. B.Al, B, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, Zn) [23, 24].

Beetroot usage for food application has been investigated by various researchers and food industries due to the prevailing effect of their colour, flavour and nutritional aspect making, Fresh beetroot or beetroot powder or extracted pigments are used to advance the red colour of tomato pastes, soups, sauces, desserts, jams, jellies, sweets ice-cream, and breakfast cereals [25,26]

MATERIALS AND METHODS

Materials

Fresh cow's milk was obtained from Sakha Animal Production Research Station (SAPRS) in Kafr-ELShiekh Governorate and was skimmed into cream and fresh skim milk (0.05%fat) which was used in frozen yoghurt making.

Skim milk powder (S.M.P) (96.5% TS; Extra, Holland) was obtained from the local market.

Stabilizer Sodium Carboxy Methyl Cellulose (C.M.C), Sugar (Commercial grade crystalline sucrose), and vanilla were purchased from the local market.

Direct Vat Starter (DVS) Yogurt starter culture type (YC380) containing *Streptococcus thermophilus and Lactobacillus delbrueckii ssp. bulgaricus* at ratio (1:1) was obtained from CHR Hansen's lab, in Denmark, and purchased from MIFAD Company, Egypt.

Preparation of the beetroot powders

Beetroots were bought in the local market and were washed, and peeled, The slices were air-dried at 45°C for 3 days and the solids obtained were milled with a domestic grinder and sieved using a vibratory shaker. Divided into small amounts and then packed in low-density polyethene bags, similar to the procedures used by [**27**] when he utilized peach powder.

Preparation of frozen yoghurt mixture:

Making frozen yogurt according to the procedures of [28] with some modifications. Frozen yogurt mixtures were standardized by adding skimmed milk powder to the b cow's milk to produce a mixture containing 3% fat, 15% sugar, 13% non-fat solids, 0.3% stabilizer, and 1% vanilla. The mixture was heated without sugar and stabilizer at 85 ° C for 30 minutes. Then cool to 42 ° C and yogurt culture was added (0.02%). The mixture was incubated at 42 °C until the appropriate pH (4.8-4.9) was reached. The resulting milk was mixed with 15% sugar, 0.3% CMC, and 1% vanilla,

Then the mixture was divided into five parts according to the proportion (0, 1, 3, 5 and 7%) of the beetroot powder.

The final mixture was stored at 5 ± 1 ° C overnight for about 16 h. Freezing of the mix was carried out in batches of 1 kg in a home ice cream freezer for 20 min. The frozen yogurt was placed in plastic cups (100 mL in volume) and transferred to a freezer at (-18 ± 2 °C) for hardening and stored for 4 weeks.

Samples after freezing were examined for chemical, physical and sensory properties. The experimental frozen yogurt was produced in five parts. The reported data are the mean values of the triplicate of each fixative concentration.

Methods of analysis:

Chemical analysis

The total solids, protein, fat, ash, Crude fibres and Minerals content (iron) of frozen yogurt were measured according to methods described by the Association of Official Analytical Chemists [**29**].

Physical properties of the resultant frozen yoghurt:

specific gravity and weight per gallon

Specific gravity was measured according to [30] and weight per gallon was estimated as described by [31, 32] where sp. gr values were multiplied by 8.345.

Overrun:

The overrun was calculated by weight using a formula described by [**31, 33**]**.** With a slight modification. The formula for overrunning was as follows: Overrun% = [(weight of a unit volume of the frozen yoghurt mixtures) - (weight of the same unit volume of the resultant frozen yogurt)] / (weight of the same unit volume of the resultant frozen yogurt) × 100.

Overrun of prepared frozen yoghurt samples were tested by using the method described by **[31, 34]**.

Melting Rate

The melting rate was calculated according to the method of [**35**] with some modifications. by taking a 100 g frozen yogurt sample and placing it on a wire mesh over a beaker at 24±1°C. The melted frozen yogurt was collected in the beaker. After 15, 30, 45, and 60 minutes the melted sample and residual sample both were weighed. The melting rate was calculated by dividing the melted sample over time (g/min). The melting rate was calculated after one week of frozen storage.

Microbiological aspects of frozen yogurt

Microbiological examinations:

The total bacterial count (TBC) of frozen yogurt samples was performed according to the American Public Health Association [**36**]. Lactic acid bacterial count (LAB) was enumerated according to [**37**]. Str. Thermophiles were counted on the M17 agar medium supplemented with 0.5% lactose according to **[38].** Yeast and moulds counts were enumerated as described by [**36**]. The coliform bacteria group was tested as suggested by the **[39].**

Organoleptic properties of the resultant frozen yogurt:

Sensory evaluation of the resultant frozen yogurt:

It was evaluated according to [**40**] with some modifications. The sensory panel comprising 6 judges were selected and they were first experienced with various sensory attributes like flavor (45), body/texture (30), melting quality (15), and colour/appearance (10).

Statistical analysis:

The statistical analysis was carried out using the **SPSS** Program according to **[41, 42]**.

Table (1). Different treatments used in the study:

T0	**Control product**
T1	Frozen yogurt with 1.00% beetroot powders
T2	Frozen yogurt with 3.00% beetroot powders
T3	Frozen yogurt with 5.00% beetroot powders
T4	Frozen yogurt with 7.00% beetroot powders

RESULTS AND DISCUSSION

Chemical composition of frozen yogurt formulas:

The results in Table No. (2) Show the following: The mean values for total solids content increase with increasing concentration of beetroot powder, ranging from 30.90 % in treatment T0 to 32.90 % for T4.

These results are consistent with those presented by [**43**]. Their study found that adding higher concentrations of beetroot increased total solids compared to their ice cream control sample; this was also observed during our experiment as Treatment T4 had significantly higher levels than Control Treatment T0.

Overall it appears that adding additional concentrations of beetroot powder does increase the amount of total solids contained within frozen yogurt mixtures.

Table (2). Chemical composition of prepared frozen yogurt formulas containing beetroot powder.

Component (%)	frozen yogurt formulas				
	T0	**T1**	**T2**	**T3**	**T4**
Total solids	**30.90 ±0.82**^{C}	**31.30 ± 0.51**^{C}	**31.50 ± 0.52**^{B}	**32.60 ± 1.21**^{B}	**32.90 ± 0.97**^{A}
Crude protein	**5.10±0.30**^{A}	**4.95±0.18**^{A}	**4.90±0.53**^{A}	**4.86±0.32**^{A}	**4.82±0.32**^{A}
fat	**2.99±0.04**^{A}	**2.97±0.04**^{AB}	**2.90±0.04**^{BC}	**2.85±0.07**^{CD}	**2.81±0.02**^{D}
ash	**0.85±0.09**^{C}	**0.90±0.18**^{BC}	**1.10±0.23**^{AB}	**1.25±0.05**^{AB}	**1.40±0.30**^{A}
Crude fibers	**0.00±0.00**^{D}	**0.57±0.21**^{C}	**1.45±0.13**^{B}	**1.83±0.25**^{A}	**2.15±0.18**^{A}
iron	**0.15±0.02**^{D}	**0.33±0.03**^{D}	**0.65±0.19**^{C}	**1.19±0.07**^{B}	**1.76±0.30**^{A}

A, B, C: Means with the same letter among treatments in the same storage period are not significantly different (p0.05<).

The protein content of fresh frozen yogurt decreased with the increase in the amount of dried beetroot powder in the sample. Table 2 shows the initial protein content, 5.10, 4.95, 4.90, 4.86 and 4.82 for T0, T1, T2, T3 and T4 treatments. Respectively.

These results are consistent with those presented by **[43]** who found that adding a level of more than 3% to beetroot reduced the total amount of proteins due to the lower percentage of proteins present in the dried beetroot compared to the milk used while making the frozen yogurt, which had a mitigating effect on the total proteins present within the samples.

The fat content of frozen yogurt shows T that when increasing proportions of beetroot powder were added, there was a decrease in lipid levels from 2.99 to 2.81 across treatments T0, T1, T2, T3 and T4 respectively.

Of course, slight variation may be due to experimental error but still, this result is in agreement with those reported by **[44]**. This suggests that adding dried beetroot powder into frozen yogurt mixtures helps significantly lower their overall lipid contents while maintaining its flavor profile intact making it a more preferred option for health-conscious consumers.

The ash content was 0.85%, 0.90%, 1.10%, 1.25% and 1.40% for treatments T0, T1, T2, T3 and T4 respectively. This slight increase is due to the higher ash content in dried beetroot compared to milk used in the mixtures preparation process.

Overall it can be concluded that incorporating a small amount (less than 10%) of dried Beetroot Powder into Frozen Yogurt Mixtures doesn't have a significant effect on Ash Content while providing potential Health Benefits from Vitamins and Minerals found naturally inside this Food Source resulting.

Adding different proportions of dried beetroot to frozen yogurt resulted in a significant increase in the content of crude fiber and iron. The percentage of crude fiber and iron increased from 0.00mg/100g to 2.15 and from 0.15 to 1.76 for treatments T0 and T4, respectively.

The result is consistent with that reported by **[45]** found that yogurt with added fruit had a higher fiber content than regular yogurt.

These findings are important because they point to potential health benefits from eating frozen yogurt that contains additional amounts of dried beetroot powders, such as improved digestive health due to increased dietary fiber or improved circulation due to increased iron intake.

Physical properties of the resultant frozen yoghurt:

specific gravity and weight per gallon

Figure (A, B) shows that the specific gravity and weight per gallon of the resulting frozen yogurt were closely related. These results indicated that the mean values of the specific gravity of frozen yogurt were 0.70, 0.71, 0.80, 0.87, and 0.92 for treatments T0, T1, T2, T3, and T4. The corresponding weight values per gallon were 5.81, 5.90, 6.70, 7.25, and 7.65. The specific gravity and weight per gallon increase in the frozen yogurt with an increase in the percentage of adding beetroot powder in the mixture. This may be due to the increase in viscosity for treatments T1, T2, T3, and T4.

Overrun:

Figure (C) shows that adding beetroot powder to frozen yogurt significantly increases the Overrun values compared to a control sample without any added ingredients (T0). All treatments T1–T4 showed increased overshoot with increasing amounts of beetroot powder added. The Overrun values of frozen yogurt were 47.32, 50.76, 55.67, 56.78, and 57.49 for treatments T0, T1, T2, T3, and T4, respectively. Similar observations regarding viscosity and Overrun were reported by [**33**].

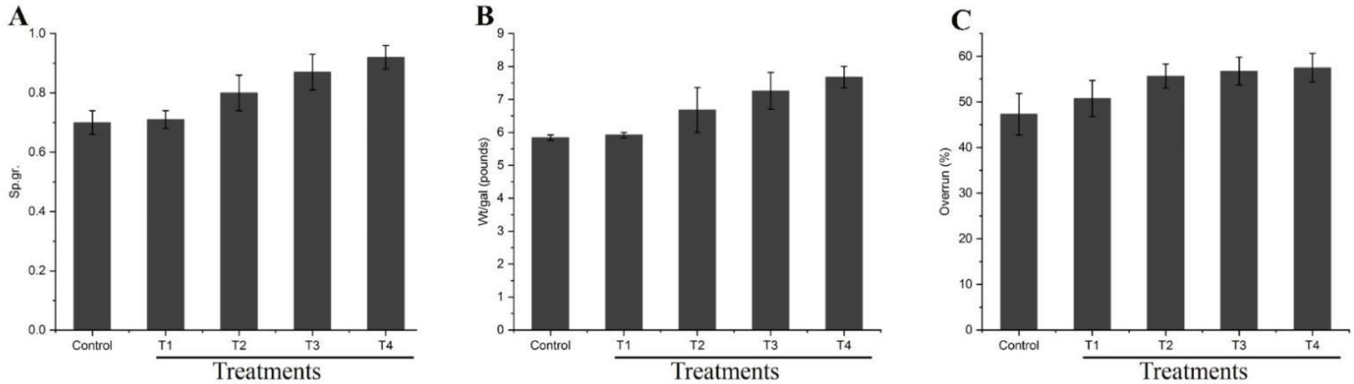

Figure (1): A: specific gravity, (B): weight per gallon, (C): Overrun

Melted portions

Adding beetroot powder to frozen yogurt had a significant effect on thawing resistance. The results in Figure (2) show that the higher the amount of beetroot powder, the lower the dissolution rate. The dissolved fractions in the first 15 minutes showed 14.50, 13.80, 11.20, 9.70, and 8.30% for comparison coefficientsT0, T1, T2, T3, and T4, respectively. The thawed portions of the resulting frozen yogurt sample were gradually increased and completely thawed after 60 min in all treatments. Similar observations regarding chemical and physical properties were reported by **[46]**

At the end of storage, the resistance of frozen yogurt was slightly higher than that of fresh frozen yogurt in all treatments. This is evidenced by its score being 12.80%, 12.30%, 11.90%, 10.50% and 8.10% for treatment T1, T2, T3 and T4 respectively compared to control (T0) levels at 0% beetroot powder. The result is consistent with that reported by [**47**]

Figure (2): Melting rate (%) of fresh and stored frozen yogurt manufactured with different ratios of beetroot powder:

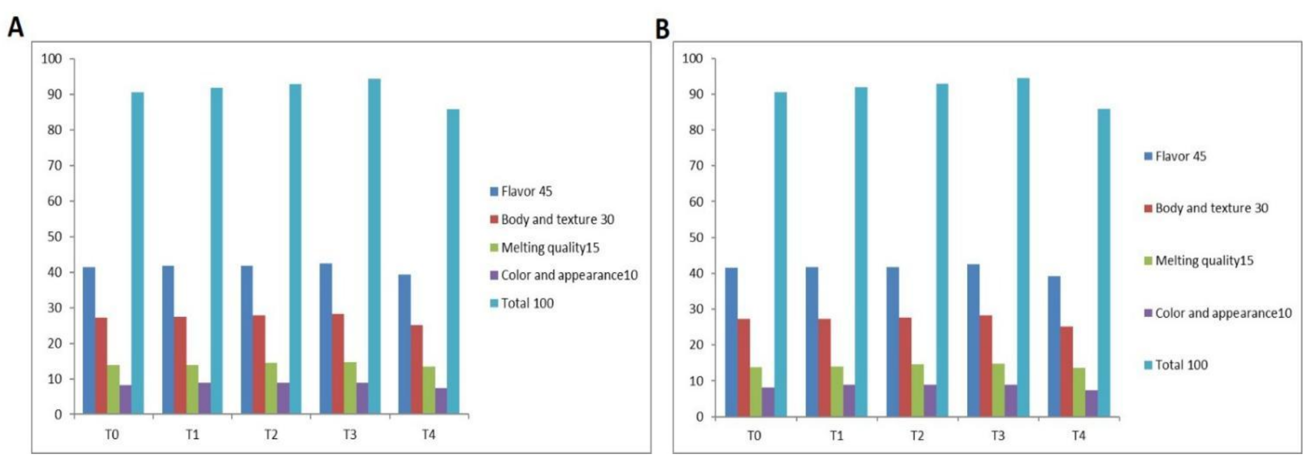

Figure 2(A): Melted portions (%) At 25℃fresh frozen yogurt (B): Melted portions (%) At 25℃end of storage frozen yogurt

Microbiological aspects of frozen yogurt:

Clear data in Table (3) represent: the count's Total bacterial count (TBC); Over the storage period, an increase in TBC was observed with an increase in the concentration of beetroot powder added for up to 7 days, Then the numbers gradually decreased until the end of the storage period. A similar trend was obtained by [**48, 49**]**.** The results of the study showed that the number of LAB in fresh processors slowly increased during storage up to 7 days and then decreased until the end of the storage period. The results obtained are consistent with those presented by other studies[**50, 51**]. Moreover, it was observed that beetroot powder added to frozen yogurt resulted in a higher initial number and total increase throughout the storage periods compared to control samples without this ingredient. Among the treatments, T4 (7% beetroot powder) had the highest logarithms of CFU/mL compared to the other treatments and control.

The results showed that Streptococcus thermophiles numbers were gradually increased in all treatments until the seventh day of cold storage, which could be due to residual activity during this period, and then slowly decreased until the end of the storage period.

These results are consistent with those obtained by[**52, 53**]**.** The largest number was observed when 7% beetroot powder was added (T4), likely because it contains high levels of total sugars which promote growth among starter cultures; **[48, 54]** also reported similar findings when using different concentrations of beetroot powders in their experiments.

Mould, yeast, and Ecoli were not detected in all treatments of yogurt, whether fresh or throughout the storage period. Similar results have been reported by **[55]** who found no mould, yeast or coli in their control samples fortified with whey powder.

Table (3) Microbiological aspects (log CFU/ml) of frozen yogurt with or without beetroot powder when fresh and during storage at -20℃ for up to 4 weeks.

Storage	Treatments				
	T0	T1	T2	T3	T4
	Total bacterial count (TBC)				
Fresh	7.89±0.18^{Bab}	7.92±0.06^{Bb}	8.15±0.15^{ABa}	8.20±0.09^{Aa}	**8.37±0.19^{Aa}**
1 week	8.10±0.10^{Ca}	8.23±0.07^{BCa}	8.35±0.09^{ABCa}	8.41±0.19^{ABa}	**8.60±0.22^{Aa}**
2 week	7.91±0.10^{Cab}	8.01±0.06^{Cb}	8.27±0.15^{B}a	8.39±0.12^{ABa}	**8.52±0.15^{Aa}**
3 week	7.86±0.08^{Bab}	7.90±0.11^{Bb}	8.19±0.22^{Aa}	8.24±0.12^{Aa}	**8.40±0.13^{Aa}**
4week	7.80±0.18^{Cb}	7.90±0.13^{BCb}	8.13±0.14^{ABa}	8.18±0.21^{ABa}	**8.35±0.13^{Aa}**
	Lactic acid bacterial (LAB) count				
Fresh	7.81±0.22^{Aab}	7.83±0.12^{Aa}	7.93±0.17^{Aa}	7.98±0.07^{Aab}	8.07±0.17^{Aa}
1 week	8.03±0.07^{Aa}	8.09±0.10^{Aa}	8.16±0.06^{Aa}	8.25±0.23^{Aa}	8.28±0.11^{Aa}
2 week	8.00±0.09^{Aab}	8.03±0.27^{Aa}	8.15±0.13^{Aa}	8.25±0.10^{Aa}	8.25±0.22^{Aa}
3 week	7.85±0.09^{Bab}	7.87±0.15^{Ba}	7.95±0.13^{ABa}	8.09±0.16^{ABab}	8.15±0.13^{Aa}
4week	7.78±0.03^{Bb}	7.87±0.13^{ABa}	7.93±0.12^{ABa}	7.96±0.07^{Ab}	8.03±0.07^{Aa}
	Streptococcus thermophiles count				

Fresh	7.29 ± 0.19^{Cbc}	7.38 ± 0.12^{Cb}	7.47 ± 0.03^{BCb}	7.61 ± 0.03^{Bcd}	7.87 ± 0.07^{Aab}
1 week	7.68 ± 0.12^{Ca}	7.70 ± 0.06^{Ca}	7.81 ± 0.05^{BCa}	7.93 ± 0.09^{ABa}	8.00 ± 0.03^{Aa}
2 week	7.65 ± 0.36^{ABab}	7.56 ± 0.07^{Bab}	7.80 ± 0.16^{ABa}	7.90 ± 0.19^{ABab}	7.96 ± 0.06^{Aab}
3 week	7.43 ± 0.03^{Cabc}	7.55 ± 0.19^{BCab}	7.51 ± 0.12^{Cb}	7.74 ± 0.05^{ABbc}	7.90 ± 0.05^{Aab}
4week	7.18 ± 0.12^{Bb}	7.30 ± 0.23^{ABb}	7.42 ± 0.08^{ABb}	7.53 ± 0.03^{ABd}	7.64 ± 0.36^{Ab}
			Yeast & mould counts X 102 (cfu g-1)		
Fresh					
1 week					
2 week	ND	ND	ND	ND	ND
3 week					
4week					
			Coliform bacterial		
Fresh					
1 week					
2 week	ND	ND	ND	ND	ND
3 week					
4week					

ND: not detected, A, B, C, D: Means with the same letter among treatments in the same storage period are not significantly different (p0.05<), a, b, c, d: Means with the same letter for same treatment during storage period are not significantly different (p0.05<).

Organoleptic properties of the resultant frozen yogurt:

Sensory evaluation results of frozen yogurt with the addition of beetroot powder in Table (4) show that there is a slight increase in body and texture when beetroot powder is added up to 5%, in addition to an improvement in the melting quality. The colour and appearance were also slightly different for each sample, but the highest acceptance rate was found at the 5% beetroot powder addition rate. At the end of the storage period, it can be seen that all samples experienced a decrease in the average values of flavor and color; However, body texture and dissolution quality still showed improvements over control samples by adding beetroot powder.

Table (4): The sensory properties of fresh and stored frozen yogurt made from different ratios of beetroot powder:

Treatments fresh	Flavor (45)	Body& Texture (30)	Melting quality (15)	Color& Appearance (10)	Total (100)
T0	41.50 ± 3.28^{AB}	27.30 ± 1.18^{A}	13.80 ± 0.79^{BC}	8.15 ± 0.44^{B}	90.55 ± 1.18^{C}
T1	41.75 ± 0.52^{AB}	27.35 ± 0.84^{A}	13.95 ± 0.18^{ABC}	8.90 ± 0.36^{A}	91.95 ± 1.18^{BC}
T2	41.80 ± 0.44^{AB}	27.75 ± 0.48^{A}	14.50 ± 0.17^{AB}	8.90 ± 0.17^{A}	92.95 ± 1.11^{AB}
T3	42.50 ± 0.46^{A}	28.20 ± 0.26^{A}	14.75 ± 0.18^{A}	8.95 ± 0.18^{A}	94.40 ± 1.00^{A}
T4	39.25 ± 0.43^{B}	25.15 ± 0.13^{B}	13.53 ± 0.49^{C}	7.45 ± 0.22^{C}	85.85 ± 1.17^{D}
Treatments end of storage	Flavor (45)	Body& Texture (30)	Melting quality (15)	Color& Appearance (10)	Total (100)

T0	41.10 ± 2.79^{AB}	27.50 ± 2.43^{AB}	14.00 ± 1.96^{AB}	8.00 ± 1.56^{A}B	90.60 ± 1.75^{AB}
T1	40.25 ± 1.23^{B}	27.60 ± 2.35^{AB}	14.20 ± 1.54^{AB}	8.60 ± 1.52^{A}	90.65 ± 2.15^{AB}
T2	41.63 ± 1.92^{AB}	28.10 ± 1.60^{A}	14.70 ± 1.65^{A}	8.80 ± 2.06^{A}	93.50 ± 1.85^{A}
T3	42.00 ± 1.65^{A}	28.20 ± 1.76^{A}	14.80 ± 2.57^{A}	8.80 ± 1.49^{A}	93.80 ± 1.15^{A}
T4	36.00 ± 2.25^{C}	26.30 ± 1.56^{B}	13.70 ± 1.75^{B}	6.10 ± 1.91^{B}	82.10 ± 2.95^{B}

A, B, C, D: Means with the same letter among treatments in the same storage period are not significantly different (p0.05<).

Conclusion

Beetroot is grown and consumed in its raw and cooked form all over the world due to its high nutritional and medicinal value. Beetroot provides valuable essential nutrients and a sufficient amount of beneficial bioactive compounds that contribute to health promotion, disease prevention and treatment response. Increased antioxidant activity of bioactive compounds and successful use of beetroot in disease prevention and health promotion have been reported in the past few decades. More research is needed to explore and use the natural colourants, antioxidants, and dietary fibre found in beetroot to create functional foods. The high amount of bioactive compounds in beetroot pulp can be used as a functional food source against many diseases such as diabetes, cancer, cardiovascular disease and many more oxidative stress-causing chronic diseases.

Beta vulgaris can be used to make different and innovative value-added products so that the consumer can obtain health benefits through food products that are combined with Beta vulgaris.

Finally, frozen yogurt can be fortified with beetroot powder by up to 5% to improve its chemical, physical, organoleptic and microbiological properties.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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