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Research Article
Impact of Konjac Glucomannan on Ice Cream-like Properties

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Abstract

Objective: This study was carried out to investigate the effect of using konjac fiber as alternative to fat and stabilizers replacer during making of free fat ice cream-like on its properties and its production cost. **Methodology:** Four concentrations (0.1, 0.3, 0.5 and 0.7%) of konjac glucomannan as fat and stabilizer replacer dietary fiber were used for making free fat ice cream-like compared with full fat ice cream (6% fat) as control. Control ice cream consists of 6% fat (derived from fresh cream 60% fat), 11% milk solids-not-fat (derived from cream, fluid skim milk and skim milk powder), 16% sucrose and 0.5% commercial stabilizer and emulsifying plus grade. Other free fat treatments made by the same method, which consists of other constituent's ratios. All ice cream treatments were made and stored at -25°C. **Results:** The obtained results revealed that there were highly significant differences in the overrun and the product volume per 1 L mix among all konjac treatments and control, except T1 and T4 (0.1 and 0.7% konjac), it were insignificant. According to melting properties significant differences among all konjac treatments and control were found, except T2 and control (0.5% konjac), it was insignificant. Economically, T1 (0.1% konjac) and T2 (0.3% konjac) were much lower cost and more highly profitability (3.26 and 3.23%) than the control (1.28). Moreover, T1 (0.1% konjac) and T2 (0.3% konjac) were characterized with the highest sensory evaluation, compared with control, while T3 and T4 achieved less scores. **Conclusion:** Free fat, emulsifying and stabilizers ice cream-like as a functional dairy product, can be made by adding 0.3% konjac dietary fiber (T2) as the optimal concentration instead of full fat and commercial emulsifying and stabilizers with a decrease in the economic cost up to 41%.

Key words: Konjac, ice cream, free fat, glucomannan, dietary fiber, economic cost

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ice cream is considered as one of the main dairy products, being consumed and widely in all age groups. It contains the same row milk constituents. Furthermore, other food ingredients such as sugar, cream and flavours, etc., being added to improve its properties. Moreover, it has some therapeutic characteristics such as, antitumor because its content of about 25-30% milk, lactoferrin, which plays a role as agents of non-specific defenses against pathogens. Also, it has an antiviral activity, particularly against cytomegalovirus and influenza. In addition, ice cream is described as an enhancing factor for the fertility. Consuming full-fat milk or ice cream may improve the chances of having a baby[1]. In addition, the consumption of ice cream stimulates the secretion of thrombotonin hormone, which uplifts the mood and prevents mood swings. This hormone also reduces stress levels[2]. On the other hand, some disadvantages might be resulted from the excess consumption of ice cream as it may, raise the cholesterol level, cardiovascular diseases and diabetes. Furthermore, the consumption of ice cream is still an urgent desire for many kinds of people, who are suffering from these diseases and those who do not have a lot of money to buy ice cream because of high prices in the present time.

Recently, many researches were directed to use the ice cream products as functional foods by adding some prebiotics such as dietary fiber, which have many benefits for human health[3]. The presence of dietary fiber such as glucomannan in food stuff with the recommended ratios improves its properties for the human health and prevents many diseases i.e., constipation, protection against colon cancer, lowering of total and low-density lipoprotein cholesterol in the blood serum, reduction of post-prandial blood glucose levels, increases of calcium bioavailability and reinforcement of the immunological system[4]. Konjac glucomannanis a sugar derived from the root of the konjac plant (*Amorphophallus konjac*). It used in several types such as glucommanan powder, tablets and capsules[5]. Moreover, using dietary fiber for instance konjac, maltodextrin, inulin and other types in food processing as fat alternatives and water binding material which give good properties for these food products[6,7]. Therefore, the main objective of the recent study is to study the effect of using konjac fiber as alternative to fat and stabilizers replacer during makingof free fat ice cream-like on its properties and its production cost.

MATERIALS AND METHODS

Materials: Pasteurized skim milk (protein 3.5%, fat<0.5%) and fresh cream 60% fat was bought by Dairy Station Unit, Faculty of Agriculture, Mansoura University. Skim milk powder (Mejerivagen I, S-59840 Vimmerby-Sweden) was used. Commercial mixture of stabilizers and emulsifiers plus grade obtained from (Danisco Co., Copenhagen, Denmark), granulated and refined cane sugar purchased from the local market. Konjac (glucomannan) dietary fiber was obtained from Christen Hansen's Laboratories, Denmark.

Methods

Ice cream making: It was made by the method described by Hugo[8]. Control ice cream consists of 6% fat (derived from fresh cream 60% fat), 11% milk solids-not-fat (derived from cream, fluid skim milk and skim milk powder), 16% sucrose and 0.5% commercial stabilizer and emulsifying plus grade. Other free fat treatments made by the same method, which, consists of other constituent's ratios. Pasteurized raw skim milk and cream were mixed and warmed to 50°C. Pre-blended dry ingredients were added and mixed prior to batch pasteurization (74°C for 10 min) and homogenized by laboratory mixer at high speed. About 0.5% commercial stabilizer and emulsifying plus grade or targeted konjac fiber ratio was added up 50°C. Mixes were cooled and aged overnight at 4°C. Ice cream mixes were whipped and frozen in a 3 L batch freezer (Model, Company, frigomat, Italy) for 10 min and whipped. Extruded ice creams were collected into 150 mL containers and hardened at -25°C. All ice cream formulations were produced in three replicates. The pH values of ice cream treatments estimated using a glass electrode pH meter type CG710, West Germany.

pH: The electrode was immersed directly into the melted sample at 25°C according to AOAC[9].

Overrun: Overrun of samples was calculated as the equation described by Marshall *et al.*[10].

Meltdown characteristics of ice cream: They were investigated according to the method used by Mendez-Velasco and Goff[11].

Viscosity: It was determined using a Visco Elite rotational viscometer (Brookfield, model Rvdve Serial Number E 6531997 Made in USA), equipped with spindle No. L6 at ambient (20±0.5°C) temperature[10].

Number of 10 trained panelists: A number of 10 trained panelists (aged 20-40 years) were requested to evaluate encoded ice creams in terms of appearance, melting and flavour according to Clarke[12].

Fat and total decreasing cost percent: They were calculated according to El-Tahra *et al.*[13].

Fat cost: It was calculated according to the following equation:

$$\text{Fat cost (\%)} = \frac{\text{Fat cost}}{\text{Mix total cost}} \times 100$$

Cost decreasing: It was calculated according to the following equation:

$$\text{Cost decreasing (\%)} = 100\text{-}\left(\frac{\text{Treatment total cost}}{\text{Control total cost}}\right) \times 100$$

Statistical analysis: Data were subjected to statistical analysis according to Coakes[14].

RESULTS AND DISCUSSION

The effect of using different ratios of konjac dietary fiber in making free fat ice cream instead of emulsifying and stabilizing salts. All tested variants were made and stored at the hardening temperature. Three replicates were done and analyzed. The obtained results were tabulated and discussed.

Effect of konjac on overrun and melting properties: Data presented in Fig. 1 show the differences in the overrun of ice cream as affected by using konjac. From these data the overrun (%) of all treatments was higher than that of the control (21.70%). In addition, treatment (T2) gained the highest overrun (%) 31.40 among other treatments and control. It could also be seen that the increase of konjac used above 0.3% had an inverse effect on the overrun, whereas, its fourth addition ratio (0.7%) had the lowest overrun (%) among other konjac treatments with value of 26.33%. The reduction of the overrun (%) by increasing the konjac addition might be due to the increase in the mix viscosity, which delays the air corporation and decreases the product volume, which, finally resulted in a decrease the overrun[4] and Akesowan[15]. Data presented in Table 1 also reveal that there were higher significant differences among all ice cream treatments. Also, there were significant differences between T3- T1 and T2-T3. On the other hand, the differences between T4 and T1 were insignificant.

Also, data in Fig. 1 indicate the differences in the melting percent of the examined ice cream compared with control. These data showed that the higher konjac concentration (0.7%) resulted in the lowest melting percent. However, data

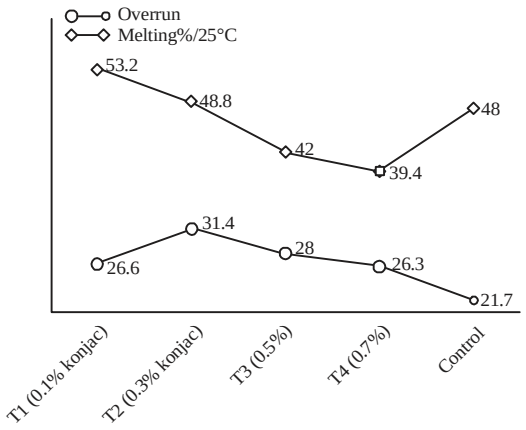

Fig. 1: Effect of konjac on overrun % (w/w) and melting of ice cream-like

Table 1: Effect of emulsifier substitution by konjac on th e overrun (w/w) of free fat ice cream

		Treatments				
Treatments	Main	T1	T2	T3	T4	Control
T1	26.57	-	-	-	0.23^{NS}	4.87**
T2	31.40	4.83**	-	3.40*	5.07**	9.70**
T3	28.00	1.43**	-	-	1.67**	6.30**
T4	26.33	-	-	-	-	4.63**
Control	21.70	-	-	-	-	-

F = 578.87, **p>0.01, control: 6% fat and 0.5% plus grade stabilizer, T1: 0% fat and 0.1% konjac, T2: 0% fat and 0.3% konjac, T3: 0% fat and 0.5% konjac, T4: 0% fat and 0.7% konjac, NS: Non significant

Table 2: Effect of emulsifier substitution by konjac on the melting properties (%) of free fat ice cream-like and control

		Treatments				
Treatments	Main	T1	T2	T3	T4	Control
T1	53.17	-	4.37**	11.17**	13.75**	4.83**
T2	48.80	-	-	6.80**	9.38**	00.47^{NS}
T3	42.00	-	-	-	2.58**	-
T4	39.42	-	-	-	-	-
Control	48.33	-	-	6.30**	8.92**	-

F = 68.58, **p>0.01, control: 6% fat and 0.5% plus grade stabilizer, T1: 0% fat and 0.1% konjac, T2: 0% fat and 0.3% konjac, T3: 0% fat and 0.5% konjac, T4: 0% fat and 0.7% konjac, NS: Non significant

revealed that there was a gradual decrease of the melting percent with the increase of konjac concentration and this might be considered result of increasing of binding water ability by increasing of konjac addition ratio as responsible for strengthening the texture and changing it pasty[2,15]. In addition, data in Table 2 revealed that, the addition of konjac (0.3%) was the closer to the control ice cream on the melting percent with respect to the decrease in its total solids content. Also, the data in the same Table 2 revealed that there were highly significant differences among all ice cream treatments at F value (68.58) and p>0.01. In addition, all treatments

resulted in highly significant differences with the control, except T2 which had insignificant differences (00.47).

Effect of konjac on the volume: Illustrated data in Table 3 indicate the differences in the product volume per 1 L of ice cream mix after freezing. These data indicate that there were pronounced changes among all treatments. Moreover, all treatments resulted in an increase in the product volume compared with the control. Treatment (0.3% konjac) also was of the highest product volume of 1314 mL, whereas, the control treatment had the lowest product volume of 1217 mL. These results might be attributed to the decrease of the air volume incorporated on the ice cream mixture during freezing process and the increase of the mix viscosity, which leads to a decrease on the product volume. These data came in harmony with that found by Dhingra *et al.*[4]. Moreover, data in the same Table 3 show that there were highly significant differences among all ice cream treatments. Meanwhile, highly significant differences were observed among all treatments except T1 and T4, which had insignificant differences.

Effect of konjac on pH and viscosity values: Data presented in Table 4 illustrate the changes on the pH values of ice cream as affected by using konjac in the different treatments compared with control. No differences could be observed among konjac treatments, as it was higher than that in control ice cream. The lower pH value in control ice cream might be attributed to the high fat content, which increases the acid value for ice cream mix[16].

In addition, data presented in Fig. 2 and Table 4 revealed the viscosity values (cp) of ice cream and control ice cream at three speeds. These data showed that there were not any changes in viscosity recorded at the different speeds in T1 (0.1% konjac) and that might be due to its low mix viscosity, which resulted in from the decrease in mix total solids, the absence of fat and the lower bulking agent content. Similar results were reported by Akesowan[17].

Moreover, the addition of 0.7% konjac resulted in the highest viscosity values at the different speeds, when compared with the other konjac treatments. Also, there was gradual increase of viscosity corresponding to the increase of konjac concentrations. The increase of viscosity by increasing the konjac concentration smight be due to the increase of bulking effect of its high concentration[11]. On the other hand, using 0.5% konjac resulted in viscosity closer to the control and its value was 430/3.4, compare with 490/4.9 in control at speed 100. These results are in agreement with Akalin *et al.*[18] and Akesowan[17].

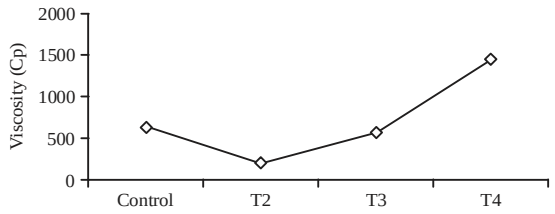

Fig. 2: Effect of konjac on ice cream-like viscosity values at (25°C/spindle ϕ6/speed 60)

Table 3: Effect of konjac on the product volume per liter of free fat ice cream mix (p.v/ 1 l mix)

		Treatments				
Treatments	Main	T1	T2	T3	T4	Control
T1	1265	-	-	-	2.33^{NS}	48.67**
T2	1314	48.33**	-	4.37**	50.67**	97**
T3	1280	14.33**	-	-	16.67**	63**
T4	1263	-	-	-	-	46.33**
Control	1217	-	-	-	-	-

F = 578.87, **p>0.01, control: 6% fat and 0.5% plus grade stabilizer, T1: 0% fat and 0.1% konjac, T2: 0% fat and 0.3% konjac, T3: 0% fat and 0.5% konjac, T4: 0% fat and 0.7% konjac, NS: Non significant

Effect of konjac on economical cost of the examined product with ice cream product: Data presented in Table 5 show the economical aspect of the examined product, compared with the total cost of control ice cream. These data revealed that all konjac treatments resulted inconsiderable decrease in economical cost of ice cream mix. The cost decrease ranged from 36.8-44.29% according to konjac additions. Using 0.1% konjac was of the highest cost decrease (%) when compared with the other treatments. The decrease in total cost was about 43%, which might be due to the absence of fat (%) in all konjac treatments, compared with control[19].

The variations in total cost of konjac treatments were due to the increase of konjac addition concentration, which cause an increase in the total cost.

Sensory evaluation of free fat ice cream made by using konjac: Data in Fig. 3 and 4 show the differences in sensory evaluation of treated with konjac ice cream treatments and control. All samples treated with konjac except T4, recorded higher scores for appearance than control and that might be due to the absence of cream, which results in product of lower appearance. Clear differences among all konjac treatments and control were observed in the melting properties. From these data, T1 (0.1% konjac) resulted in the lowest melting scores than other treatments and control. The

Table 4: Effect of konjac on pH and viscosity values at (25°C/spindle ϕ6)

					Viscosity (cp)		
					Speed value		
Treatment	Fat (%)	Stabilizer and emulsifier (%)	Konjac (w/w)	pH	50	60	100
T1	0	0	0.1	6.6	ND	ND	ND
T2	0	0	0.3	6.6	260/1.3	200/1.2	160/1.6
T3	0	0	0.5	6.6	680/3.4	570/3.4	430/3.4
T4	0	0	0.7	6.6	1600/0.8	1450/8.7	1030/10.3
Control	6	0.5	0.0	6.4	700/3.5	630/3.8	490/4.9

Control: 6% fat and 0.5% plus grade stabilizer, T1: 0% fat and 0.1% konjac, T2: 0% fat and 0.3% konjac, T3: 0% fat and 0.5% konjac, T4: 0% fat and 0.7% konjac, ND: Not determined

Table 5: Effect of konjac on economical cost of the examined product compared with the normal ice cream

Ingredients	T1	T2	T3	T4	Control
Sugar					
kg/100 kg mix	16	16	16	16	16
Price of kg/LE	5	5	5	5	5
Total cost	80	80	80	80	80
Commercial stabilizer (pluss grade)					
kg/100 kg mix	0.00	0.00	0.00	0.00	0.5
Price of kg (LE)	0.00	0.00	0.00	0.00	100
Total cost (LE)	0.00	0.00	0.00	0.00	50
Skim milk					
kg/100 kg mix	79.3	79.3	79.3	79.3	69
Price of kg (LE)	3	3	3	3	3
Total cost (LE)	237.9	237.9	237.9	237.9	207
Skim milk powder					
kg/100 kg mix	4.7	4.7	4.7	4.7	4.5
Price of kg (LE)	25	25	25	25	25
Total cost (LE)	117.5	117.5	117.5	117.5	112.5
Cream					
kg/100 kg mix	0.00	0.00	0.00	0.00	10
Price of kg (LE)	35	35	35	35	35
Total cost (LE)	0.00	0.00	0.00	00	350
Konjac powder					
kg/100 kg mix	0.1	0.3	0.5	0.7	0.00
Price of kg (LE)	100	100	100	100	0.00
Total cost (LE)	10.00	30.00	50.00	70.00	0.00
Total cost	445.40	465.40	485.40	505.40	799.50
Cost decreasing (%)	44.29	41.80	39.30	36.8	

Control: 6% fat and 0.5% plus grade stabilizer, T1: 0% fat and 0.1% konjac, T2: 0% fat and 0.3% konjac, T3: 0% fat and 0.5% konjac, T4: 0% fat and 0.7% konjac

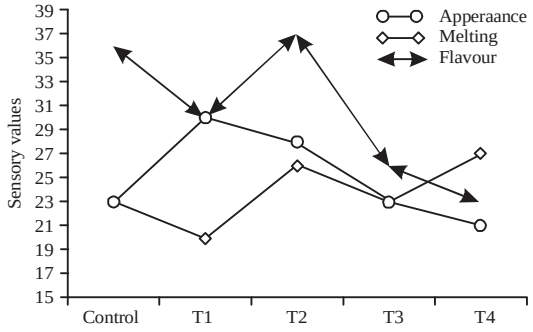

Fig. 3: Effect of konjac in sensory properties of ice cream-like at zero time

lowering in melting score might be due to the decrease of mixing total solid and stabilizing agents. On the other hand, T4 (0.7% konjac) recorded the highest melting score compared with the other konjac treatments and control, which might be due to high content of konjac fiber, which results in more viscosity and increase of the water binding ability of the ice cream product.

Data in the same Table 5 also indicated that T2 (0.3% konjac) have higher flavor score than other konjac treatments. Also, it was closer treatment to control although its less total solids and fat free. Similar results were found by Jennifer[20].

According to the sensory evaluation, the results show that the high ratios of konjac (T3 and T4) caused a decrease in all sensory evaluation scores. From these findings, (T2) appeared to be more suitable for using as a functional and dietary product, which was free from fat and any artificial

Table 6: Effect of konjac on some economical parameters of ice cream and ice cream-like

	Product volume			Total cost		Total income		Net profit				
Treatments	%	L	Price LE/L	%	LE	%	LE	%	LE	Rate of return for the costs	Profitability of pound spent	Profitability of liter
T1	104.02	1266	15	55.71	4454	104.02	18990	141.67	14536	426.35	3.26	11.48
T2	107.97	1314	15	58.21	4654	107.97	19710	146.74	15056	423.50	3.23	11.45
T3	105.17	1280	15	60.71	4854	105.17	19200	139.82	14346	395.55	2.95	11.20
T4	103.78	1263	15	63.21	5054	103.78	18945	135.39	13891	374.85	2.74	10.99
Control	100	1217	15	100	7995	100	18255	100	10260	228.33	1.28	8.43

Control: 6% fat and 0.5% plus grade stabilizer, T1: 0% fat and 0.1% konjac, T2: 0% fat and 0.3% konjac, T3: 0% fat and 0.5% konjac, T4: 0% fat and 0.7% konjac

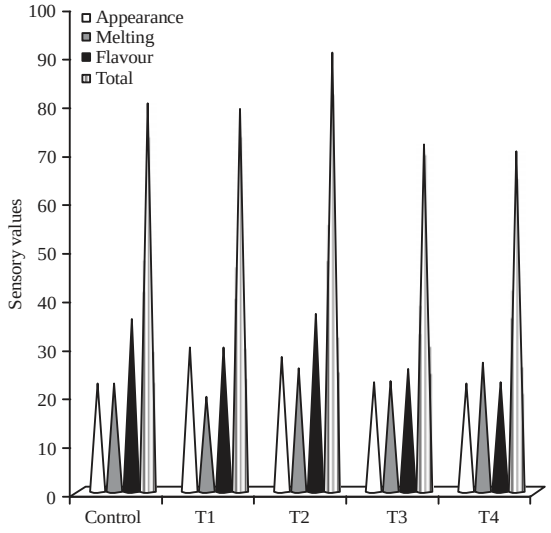

Fig. 4: Effect of konjac on sensory properties of ice cream-like after storage untile 15 days

emulsifying and stabilizers. Also, it recorded the highest score of the total sensory evaluation. Also, similar results were estimated by Ahmed *et al.*[21].

. Data presented in Table 6 indicate some economical parameters, which reveal the profit rate in the ice cream processing field. These data show that all ice cream treatments gained profitability of pound spent higher than the control (1.28). Moreover, treatment T1 (0.1% konjac) and T2 (0.3% konjac) gained the highest profitability of pound spent than other treatments (3.26 and 3.23%). On the other hand T4 have the lowest profitability of pound spent comparing with other konjac treatments and that might be due to the lowest overrun, which was of the decrease in the whippability of the ice cream mix, which results in the decrease in air amount which incorporated in ice cream[19].

CONCLUSION

It could be recommended that free fat emulsifying and stabilizers ice cream-like as a functional dairy product can be made by adding 0.3% konjac dietary fiber (T2) as the optimal concentration instead of full fat and commercial emulsifying and stabilizers with a decrease in the economic cost up to 41%.

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