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Evaluation of Frozen Yoghurt Produced with Vegetable Oils

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THE EFFECT of substituting milk fat with vegetable oils (Sesame, Flaxseed and Olive) at a ratio of 50 and 100%, the characteristics of frozen yoghurt were investigated. Chemical composition, physical, and organoleptic properties were studied in the mix and resultant product. The results showed thatthe values ofpH, specific gravity, and titratable acidityof frozen yoghurt mixes were not significantly affected by the replacement of milk fat with vegetable oils($p \le 0.05$). When the substituted by 50% of milk fat in frozen yoghurt mixes was swapped out for flaxseed oil, their apparent viscosity and freezing point significantly decreased, but their whipping ability significantly improved ($p \le 0.05$). The same tendency was seen when olive oil was used in place of milk fat. When milk fat was replaced with 100 percent flaxseed oil, the apparent viscositydecreased noticeably. In contrast, frozen yoghurt manufactured with sesame oil showed no discernible effect on titratable acidity or pH values as well as the specific gravity of final frozen yoghurt ($p \le 0.05$) When 50% of the milk fat was substituted by olive oil, the freezing point and apparent viscosity of the frozen yoghurt were dropped, but their overrun was decreased. The obtained frozen yoghurt containing 50 or 100% olive oil showed the lowest overrun value and melting resistance among all frozen yoghurt. However, replacing the milk fat with sesame oil increased the melting resistance of the resultant frozen yoghurt. The lowest organoleptic ratings were achieved with flaxseed substitution 50 and 100 %levels, which resulted in an oily test and a weak body of frozen products.At 50% replacement ratio for sesame oil recorded the highest sensory scores, which were confirmed by all the opinions of the arbitrators.

Keywords: Frozen yoghurt, Vegetable oils, Milk fat, physicochemical properties.

Introduction

Frozen yogurt is a fermented frozen dairy dessert that combines the physical qualities of ice cream with the sensory and nutritional benefits of fermented milk. Due to its low- fat content and reduced lactose concentration, which strictly depends on the type and magnitude of the fermentation step, frozen yoghurt can be considered a healthy alternative to ice cream for individuals suffering from obesity, cardiovascular diseases, and lactose intolerance (Akbari et al., 2019) The process consists in mixing all ingredients to make naturally stirred yoghurt with stabilizers/emulsifiers and sugar, then freezing the mix in a conventional ice cream freezer (Tamime & Robinson, 2007).

Frozen yoghurt popularity has increased and continues to grow; making it one of the most frequently consumed frozen desserts around the world. As the popularity of yoghurt products continues to grow, manufacturers are continuously investigating value-added ingredients to entice health-conscious consumers (Allgeyer & Lee, 2010). Consumers find frozen yoghurt appealing because it offers a low-fat alternative to ice cream and because the living cultures in the yoghurt provide probiotic properties (*lactobacillus delbrueckii spp bulgaricus*) In most nations, the official standard of identity for frozen yoghurts has not yet been established (El-Ansaryet al.,2014).One of the most preferred edible vegetable oils for stability is sesame. The oil was shown to be cyanide-free and hence acceptable for human

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consumption. Tocopherol and vitamin E activity are both enhanced by sesame oil, which is thought to aid in the prevention of cancer and other cardiac conditions. Due to its higher proportion of polyunsaturated fat than other oils, sesame also has the lowestcholesterol levels. Due to its higher proportion of polyunsaturated fat than other oils (Abbas et al., 2022).

Since the dawn of civilization, flaxseed has been grown, making it one of the oldest crops. Due to the possible health advantages linked to certain of its biologically active components, flaxseed has drawn more attention in the area of food and disease studies. Alpha-linoleic, short-chain polyunsaturated fatty acids (PUFA), soluble and insoluble fibers, phytoestrogen lignans, proteins, and a variety of antioxidants are among the nutrients found in flaxseeds (Singh et al., 2011; Ooma & Mazza, 2001; Touré & Xueming, 2008). Due to its health-improving effects in lowering cardiovascular illnesses, its popularity is expanding. With a laxative effect, a lower risk of cancer, particularly prostate and breast cancer, and relief from menopausal symptoms and osteoporosis, flaxseed has significant potential as a source of phenolic chemicals and is a vital source of high-quality protein, and soluble fiber.

The health advantages of olive oil are well-established (Psaltopoulou et al., 2011). Oil is an essential component of the Mediterranean diet, and growing evidence suggests that it may have health benefits such as moderating immunological and inflammatory responses, lowering risk concentration of mono-unsaturated factors for coronary heart disease, and preventing a variety of cancers. Olive oil appears to be a functional food because it contains a variety of components that may help explain some of its overall therapeutic properties. The significant fatty acids in olive oil are well recognized (Schwingshackl & Hoffmann, 2014). It is an excellent source of phytochemicals, including tocopherol, squalling, and polyphenolic substances. In addition, olive oil was employed as a tonic, laxative, sedative, and aphrodisiac. To cure conditions as varied as colic, paralysis, rheumatic pain, hypertension and sciatica, olive oil was also employed as an aphrodisiac, laxative, sedative, and tonic (Fitó et al., 2005). The major difficulties currently associated with producing traditional frozen yoghurt include the contributions to the microstructure and colloidal properties provided by the ingredients and/or components present in the formulation; the knowledge and control of the ice crystallization; the selection of suitable stabilizers; and, control of the fat destabilization and the emulsifier functionality

The major difficulties currently associated with producing traditional frozen yoghurt include the contributions to the microstructure and colloidal properties provided by the ingredients and/or components present in the formulation; the knowledge and control of the ice crystallization; the selection of suitable stabilizers; and, control of the fat destabilization and the emulsifier functionality reported by Jing et al. (2022). One emerging trend in the manufacture of functional frozen yoghurt has been the use of non-dairy products. It is important to encourage consumers to consume more plant-derived products, such as dairy substitutes, but this can only happen if these products are accepted by consumers in terms of taste and texture (Hickisch et al.,2016). The present study was designed to prepare frozen yoghurt with different levels of sesame, flaxseed, and olive oils as a substitution of milk fat. Effects on various physical, chemical, and sensory properties of prepared frozen yoghurt were also evaluated.

Materials and Methods

Materials

Raw milk; fresh cow's milk (TS 12.15%, protein 3.4%, and fat 3.25%) used in the study was obtained from the herd of the Faculty of Agriculture, Cairo University. Skim milk powder (SMP) was obtained from Dina farm, Egypt. Freeze-dried probiotic starter culture (FD-DVS ABT -2- Probiotic) containing *Lb. acidophilus*, *Bifidobacterium sp.,* and *Str. thermophiles* were obtained from Chr. Hansen A/S, DK-2970 Horsholm, Denmark. Commercial-grade cane sugar was obtained from the Sugar and Integrated Industries Company in Giza, Egypt.Carboxymethyl cellulose (CMC) produced by TLC gums, MD, USA was used as a stabilizer. Vegetable oils (sesame, olive, and flaxseed) used in this study were obtained from the local market of Cairo. The frozen yoghurt was flavored with vanilla that was purchased from the local market.

Methods

Preparation of frozen yoghurt

Frozen yoghurt was manufactured as described by Abdul-Aziz et al. (2017) and Azari et al. (2021). All frozen yoghurt mixes were needed to meet the following standards: 15% sugar, 12% milk solids not fat (MSNF), and 0.2% CMC. Sesame, olive, and flaxseed oils were used in 6 treatments in place of 50% and 100% of milk fat in frozen yoghurt, in addition to the control treatment. Forthe preparation of functional frozenyoghurt,clean milk was heated to 90°C for 10 sec. then cooled gradually until reached 43° – 45 ºC, and the milk was divided into seven separate sections, a control sample without adding vegetable oils.Sesame, olive, and flaxseed oilswere replaced of 50and 100% of milk fat. Treated and untreated milk samples were inoculated with 2.5% of probiotic starter culture and incubated at 45°C until pH 4.8. When the pH endpoint was achieved, the samples were cooled to 5±٢°C and kept at the same temperature overnight for 15 hr, then the frozen yoghurt mixture was frozen using ice cream machine, then the resulting frozen yoghurt was filled in plastic cups (50 ml) and hardened at -18ºC for the control sample, as well as the manner steps that were followed in all treatments.

Methods of analysis

Chemical analysis

The total protein and total solid (TS) contents of frozen yoghurt samples were determined as the method described byAOAC (2016). Fat and titratable acidity (TA) contents for samples were determined as given by Ling (1963).The pH values of the samples were recorded using a digital pH meter (HI 93 1400, Hanna Instruments, Italy).

Physical nalysis

The specific gravity of mixes and the final frozen yoghurt was determined according to Winton (1958). The freezing point of frozen yoghurt was measured as described in FAO (1977) Using a digital probe thermometer (Digitemp D 200/20, Germany).The overrun percent was calculated as mentioned by Marshall et al. (2003) .

Rheological analysis

The apparent viscosity was measured in all mixes of frozen yoghurt samples using an Ametek Brookfield model LV rotary viscometer, (DV-lllTM, USA) with spindle 03 and 50 rpm for different treatments. Apparent viscosity was estimated using 200 mL of frozen yoghurt mix at 20ºC. Measurements were taken every 3 min of spindle operation and at least 3 replicates were performed. Values are expressed in centipoises (cp).

Sensory evaluation

The Sensory evaluation of frozen yoghurt samples was done by regular score panels including the staff members atthe Food Science Department, Faculty of Agriculture, Ain Shams University. The samples scored for flavor (45), body & texture (35), melting properties (10), and color (10) as suggested byArbuckle (1986).

Statistical analysis

The obtained data of the experiments were presented as mean values. The statistical analysis was done using the SPSS Syntax Reference Guide **(SPSS, 1998)** and the statistically differences at ($p \leq 0.05$) were determined by the least significant difference (LSD) test.

Results and Discussion

Chemical properties

As shown in Table 2, there were no marked differences among pH and titratable acidity values of frozen yoghurt mixes containing vegetable oils as compared with that of control treatment. The pH ranged from 5.43 to 5.60 while the titratable acidity ranged from 0.40 to 0.46. These values of all treatments are within the normal range reported by Kosikowski & Frank (1981).

As shown in Table 3, it could be seen that there were no differences in the total solid contents of treatments ($p \leq 0.05$). Average total solids ranged from 33.21 to 33.50. The total protein content was unaffected in all of treatments. Also, no differences in the percentages of total fat in treatments ($p \leq 0.05$). Average percentages ranged from 8.25 to 8.82%. These values of all treatments are within the normal range reported by Im et al. (1999)

TABLE 1. Composition (Kg/100 Kg) of frozen yoghurt mixes containing different levels of vegetable oils.

Component	Control	Plant Oils	
		% replacement of milk fat	
		50 %	100%
Sugar	15	15.0	15.0
Stabilizer	0.2	0.20	0.20
Skim milk powder	8.06	8.06	8.06
Cream (50%fat)	16	8.00	0.00
vegetable oil	-	8.00	16.0
Fresh skim milk	60.74	60.74	60.74
Total	100	100.0	100.0

TABLE 2.Titratable Acidity and pH valuesof frozen yoghurt manufactured with vegetableoils.

Treatments	Titratable acidity %	pH value
C	0.45[a]	5.43
T1	0.44[ab]	5.54
T2	0.45[a]	5.55
T3	0.43[ab]	5.55
T4	0.45[a]	5.56
T5	0.41[b]	5.60
T6	0.42[ab]	5.58

C:control without any addition.
T1: frozen yoghurt manufactured by 50% replacement milk fat with sesameoil.
T2: frozen yoghurt manufactured by 100% replacement milk fat with sesame oil.
T3: frozen yoghurt manufactured by 50% replacement milk fat with flaxseed oil.
T4: frozen yoghurt manufactured by 100% replacement milk fat with flaxseed oil.
T5: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.
T6: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.

TABLE 3. Chemical composition (%)offrozen yoghurt mixes manufactured by substituting milk fat with vegetable oils

Treatments	TS%	Fat%	Total Protein%
C	33.26 [c]	8.25	4.17[bc]
T1	33.28 [bc]	8.45	4.14[c]
T2	33.31 [bc]	8.77	4.19[bc]
T3	33.35 [b]	8.55	4.21[ab]
T4	33.51[a]	8.70	4.18[bc]
T5	33.23 [bc]	8.57	4.21[b]
T6	33.31 [bc]	8.82	4.26[a]

C: control without any addition.
T1: frozen yoghurt manufactured by 50% replacement milk fat with sesame oil.
T2: frozen yoghurt manufactured by 100% replacement milk fat with sesame oil.
T3: frozen yoghurt manufactured by 50% replacement milk fat with flaxseed oil.
T4: frozen yoghurt manufactured by 100% replacement milk fat with flaxseed oil.
T5: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.
T6: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.

Physical properties

As shown in Table 4, The specific gravity of the treatments did not differ significantly from the control sample, with the exception of frozen yoghurt with olive oil. It was the lowest among all frozen yoghurt treatments including control and this may be due to the lower density of olive oil. Regarding the freezing point and apparent viscosity values of the frozen yoghurt mixes made with vegetable oils, it was found that both of freezing point and apparent viscosity values were lower than that of their respective value in control sample. The decrease in viscosity values could be related to the incorporation of vegetable oil in frozen yoghurt mixes which had higher unsaturated fatty acids with lower viscosity

The results showed that the overrun values decreased by adding the vegetable oils at ratio 100% compared to other treatments, and there were no significant differences between the treatments. From Table 5, it could be noticed that the highest overrun was for control. Also, it could be observed that the lowest overrun was recorded in treatment with 100% substitution of olive oil. Generally, overrun decreased slightly when vegetable oils used especially at high concentrations. This result was nearly in agreement with Im & Heymann(1994).

TABLE 4. Physical characteristic of frozen yoghurt mixes manufactured by substituting milk fat with vegetable oils

Treatments	Specific gravity (g/cm^3)	Freeing point (ºC)	Apparent viscosity (cP)
C	1.073 ^{b}	-1.82^{a}	850.12^{a}
T1	1.069^{b}	-1.87^{abc}	788.06^{d}
T2	1.070^{b}	-1.90^{bc}	751.44^{f}
T3	1.075^{ab}	-1.91^{c}	830.06^{b}
T4	1.082^{a}	-1.89^{bc}	822.24^{c}
T5	1.041^{c}	-1.85^{ab}	770.12^{e}
T6	1.033^{d}	-1.89^{bc}	688.05^{g}

C: control without any addition.
T1: frozen yoghurt manufactured by 50% replacement milk fat with sesame oil.
T2: frozen yoghurt manufactured by 100% replacement milk fat with sesame oil.
T3: frozen yoghurt manufactured by 50% replacement milk fat with flaxseed oil.
T4: frozen yoghurt manufactured by 100% replacement milk fat with flaxseed oil.
T5: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.
T6: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.

TABLE 5. Physical characteristics of resultant frozen yoghurt manufactured by substituting milk fat with vegetable oils.

Treatments	Overrun(%)	Freezing time
C	70.91^{a}	15.57^{d}
T1	65.81^{c}	15.99^{d}
T2	60.87^{e}	16.17^{d}
T3	66.77^{b}	17.22^{c}
T4	61.81^{d}	18.62^{b}
T5	58.43^{f}	18.35^{b}
T6	51.42^{g}	20.35^{a}

C: control without any addition.
T1: frozen yoghurt manufactured by 50% replacement milk fat with sesame oil.
T2: frozen yoghurt manufactured by 100% replacement milk fat with sesame oil.
T3: frozen yoghurt manufactured by 50% replacement milk fat with flaxseed oil.
T4: frozen yoghurt manufactured by 100% replacement milk fat with flaxseed oil.
T5: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.
T6: frozen yoghurt manufactured by 50% replacement milk fat with olive oil

The sensory evaluation results showed that frozen yoghurttreatments made by substituting 50% sesame oil or olive oil instead of milk fat were the best, receiving the highest sensory scores in terms of appearance,body &texture, as well as taste and aroma (flavor). The panelists preferred it with no significantdifferencesfrom the control sample (p 0.05), while most of the arbitrators did not prefer frozen yoghurt containing flaxseed oil due to its oily taste, poor texture, and faster melting. From the foregoing results, it can be noticedthat replacing half of milk fat in the frozen yoghurt treatmentswith sesame or olive oil was better in replacement rate of 50%, as the frozen yoghurt acquired better sensory characteristics. Replacing the milk fat in frozen yoghurt with flaxseed oil comes last in sensory characteristics and is not recommended to replace the milk fat in frozen yoghurt samples.

TABLE 6. Sensory evaluation of resultant frozen yoghurt manufactured by substituting milk fat with vegetable oils

Treatment	Sensory properties				
	Flavor (45)	Body &texture (35)	Melting property (10)	Color (10)	Total score (100)
C	42.50	32.50	8.50	8.00	91.5^{a}
T1	41.50	32.00	8.50	7.50	89.5^{ab}
T2	37.25	27.25	7.00	6.50	$78.^{bc}$
T3	36.00	26.50	6.50	7.50	76.5^{bc}
T4	34.50	24.00	6.75	7.00	72.25^{c}
T5	41.00	32.00	8.00	8.00	$89.^{ab}$
T6				82.25^{bc}	
	39.25	29.00		7.50	
				6.50	

C: control without any addition.
T1: frozen yoghurt manufactured by 50% replacement milk fat with sesame oil.
T2: frozen yoghurt manufactured by 100% replacement milk fat with sesame oil.
T3: frozen yoghurt manufactured by 50% replacement milk fat with flaxseed oil.
T4: frozen yoghurt manufactured by 100% replacement milk fat with flaxseed oil.
T5: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.
T6: frozen yoghurt manufactured by 50% replacement milk fat with olive oil.

Conclusion

Finally, from the obtained results, it can be concluded that replacing milk fat with sesame or olive oil by 50% can be recommended in making frozen yoghurt, since it does not adversely affect the properties of the resulting ice products. Sesame or olive oil as vegetable oilscan be used with a substitution rate of 50% to replace the milk fat to produce functional frozen yoghurt with no significant differences than control with milk fat.

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