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Effect of Supplementation of Flaxseed Oil on Physicochemical and Sensory Properties of Lactose Hydrolyzed *Kulfi*

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Abstract:- In *kulfi* prepared with 70 % lactose hydrolyzed milk added with 7.8 % sugar and 2 % oat flour, flaxseed oil (0.5, 1 and 1.5 per cent) was separately incorporated in order to enrich ω_3 fatty acid (Alpha Linolenic Acid) to *kulfi*. The effect of flaxseed oil on chemical composition, sensory attributes and physical properties such as melting rate and penetration value were studied separately. As the level of flaxseed oil increased from 0 to 1.5 % the fat content, melting rate and penetration values increased whereas specific gravity and sensory evaluation scores decreased significantly. 70 per cent lactose hydrolyzed *kulfi* with 1 per cent flaxseed oil was found better in physico-chemical and sensory attributes.

Keywords:- *Kulfi, flaxseed oil, ω_3 fatty acid, l physico-chemical and sensory properties*

I. INTRODUCTION

Flaxseed (*Linum usitatissimum*) commonly known as linseed, is a member of the genus Linum in the family Linaceae. Commercially, flax is grown both for its seeds and for its fibres and its seed is one of the richest plant sources of the α-linolenic acid (ALA), an ω-3 fatty acid (Gebauer *et al*., 2006). Besides ALA, soluble and insoluble fibres, phytoestrogenic lignans, and an array of antioxidants (tocopherols) are also present in flax seed oil significantly. Flax contains approximately fat 40 per cent, proteins 21 per cent, dietary fibres 28 per cent, ash 4 per cent and carbohydrates such as sugars, phenolic acids, lignans, hemicelluloses 6 per cent (AOCS, 2000). Flax oil from common flax varieties contains around 60 per cent ALA (Duguid, 2009). A- Linolenic acid is the major fatty acid (59.85 g/100 g), followed by oleic (16.04 g/100 g), linoleic (15.86 g/100 g), palmitic (5.17 g/100 g) and stearic (3.07 g/100 g) acids (Condori *et al*., 2011). Flaxseed oil is considered to be rich source of phenolics (Baba *et al*., 2018).

The bioavailability of ALA is dependent on the type of flax consumed. ALA has greater bioavailability in oil than in milled seed, and in milled seed compared to whole seed (Austria *et al*., 2008). The colon bacteria are more accessible to the crushed flaxseed. Hence crushing and milling substantially improve the bioavailability of lignans in flaxseed (Kuijsten *et al*., 2005). Due to its less oxidative stability during cooking, flax oil is not commonly used as food oil (Kris- Etherton *et al*., 2000).

It is reported that omega-6: omega-3 ratio in current Indian urban and Western diet is about 38–50:1 and 16:1, respectively over the recommended ratio of 5:1 (Singh *et al*., 2011). Flaxseed oil is a promising functional ingredient for the preparation of delivery systems to fulfill this nutritional gap of omega-3 fatty acids (Goyal *et al*., 2016).

"The potential health benefits of ω-3 fatty acids have been widely reported for several conditions including cardiovascular disease, hypertension, atherosclerosis, brain development, diabetes, cancer and neurological disorders (Gogus and Smith, 2010). Omega-3 fatty acids are reported to reduce cellular and vascular inflammation in the brain, and ensure integrity of brain cell membrane to keep them soft and pliable. DHA and EPA are credited to reduce the level of thromboxanes (TXA2) and increase prostacyclins (PGI2) level leading to enhance tissue perfusion and oxygen delivery due to vasodilation and decreased blood viscosity. EPA and DHA have been found to reduce the total serum cholesterol and serum triglycerides thereby reducing the risk of cardiovascular disease (Wang *et al*., 2006).

Kulfi, a frozen dessert which is enjoyed by consumers of all ages, is a fair means of offering good nutrition to the consumer. If lactose hydrolyzed milk is used along with addition of flaxseed oil it becomes a functional *kulfi* and can extend therapeutic benefits to consumers. The objective of this study was to optimize the level of supplementation of flaxseed oil to *kulfi* prepared from 70 % lactose hydrolyzed milk.

II. MATERIALS AND METHODS

Ingredients Whole milk was procured from dairy farm, KVAFSU, Hebbal, Bangalore. Fresh cream (40 % fat and 6 % SNF) obtained after separating the fresh whole milk and 'Sagar' brand skim milk powder (SMP) were used for standardization of milk (fat 5%, SNF 8.5%). Carboxy Methyl Cellulose (CMC) was used as the stabilizer and emulsifier in

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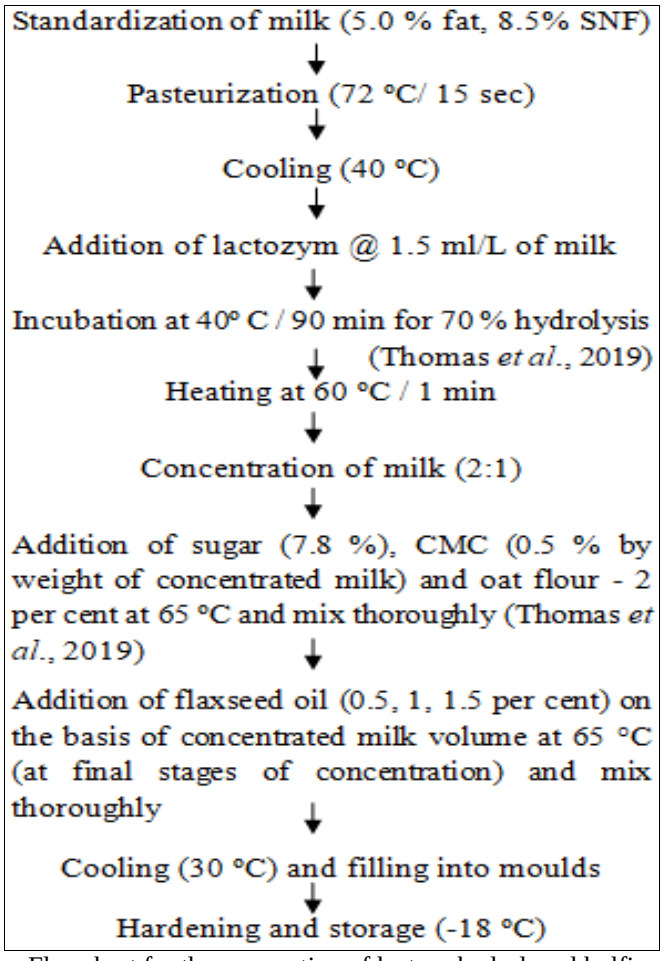
this study. Enzyme lactase (β-galactosidase), commercially available as 'LACTOZYM', manufactured by Novo Nordisk A/S, Denmark, 3000 LAU/ml activity, type HP-G was used for hydrolysing lactose. Virgin single press processed flaxseed oil manufactured by 'UNIFINE', Ahmedabad was obtained from local market.



Flowchart for the preparation of lactose hydrolyzed kulfi supplemented with flaxseed oil

Analytical methods Standard of ISI: SP 18 (Part XI) 1981 was adopted for carrying out chemical analysis such as fat, moisture, protein, lactose and ash contents.

Specific gravity of *kulfi* mix was estimated at 30 ºC by using a standard specific gravity bottle of 50 ml capacity, taking distilled water as the standard liquid. The melting rate of the *kulfi* was observed by drawing 10 g of the sample on to a wire net placed on a funnel over a beaker immediately after removal from the *kulfi* moulds. The time taken by the sample for complete melt down and dripping into the beaker at room temperature was noted. The melting rate was expressed as ml/15 min. Using a cone penetrometer, penetration value was determined as soon as *kulfi* were drawn from the molds after hardening. The distance in millimeter by which the cone travels in 5 s of the sample was noted. For each sample reading were recorded at 3 different spots and the mean value was noted.

Sensory evaluation Kulfi samples were given to a panel of five judges for sensory evaluation. Each judge was supplied with standard score card of a total of 9 Point Hedonic Scale for colour and appearance, body and texture, flavor and overall acceptability. The scores given by panel of judges were then statistically analyzed.

Statistical analysis The results which are the average of three replications will be statistically analyzed by subjecting to statistical analysis (R Programme, R- Version 3.1.3) using ANOVA technique for one way analysis with independent samples that helps in interpretation (Zar, 2003).

III. RESULTS AND DISCUSSION

Effect of flaxseed oil on chemical composition of lactose hydrolyzed kulfi The effect of supplementation of flaxseed oil on the chemical composition of *kulfi* is presented in Table 1. It is evident that supplementation of flaxseed oil only affected the fat content significantly and did not show any effect on moisture, protein, lactose and ash.

Level of flaxseed oil (per cent of kulfi mix)	**Chemical constituents (per cent)**				
	Moisture	**Fat**	**Protein**	**Lactose**	**Ash**
0 (control)	60.60	10.26[a]	7.01	4.03	1.27
0.5	60.60	10.75[b]	7.01	4.03	1.27
1.0	60.61	11.25[c]	7.02	4.04	1.28
1.5	60.59	11.77[d]	7.01	4.04	1.28
CD(*P*=0.05)	**0.01**	**0.02**	**0.01**	**0.006**	**0.01**

Table 1:- Effect of supplementation of flaxseed oil on chemical constituents of lactose hydrolyzed *kulfi*

Note:

- Each value is mean of three trials
- Figures in a column with different alphabets differ significantly
- Control- 70 per cent lactose hydrolyzed *kulfi* with 7.8 per cent sugar and 2 per cent oat flour

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As the level of flaxseed oil increases from 0 to 1.5 per cent, the fat content also increased significantly from the initial 10.26 in the control kulfi to 11.77 in the kulfi supplemented with 1.5 per cent flaxseed oil. The flaxseed oil has contributed for the higher fat in the kulfi. Similar observations have been made by Goyal *et al*. (2016) in dahi fortified with omega-3 fatty acids using flaxseed oil powder (FOP). They reported that dahi fortified at 2 per cent level had the total fat 3.74 per cent compared to 3.04 in control dahi without any addition of flaxseed oil.

Effect of flaxseed oil on physical properties of lactose hydrolyzed kulfi The effect of supplementation of flaxseed oil on the specific gravity, melting rate and penetration value of *kulfi* is presented in Table 2 and Figures 1 and 2. From the results it is evident that the supplementation of flaxseed oil in kulfi has significant effect on melting rate and penetration value. As the level of flaxseed oil in the kulfi increased from 0 to 1.5 per cent, the meltdown rate and penetration value increased significantly, indicating the reduced hardness. The meltdown rate values for 0, 0.5, 1and 1.5 per cent flaxseed oil added kulfi was 16.35, 17.03, 17.48 and 17.91 ml/15min, respectively and the penetration values for kulfi with same level of addition of flaxseed oil was 32.27, 33.67, 34.30 and 34.76 mm/5s, respectively.

The factor, which could be responsible for lower hardness in omega-3 fortified kulfi, was the nature of fat/oil used in the preparation of kulfi. In the present study, the kulfi was supplemented with flaxseed oil, which might have caused the decrease in hardness of fortified kulfi samples as the vegetable oils have lower melting point, thus decrease the hardness of kulfi when used as a supplement (Nadeem *et al*., 2009).

The results are in accordance with the findings of Goh *et al*. (2006) who studied the hardness at -18 °C of ice cream containing different levels of flaxseed oil. They reported that ice cream made with a high proportion of flaxseed oil showed minimal fat flocculation, and hence, could not effectively stabilize the air cells resulting in a soft ice cream that has a high meltdown rate and high penetration value. Lim *et al*. (2010) also reported that the supplementation of flaxseed oil in reduced fat ice creams result in reduced hardness of the product.

Level of flaxseed oil (per cent of kulfi mix)	**Physical properties**		
	Specific gravity	**Melting rate (ml/15min)**	**Penetration value (mm/5s)**
0 (control)	1.113	16.35^{a}	32.27^{a}
0.5	1.113	17.03^{b}	33.67^{b}
1	1.112	17.48^{c}	34.30^{bc}
1.5	1.112	17.91^{d}	34.76^{c}
CD(*P*=0.05)	**0.005**	**0.09**	**0.29**

Table 2:- Effect of supplementation of flaxseed oil on physical properties of lactose hydrolyzed *kulfi*

Note:

- Each value is mean of three trials
- Figures in a column with different alphabets differ significantly
- Control- 70 per cent lactose hydrolyzed *kulfi* with 7.8 per cent sugar and 2 per cent oat flour

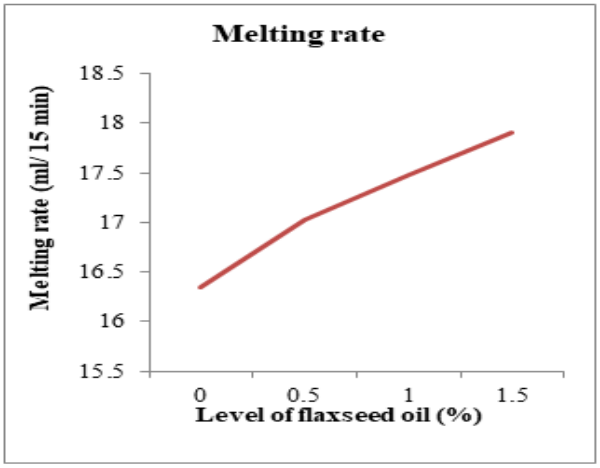

Fig 1:- Effect of supplementation of flaxseed oil on melting rate of lactose hydrolyzed *Kulfi*

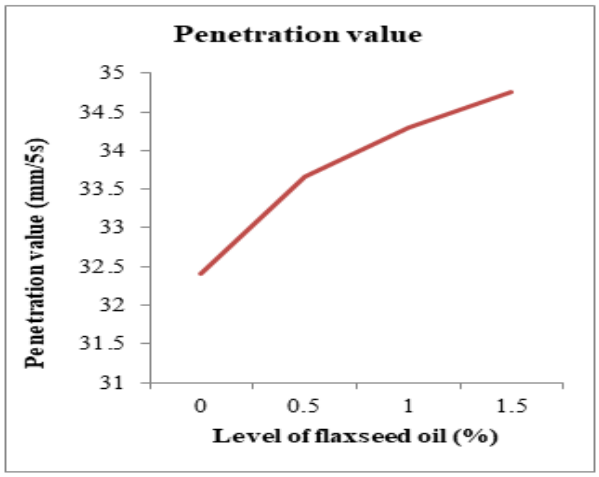

Fig 2:- Effect of supplementation of flaxseed oil on penetration value of lactose hydrolyzed *Kulfi*

Effect of flaxseed oil on sensory attributes of lactose hydrolyzed kulfi The effect of supplementation of flaxseed oil on the sensory attributes of *kulfi* is presented in Table 3. The result shows that the supplementation of flaxseed oil has significant effect on all the sensory attributes of kulfi except body and texture. The supplementation of 1 and 1.5 per cent flaxseed oil to kulfi significantly increased the colour and appearance score (7.88 and 7.95, respectively) than that of control (7.84). The evaluation on kulfi colour revealed that the amount of flaxseed oil substitution was positively correlated to yellowness intensity and also upon hardening the flaxseed oil imparts a glossy appearance to the kulfi surface which increases the colour and appearance scores. This concurs with the findings of Goyal *et al.* (2016) in dahi fortified with omega-3 fatty acids using flaxseed oil powder. They reported that for colour and appearance the control scored 8.0 out of 10 whereas dahi fortified with ω_3 fatty acid scored 8.60.

Supplementation of flaxseed oil affected the kulfi scores significantly and as the level of oil increased, the kulfi scores were significantly decreased from initial 7.68 to 7.05, respectively. The scores awarded for kulfi were 7.68, 7.43, 7.25 and 7.05 for control and kulfi samples with 0.5, 1 and 1.5 per cent flaxseed oil, respectively. Lower Kulfi scores in flaxseed oil fortified kulfi could be attributed to the presence of more quantity of unprotected flax seed oil, thereby generating the oily kulfi in the resulted product.

The kulfi scores may be improved by either encapsulation methods or by adding any additional kulfi to the kulfi instead of preparing plain kulfi. This is reported by Avinash (2014) in stability of microencapsulated omega-3 fatty acids rich flaxseed oil powder in ice-cream. From his research he found out that that on incorporating strawberry or butterscotch flavours, higher fortification level (4 per cent) could be achieved, which was 3 per cent when vanilla kulfi was used in the development of omega-3 fortified ice-cream.

The kulfi with 1 per cent flaxseed oil was rated higher for its overall acceptability than the control, whereas the 0.5 per cent and 1.5 per cent flaxseed oil added kulfi scored lower than that of control. The kulfi with 0.5 per cent flaxseed supplementation had weak body and texture and poor kulfi, whereas the kulfi with 1.5 per cent flaxseed had intense flaxseed oil kulfi.

Addition of flaxseed oil (per cent of kulfi mix)	**Colour & appearance**	**Body & texture**	**Flavour**	**Overall acceptability**
	Scores on nine point hedonic scale			
0(control)	7.84^{c}	8.04^{a}	7.68^{a}	7.82^{a}
0.5	7.81^{c}	7.99^{a}	7.43^{b}	7.69^{b}
1.0	7.88^{b}	8.05^{a}	7.25^{c}	7.83^{a}
1.5	7.95^{a}	8.13^{a}	7.05^{d}	7.57^{c}
CD (*P*=0.05)	**0.01**	**0.07**	**0.04**	**0.02**

Table 3:- Effect of supplementation of flaxseed oil on sensory properties of lactose hydrolyzed *kulfi*

Note:

- Each value is mean of three trials
- Figures in a column with different alphabets differ significantly
- Control- 70 per cent lactose hydrolyzed *kulfi* with 7.8 per cent sugar and 2 per cent oat flour

IV. CONCLUSION

The present investigation was carried out to develop lactose hydrolyzed *kulfi* supplemented with flaxseed oil. The effect of supplementation of flaxseed oil on chemical composition, physical properties and sensory attributes shows that, as the level of flaxseed oil increased from 0 to 1.5 % the fat, melting rate and penetration value increased whereas sensory evaluation scores decreased significantly. All other attributes remained without significant difference. 70 per cent lactose hydrolyzed *kulfi* with 1 per cent flaxseed oil was found better in physico-chemical and sensory attributes than 0.5 % and 1.5 % flaxseed oil added 70 % lactose hydrolyzed *kulfi*.

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