J. Food and Dairy Sci., Mansoura Univ., Vol. 7 (8): 371 - 382, 2016

Physicochemical and Sensory Properties of Ice Cream Mix Using Different Whole Mill Grains

Jehan B. Ali*; T.T. El-Sisy * and Mervat S.H. Youssef *
***Regional Center for Food and Feed, Agriculture Research Central.**

ABSTRACT

The aim of the present study was to produce healthy ice cream mixes by replacement of stabilizer with whole mill grains and study their effect on the physicochemical and sensory properties. Total solid (%) was increased with added the powder of grains in all mixes. Protein ranged between3.6 to 4.9 and increased by adding whole grain meal and oats mixes contained the highest protein value. Ash % increased with added milled whole grains Oats mixes contain the highest value of ash. Fat % ranged from 20.66 to 25.90 and oats mixes contained the highest fat %. Total carbohydrate increased with adding the milled whole grains and white corn mixes contained the highest carbohydrate values. Oat mixes gave the highest overrun values. Use of 0.5% milled grain gave the highest melting rate. Increasing apparent viscosity as a result of changing kind of whole mill grains and concentration of adding: (oats; sorghum; white corn; yellow corn) and control samples. Viscosity of ice cream mixes contained1% milled grain was the highest between mixes and were the best in organoleptic properties Thus we recommend to use the milled whole grain in ice cream mixes especially oats to give the consumer a new nutraceutical product with prebiotic substances e.g β glucans , vitamins …etc. .

Keywords: Whole mill (white and yellow) Corn, Sorghum, Oats and ice cream mix, physicochemical properties, Sensory properties.

INTRODUCTION

Ice cream has a general formula, which can be added to or slightly modified to create the desired product. The major constituents in the ice cream formula back bone are milk fat, milk solids not fat, sweetener, stabilizer and/or emulsifiers, water and air (Goff and Hartel, 2013).

Ice cream is one of the popular frozen-dessert worldwide. It is a complex colloidal frozen food system which consists of partially coalesced fat droplets, air cells, ice crystals and a viscous aqueous phase. In the aqueous phase, polysaccharides, proteins, lactose and mineral salts are dispersed (Marshall *et al*., 2003). On the other hand, the carbohydrate-based fat replacer provided the ice cream with poor texture properties but good melting characteristic (Muhammet, 2006).

The basic role of a stabilizer is to reduce the amount of free water in the ice cream mix by binding it as "water of hydration", or by immobilizing it within a gel structure. Also it is the ability of small percentage of stabilizer to absorb and hold large amounts of bound water, which produces good body, smooth texture, slow melt down and heat shock in the resultant product (Keeney, 1982). A good stabilizer should be nontoxic, readily disperse in the mix, not produce excessive viscosity or separation or foam in the mix, not clog strainers and filters, provide ice cream with desirable meltdown, be economical, and not impart off flavor to the mix (Kilara and Chandan, (2008).

Dietary fibers include a group of heterogeneous food constituents such as celluloses, hemicelluloses, lignins, pectins, and seaweed. Dietary fibers can be found in different food sources such as oat, wheat and apple. Several studies show the physiological and nutritional aspects of dietary fibers.

The physiological effects of food products supplemented with dietary fibers include the improvement of gastrointestinal health, protection against colon cancer, reducing blood total and low-density lipoprotein cholesterol, lower blood glucose after meal, and immune stimulants Tungland and Meyer, (2002). The use of dietary fibers shows a significant improvement in melting quality of ice cream with a minimal effect on viscosity, overrun and texture Dervisoglu, and Yazici (2006) and Tiwari et al., (2015). In another study, both oat and wheat fibers improve viscosity development due to water-binding capacity Soukoulis, et al., (2009).

Dietary fibers (oat & wheat germ), whey protein and modified starch could be used to replace fat in ice cream and to give a healthy reduced fat ice cream with high fiber content and with high antioxidant activity (Salem et al., 2016).

Sorghum (S. bicolor) is the fifth most important cereal crop after wheat, rice, maize, and barley in terms of production (FAO, 2005). Oats *(Avena sativa)* contain many natural compounds beneficial to health. These include tocopherols, phenols and phytosterols compounds as well as soluble and insoluble fibers.β-glucan a unique soluble fiber, is the most recognized health promoting compound. Of the common cereals (wheat, rye, oats and barley), the largest (seed) amounts of β-glucan are found in barley (3-11%) and oats (3-7%), (Wood and Beer, 1998). In oats, the β-glucan is in the endosperm and its wall, making dehulling and fractionation of the whole grain necessary to produce commercial β-glucan enriched brans. Using technology and processing controls, natural oat bran with high dietary fiber content (44%) and β-glucan content (up to 22%) can be achieved. Over the years, oat has gained in importance because of the size and makeup of the livestock industry, and an increased interest in oats in the human food market. Oats is one of the best sources of inositol, which is very important for maintaining blood cholesterol level. It also contains very high levels of calcium, potassium, and magnesium, coupled with vitamin B-complex. All these vitamins and minerals are very essential for the nervous system Eating oats regularly helps to keep the blood cholesterol level low, act as anti-depressants reduce stress prevents bowel cancer cure constipation, and help in lowering chances of heart-disease, (Fulcher and Miller, 1993).

At present, there is an increasing concern about the effect of diet on health and quality of life. The future will continue to bring many changes in the composition and form of frozen dairy desserts as manufacturers try to gain market share and increase profitability. As an example, frozen desserts can be used to carry health-promoting constituents—vitamins and minerals or fiber or other nutraceuticals. Since the consumption of ice-cream is higher among children of vulnerable age groups, there is a need to maintain a high nutritional value and reduced chemical additive in industries of ice cream. So the aim of this study was to evaluate the effects of added some whole grains mill on ice cream mixes for increase the nutrition value and as stabilizer replacer system on physical, chemical and sensory properties of ice cream mix.

MATERIALS AND METHODS

Materials

Grains samples.

Two imported grains are yellow Corn (*Zea mays)* and oats *(Avena sativa)* were obtained from U.S.A which were obtained from two Government (Alexandria and El-Suez) and Egyptian yellow sorghum grains (Sakha 80), *(Sorghum bicolor)* and Egyptian white corn (Giza 10), (*Zea mays)* were obtained from El-Ghrbia. They were taken from two different Companies during 2015.

Whole pasteurized cow's milk (3% fat, SNF 8.5%), Cream pasteurized (35% fat), Sucrose and vanilla powder were obtained from local market. Stabilizers that were purchased from Polsgaard Mould Ice 156 (Food Emulsifier and stabilizer) (Denmark- Eu).

Media and Reagents: Peptone water, Rose Bengal chloramphenicol agar (Biolife, Italy).were used for mold enumeration and identification:

Methods

Preparation of grains

A five kg of each grain samples used in this investigation were stored at temperature 25°C and relative humidity less than 62% and taken samples from stores according to the methods described in USDA, (1995). Grains samples were cleaned mechanically to remove dirt, dockage, imparters and other strange grains by Carter Dockage Tester according to the methods described in USDA, (2002).The (white and yellow) corn and sorghum samples were milled by Laboratory mill 3100 Perten while oat samples were milled by Vibratory bran finishers Chopin According to the methods described in AACC method (2000).

Ice Cream Formulations

Ice cream mix contained 63.8% of water, 16% fat, 16% sugar, 0.5 , 0.7 or 1% meal whole grains and 0.4% vanilla as flavor. Three ice cream formula (A, B and C) and three controls were designed. Control samplecontains 0.5%, 0.7%, 1% stabilizer (Denmark-Eu). A, B and C contain 0.5%, 0.7% and 1% whole meal grains of (white corn, yellow corn, sorghum, oats) respectively alternative to stabilizer.

Ice Cream Preparation

Ice creams mixes were prepared by made from milk and sugar then milled whole grains were added (A 0.5% added, B 0.7% added, C 1% added) in some milk and mixed with the milk sugar solution then cooled for 2 hours and admixed with cream and vanilla. The mixes were chilled for a minimum of eight hours. The chilled mixtures were frozen the following day in batch ice cream maker. After that all mixes were stored at – 20°C.

Physico-chemical analysis:

Physical properties

Cleanliness, dockage, broken kernel, sound, foreign materials, total damaged kernels and total defects were separated and determined manually (hand picking). Test weight pound per bushel, Test weight P/B = (Kg / Hectoliter) ÷1.278 according to USDA, (2006).

Chemical properties

Moisture, crude protein, vitamins, ash, crude fiber, amino acid, minerals , titratable acidity and fat were determined according to AOAC, (2005) and Grains Moisture according to USDA, (1999). The nitrogen free extract (NFE) was calculated by difference. . The pH value was examined for samples. The pH of ice cream was measured using a pH meter model HANNA pH instruments. Total carbohydrate (%) was calculated by difference. Minerals content (Mg, Zn, Ca, P, Cu, Mn, K, Na, Fe, Co, Se and Ba) were determined after aching of different samples according to AOAC (2005). Elements were carrying out using Atomic absorption spectrophotometer model 3300 Perkin Elmer. The data were calculated as ppm dry sample.

Microbiological methods

Total mold count & fungal identification were carried out using Rose Bengal chloramphenical agar and incubated for 5-7 days at 25 ^{o}C. Fungal identification was performed for isolated fungi in Food Safety Lab, Regional Center for Food & Feed, Agriculture Research Center and identified according to (Samson *et al.*, 1995). Estimation of Aflatoxins content, Ochratoxin, Zearalenone and Fumonisin were determined by HPLC using the method of AOAC (2005).

Apparent viscosity and shearing properties (flow behavior):

Apparent viscosity of ice cream was measured directly using Brookfield Digital Rheometer, Model DV III Ultra. Shear stress / shear rate data of the investigated casein protein solutions were obtained by using a rotational viscometer (Brookfield Engineering Labs DV-III Ultra Rheometer .The temperature of the outer cylinder was adjusted to 25 ± 1°C by means of a circulating water bath.

Over-run and Melting Resistance:

The overrun of ice cream samples was determined using the formula of Marshal and Arbuckle (1996). The melting resistance of ice cream samples was determined according to Sakurai *et al*., (1996).

Sensory Evaluation:

The samples were rated for colour and appearance, flavor, body/texture and overall acceptability as prescribed by Herald *et al*., (2008).

Statistical analysis

Data of three replicates were computed for the course of scoring for each sample was statistically analyzed according to SAS, (1999) using Duncan's multiple range tests.

RESULTS AND DISCUSSION

Physical and chemical properties of grains cultivars and their flours

Chemical composition of different grains cultivars used in this study is given in Table (1) Grains moisture content of ranged from (9.50 to 13.30) for all studied samples. Oats had the highest value while white corn had lowest value among all samples. As regards protein content, oats had the highest protein (11.30%) followed by white corn (10.50%), while yellow corn (8.30%) had the lowest protein content. On other hand nitrogen free extracts (NFE) % ranged from 54.50% (oats) to 72.90% (white corn). Additionally sorghum was lower in fat (1.50) than other samples and yellow corn lower in ash content (1.40). Ash content of all grains was found quite close to each other. The results of fiber showed that oats had significant the highest value (11.90%). The sorghum had the significant lowest value (0.185%) of tannic acid.

Data in Table (2) showed the mineral contents of the tested grains. It can be noticed that (Mg) ranged from 45.0 to 370 ppm for all samples, Fe ranged between 30.0 to 108.0 ppm for all samples. Additionally some micro elements have the highest range for Ca (0.13 to 0.50 ppm), P (1.28 to 90.0 ppm) and K (0.50 to 270.0 ppm) than the other elements. The same trends are noticed in heavy metals for all samples. These results agree with result obtained by Nagarajan, (2005).

Vitamins content of different grains cultivars used in this study are given in Table (3) Thiamine (B1) content ranged from 0.77 to 4.62 ppm for all studied samples. Sorghum had the highest value while oats had lowest value among all samples. As regards Riboflavin (B2), sorghum had the highest (B2) (1.54 ppm) while oats (0.14 ppm) had the lowest (B2). On other hand Niacin (B3) range from 0.97 ppm (sorghum) to 48.4 ppm (oats). Additionally oats was lower Pantothenic (1.36 ppm) than other samples and white corn was the lower in Pyridoxine (0.93 ppm) in completely in other samples. However, highest folic acid was observed in white corn (3.10 ppm). On the other hand vit. (A) range from 8.0 ppm (yellow corn) to 9.0 ppm (white corn). Additionally yellow corn was lower vit. (E) (24.0 ppm) and lower in biotin (0.80 ppm) in completely in other samples. These results agree with result obtained by (FAO, 2009).

Amino Acids content of the different grains cultivars used in this study is given in Table (4). Arginine content ranged from 4.79 to13.10 ppm for all studied samples. Cysteine, content of yellow corn had the highest value (2.50 ppm) while sorghum (2.19 ppm) had the lowest value. On other hand lysine ranged from 2.10 ppm (sorghum) to 13.70 ppm (white corn). Additionally white corn was lower in methionine (0.67 ppm) than the other samples and lower in histidine (0.89 ppm) in comparison with the other grain. However, highest aspartic was observed in white corn (24.40 ppm). The results of Tryptophan showed that white corn had significant highest value (2.30 ppm) while oats had lowest value (0.90 ppm). These results agree with result obtained by (FAO, 2009).

Table 1: Proximate analysis of different grains cultivars.

	Grains			
	White corn	Yellow corn	Sorghum	Oat
Moisture	9.50 ^{D}	13.20 ^{B}	11.60 ^{C}	13.30 ^{A}
Protein	10.50 ^{A}	8.30 ^{B}	10.40 ^{A}	11.30 ^{A}
Fat	3.30 ^{B}	4.0 ^{B}	1.50 ^{C}	5.80 ^{A}
Ash	1.50 ^{B}	1.40 ^{B}	1.79 ^{B}	3.20 ^{A}
Fiber	2.30 ^{C}	3.0 ^{C}	6.50 ^{B}	11.90 ^{A}
Nitrogen free extracts	72.90 ^{A}	70.10 ^{A}	68.21 ^{A}	54.50 ^{B}
Total caloric values	363.30 ^{AB}	349.60 ^{BC}	332.74 ^{C}	372.60 ^{A}
Tannic acid	*	*	0.185	*

*** = Not detected,**

Means with same letter are not significantly different.

Table 2: Minerals for different grains cultivars

Minerals	Grains			
(ppm)	White corn	Yellow corn	Sorghum	Oats
Mg	370 ^{A}	140 ^{C}	190 ^{B}	45 ^{D}
Zn	4.6 ^{D}	14.0 ^{C}	15.4 ^{B}	82.8 ^{A}
Mo	-	-	-	-
Ca	0.4 ^{AB}	0.3 ^{B}	0.5 ^{A}	0.13 ^{C}
P	890 ^{A}	90.0 ^{B}	3.5 ^{C}	1.28 ^{C}
S	15.1 ^{A}	12.0 ^{B}	-	-
Cu	2.3 ^{D}	4.0 ^{C}	10.8 ^{A}	7.75 ^{B}
Mn	1.63 ^{D}	5.0 ^{C}	163 ^{A}	118.6 ^{B}
K	270 ^{A}	37.0 ^{B}	0.5 ^{C}	1.16 ^{C}
Na	5.2 ^{A}	3.0 ^{B}	4.6 ^{A}	-
Fe	50.20 ^{B}	30.0 ^{C}	50 ^{B}	108.0 ^{A}
Al	-	-	-	-
Ba	-	-	-	2.6
Co	0.3 ^{B}	0.5 ^{B}	3.1 ^{A}	-
Se	5.0 ^{B}	8.0 ^{A}	-	-

(-) = Not determined

Means with same letter are not significantly different.

Table 3: Vitamins content of some grains cultivars.

Vitamins ppm	Grains			
	White corn	Yellow corn	Sorghum	Oats
Thiamine(B1)	1.55 ^{B}	3.8 ^{A}	4.62 ^{A}	0.77 ^{B}
Riboflavin(B2)	0.55 ^{B}	1.4 ^{A}	1.54 ^{A}	0.14 ^{C}
Niacin (B3)	17.7 ^{C}	28.0 ^{B}	48.4 ^{A}	0.97 ^{D}
Pantothenic	7.17 ^{C}	66.0 ^{A}	12.54 ^{B}	1.36 ^{D}
Pyridoxine(B6)	0.93 ^{D}	53.0 ^{A}	5.94 ^{C}	11.90 ^{B}
Folic Acid	3.10 ^{A}	3.0 ^{A}	-	0.12 ^{B}
Bitotin	0.9 ^{B}	0.8 ^{B}	2.9 ^{A}	-
Folacin	-	-	0.2	-
Vitamin A	9.0 ^{A}	8.0 ^{B}	-	-
Vitamin E	25.0 ^{A}	24.0 ^{B}	-	-

(-) = Not determined

Means with same letter are not significantly different.

Table 4: Amino Acids content of the different grains cultivars.

Amino Acids	Grains			
content (ppm)	White corn	Yellow corn	Sorghum	Oats
Aspartic	24.40 ^{A}	6.80 ^{C}	5.46 ^{D}	8.90 ^{B}
Alanine	29.50 ^{A}	7.80 ^{B}	3.5 ^{D}	5.0 ^{C}
Arginine	13.10 ^{A}	4.80 ^{C}	4.79 ^{C}	6.90 ^{B}
Cystine	-	2.50 ^{A}	2.19 ^{B}	-
Glutamic	63.60 ^{A}	17.70 ^{D}	31.25 ^{B}	23.90 ^{C}
Glycine	12.70 ^{A}	4.20 ^{D}	6.11 ^{B}	4.90 ^{C}
Leucine	34.8 ^{A}	13.70 ^{B}	14.2 ^{B}	7.4 ^{C}
Lysine	13.7 ^{A}	2.80 ^{C}	2.10 ^{C}	4.20 ^{B}
Methionine	0.67 ^{D}	1.90 ^{B}	1.0 ^{C}	2.50 ^{A}
Histidine	0.89 ^{C}	2.90 ^{A}	2.10 ^{B}	2.20 ^{B}
Isoleucine	12.9 ^{A}	3.90 ^{B}	4.10 ^{B}	3.90 ^{B}
Phenylalanine	15.0 ^{A}	5.40 ^{B}	4.94 ^{B}	5.30 ^{B}
Proline	29.9 ^{A}	8.40 ^{B}	5.10 ^{C}	4.70 ^{C}
Alanine	-	-	-	5.0
Serine	15.3 ^{A}	5.70 ^{B}	4.61 ^{C}	4.20 ^{D}
Threonine	12.9 ^{A}	4.0 ^{B}	3.30 ^{B}	3.30 ^{B}
Tryptophan	2.30 ^{A}	0.90 ^{B}	1.0 ^{B}	-
Tyrosine	12.30 ^{A}	3.40 ^{B}	3.74 ^{B}	3.10 ^{B}
Valine	18.5 ^{A}	5.0 ^{B}	5.40 ^{B}	5.30 ^{B}

(-) = Not determined

Means with same letter are not significantly different.

Aflatoxin content of the different grains cultivars illustrated in Table (5) It can be noticed that all samples content of mycotoxin were under detection limit (0.5ppb) for aflatoxin , ochratoxin ,zearalenone, fumonisin. Aflatoxin content was within the safe limit recommended by FAO (2001).

Table 5: Mycotoxin content of the different grains cultivars

Mycotoxins		Grains			
		White corn	Yellow corn	sorghum	oats
Ochratoxin ppb		*	*	*	*
Zearalenone ppb		*	*	*	*
Fumonisin ppb		*	*	*	*
Aflatoxin ppb	B1	*	*	*	*
	B2	*	*	*	*
	G1	*	*	*	*
	G2	*	*	*	*
	Total	*	*	*	*

***= Under detection limit (0.50ppb)**

Chemical attributes of formulated ice cream mixes:-

After making ice cream from cow milk, cream mix 35% fat, whole grains milled from white corn, yellow corn, sorghum, oats, in different ratio. Samples for control and mixes with adding milled whole grains were divided in 3 groups: (A) 0.5% whole meal grains were added, (B) 0.7% and (C) 1%. Control of the 3 groups was manufactured using stabilizer with the same percent of (A) 0.5%, (B) 0.7 % and (C) 1%. Table 6 shows the physicochemical attributes of formulated ice cream mixes. The moisture content of the ice cream mixtures were ranged from 36.62 to 46.79%. The highest value of moisture was in control C mix). The pH of all samples ranged from 6.7 to 7.00 in all samples and Titratable acidity ranged from 0.08 to 0.1% for all samples. Total solid (%) was increased with added the powder of grains in all samples.

Protein ranged between 3.6 to 4.9 and oats was the highest in protein values. Ash increased with added milled whole grains. Oats samples contained the highest value of ash. Mixes with 1% addition contained the highest value of ash then with 0.7% and then with 0.5% in all treatment. Fat in the mixes ranged from 20.66 to 25.90 and the highest values were found in the mixes contained 1% milled oats. Higher fat and total solids will lead to progressively higher quality products.

Total carbohydrate increased with adding the whole grains meal in all treatment. White corn gave the highest value of carbohydrate then with added oats, sorghum, and yellow corn.

Generally, ice cream is not a good source of iron and some of the trace minerals but addition of milled grains increased the iron and other elements which improved the nutritional value and rheological properties of ice cream.

Ice cream is an excellent source of food energy. The fact that the constituents of ice cream are almost complete the highest Cutely assimilated makes ice cream an especially desirable food for growing children and for persons who need to maintain or put on weight, for example the elderly. For the same reason, though, portion control is essential for persons who need to reduce or who do not wish to gain weight, so that it becomes part of a balanced and healthy diet and the contribution it makes to energy Goff and Hartel (2013) and Salem et al., (2016).

Data in Table (7) showed that (Mg) content ranged from 82.33 to 171.32 ppm in all mixes where white corn had the highest Mg (171.32 ppm) followed by sorghum, yellow corn and oats Zn in white corn was the highest (2.468 ppm) and control is the lowest (1.754 ppm). Moreover it can be observed that Ca content ranged from 751.72 to 1513.42 ppm, P ranged from 1005.48 to 1796.1 ppm. Sorghum treatment contained high Cu (0.516 ppm). . The same trends are noticed in heavy metals in all treatment. These results agree with Goff and Hartel (2013). Fortunately, milk contains little copper or iron, the two minerals that catalyze oxidation. Addition of whole mill grains increased this mineral and increased nutritional value of ice cream mixes. White corn mix © ice cream at 1% was the highest value of iron content.

Results of vitamins contents of the different ice cream mixes used in this study is given in Table (8). Thiamine (B1) of different samples ranged from (0.026 to 0.069 ppm) for all studied samples. Sorghum had the highest value while Oats had lowest value among all samples. As regards Riboflavin (B2), oats had the highest value (0.245 ppm) at mix c but the concentrations in the other mixes were not significantly different. On other hand Niacin (B3) ranged from 0.103 ppm (oats) to 0.583 ppm (sorghum). Additionally Oats was lower in Pantothenic (0.046 ppm) than other mixes and white Corn was the highest (0.699 ppm) in pantothenic. Pyridoxine in white corn mix C was the highest (0.543 ppm) in comparison with other mixes. However, folic Acid was not affected –significant in all mixes on the other hand vit. (A) ranged from 0.106 ppm (yellow Corn mix C) to 0.014 ppm (oats mix A). Additionally yellow Corn was higher in vit. (E) then white corn and sorghum mix These results agree with result obtained Goff and Hartel (2013).

Results of amino acids content of the different ice mixes are presented Table (9) .The highest aspartic and alanine concentration was observed in white corn mix at 1% (0.44 ppm)and (0.19 ppm)respectively. Arginine content ranged from (0.11 to0.17 ppm) in all mixes. Sorghum had the highest value. Cysteine, glycine and histidine were no significantly different in all ice cream mix. As regards glutamic, sorghum mix ice cream was the highest value at 1% then white corn had the highest value at different concentrate 0.5%.0.7%.1% while yellow corn had the lowest value. On other hand leucine range from 0.41 ppm (oats at 0.5% ice cream mix) to 0.50 ppm (white corn at 1% ice cream mix). While lysine ranged from 0.30 ppm (sorghum at 1% ice cream mix) and 0.22 ppm (oats and yellow corn at 0.5% ice cream mix).Additionally yellow corn and sorghum at 0.5% ice cream mix was lower methionine (0.06 ppm) than other samples. Isoleucine was the highest value with white corn ice cream mix at 1% (0.27ppm) and the lowest value with oats ice cream mix at 0.5% (0.22 ppm).The difference of result at phenylalanine control was the highest value then white corn, oats, sorghum, yellow corn. White corn and sorghum ice cream mix at 1% was the highest value of proline (0.48ppm) and serine (0.28 ppm) at different samples. Threonine was highest value with yellow corn ice cream mix at 1% (0.24ppm), sorghum and oats ice cream mix at 0.5% was lowest value (0.18 ppm).The results of tyrosine showed that control ice cream at 1% had significant highest value (0.26 ppm) while sorghum ice cream mix at 0.5% had lowest value (0.16 ppm). Later oats ice cream mix at 1% was the highest value of valine (0.40 ppm) and the lowest value at 0.5%. The best of amino acid in all samples with white corn mix C 1%.These results agree with result obtained by Goff and Hartel (2013).

Table 6: Physicochemical attributes of formulated ice cream mixes.

Formulations	Moisture (%)	pH	Titratable acidity (%)	Total solid (%)	Protein (%)	Ash (%)	Fat (%)	Total carbohydrate %
Control A	41.38 ^{CDE}	7.0 ^{A}	0.08 ^{B}	58.62 ^{BCD}	3.6 ^{B}	0.56 ^{D}	20.66 ^{F}	26.39 ^{D}
White corn A	38.98 ^{CDEF}	6.9 ^{AB}	0.1 ^{A}	61.11 ^{BCD}	4.4 ^{A}	0.68 ^{C}	21.90 ^{CDEF}	34.52 ^{AB}
Yellow corn A	40.70 ^{CDEF}	6.8 ^{BC}	0.1 ^{A}	59.30 ^{ABCD}	3.9 ^{AB}	0.67 ^{C}	22.40 ^{BCDEF}	31.38 ^{BC}
Sorghum A	42.40 ^{BC}	6.8 ^{BC}	0.08 ^{B}	57.60 ^{DE}	4.3 ^{AB}	0.69 ^{BC}	21.16 ^{EF}	31.69 ^{ABC}
Oats A	37.38 ^{DEF}	6.8 ^{BC}	0.09 ^{B}	62.62 ^{ABC}	4.6 ^{A}	0.70 ^{BC}	23.14 ^{BCDE}	32.31 ^{AB}
Control B	45.84 ^{AB}	7.0 ^{A}	0.08 ^{B}	54.16 ^{EF}	3.8 ^{AB}	0.66 ^{C}	21.20 ^{EF}	28.43 ^{CD}
White corn B	36.87 ^{F}	6.7 ^{c}	0.09 ^{B}	62.83 ^{AB}	4.6 ^{A}	0.69 ^{BC}	22.17 ^{CDEF}	35.05 ^{AB}
Yellow corn B	39.79 ^{CDEF}	6.8 ^{BC}	0.09 ^{B}	60.23 ^{ABCD}	4.0 ^{AB}	0.68 ^{C}	23.36 ^{BCD}	32.10 ^{AB}
Sorghum B	40.92 ^{CDEF}	6.8 ^{BC}	0.08 ^{B}	59.08 ^{ABCD}	4.5 ^{A}	0.70 ^{BC}	21.79 ^{DEF}	32.12 ^{ABC}
Oats B	38.10 ^{CDEF}	6.7 ^{C}	0.09 ^{B}	61.90 ^{ABCD}	4.8 ^{A}	0.74 ^{ABC}	23.97 ^{ABC}	32.32 ^{AB}
Control C	46.79 ^{A}	6.8 ^{BC}	0.08 ^{B}	53.21 ^{F}	4.2 ^{AB}	0.68 ^{C}	21.94 ^{CDEF}	33.75 ^{AB}
White corn C	36.62 ^{F}	7.0 ^{A}	0.08 ^{B}	63.54 ^{A}	4.7 ^{A}	0.72 ^{ABC}	22.97 ^{BCDE}	35.29 ^{A}
Yellow corn C	37.86 ^{CDEF}	7.0 ^{A}	0.09 ^{B}	62.14 ^{ABCD}	4.2 ^{AB}	0.70 ^{BC}	24.45 ^{AB}	32.68 ^{AB}
Sorghum C	38.85 ^{CDEF}	7.0 ^{A}	0.09 ^{B}	61.15 ^{ABCD}	4.6 ^{A}	0.76 ^{AB}	22. 46 ^{BCDEF}	33.22 ^{AB}
Oats C	41.91 ^{BCD}	7.0 ^{A}	0.09 ^{B}	58.09 ^{CDE}	4.9 ^{A}	0.79 ^{A}	25.90 ^{A}	34.13 ^{AB}

A: added 0.5% powder grains, B: added 0.7% powder grains, C: added 1% powder grains.
Means with same letter are not significantly different.

Table 7: Minerals content of the different ice mixes.

Ice cream		Minerals ppm									
		Mg	Zn	Ca	P	Cu	K	Na	Fe	Co	Se
control	A	107.41 ^{BCD}	2.127 ^{BCD}	971.99 ^{EF}	1343.71 ^{B}	0.148 ^{B}	1801.49 ^{CD}	474.18 ^{AB}	1.61 ^{EF}	0.007 ^{A}	0.020 ^{A}
	B	102.64 ^{CD}	2.122 ^{BCD}	923.13 ^{F}	1245.75 ^{BC}	0.089 ^{B}	1720.86 ^{DE}	434.64 ^{ABC}	1.43 ^{F}	0.025 ^{A}	0.030 ^{A}
	C	82.33 ^{D}	1.754 ^{E}	751.72 ^{F}	1005.48 ^{C}	0.01 ^{B}	1403.76 ^{E}	420.2 ^{BC}	1.32 ^{F}	0.037 ^{A}	0.030 ^{A}
White corn	A	130.05 ^{BC}	2.262 ^{AB}	976.61 ^{EF}	1472.15 ^{B}	0.105 ^{B}	1825.3 ^{CD}	357.29 ^{DE}	2.36 ^{BCDE}	0.031 ^{A}	0.010 ^{A}
	B	142.68 ^{AB}	2.291 ^{AB}	1059.27 ^{CDEF}	1376.12 ^{B}	0.114 ^{B}	1991.17 ^{CD}	392.29 ^{CDE}	2.62 ^{ABCD}	0.038 ^{A}	0.020 ^{A}
	C	171.32 ^{A}	2.468 ^{A}	1212.05 ^{BCDE}	1796.1 ^{A}	0.119 ^{B}	2374.11 ^{AB}	465.66 ^{AB}	2.81 ^{ABC}	0.043 ^{A}	0.025 ^{A}
Yellow corn	A	126.91 ^{BC}	1.858 ^{DE}	1032.1 ^{DEF}	1310.49 ^{B}	0.105 ^{B}	1753.9 ^{CD}	361.22 ^{DE}	2.48 ^{ABCDE}	0.037 ^{A}	0.015 ^{A}
	B	129.05 ^{BC}	2.177 ^{B}	1066.2 ^{CDEF}	1472.21 ^{B}	0.13 ^{B}	2000.99 ^{CD}	396.2 ^{CDE}	2.85 ^{AB}	0.045 ^{A}	0.025 ^{A}
	C	138.14 ^{ABC}	2.181 ^{B}	1513.42 ^{AB}	1513.42 ^{B}	0.132 ^{B}	2103.53 ^{ABC}	437.85 ^{ABC}	3.28 ^{A}	0.047 ^{A}	0.030 ^{A}
Sorghum	A	128.33 ^{BC}	2.046 ^{BCD}	1474.41 ^{ABC}	1435.76 ^{B}	0.083 ^{B}	1907.39 ^{CD}	381.49 ^{CDE}	1.83 ^{DEF}	0.022 ^{A}	0.005 ^{A}
	B	131.47 ^{BC}	2.148 ^{BC}	1782.31 ^{A}	1474.41 ^{B}	0.098 ^{B}	2039.21 ^{BCD}	409.92 ^{BCDE}	1.95 ^{BCDEF}	0.027 ^{A}	0.01 ^{A}
	C	169.55 ^{A}	2.253 ^{AB}	1435.76 ^{ABCD}	1782.31 ^{A}	0.516 ^{A}	2396.39 ^{A}	487.82 ^{A}	2.08 ^{BCDEF}	0.035 ^{A}	0.015 ^{A}
Oats	A	111.94 ^{BCD}	1.875 ^{CDE}	1291.67 ^{BCDE}	1291.67 ^{B}	0.090 ^{B}	1740.54 ^{CDE}	347.6 ^{E}	1.68 ^{EF}	0.027 ^{A}	0.015 ^{A}
	B	126.1 ^{BC}	2.075 ^{BCD}	1412.61 ^{ABCD}	1412.61 ^{B}	0.109 ^{B}	1863.83 ^{CD}	376.37 ^{CDE}	1.78 ^{DEF}	0.031 ^{A}	0.030 ^{A}
	C	129.17 ^{BC}	2.081 ^{BCD}	1437.29 ^{ABCD}	1437.29 ^{B}	0.138 ^{B}	1874.24 ^{CD}	377.47 ^{CDE}	2.59 ^{ABC}	0.032 ^{A}	----

A: added 0.5% powder grains, B: added 0.7% powder grains, C: added 1% powder grains.
Means with same letter are not significantly different.

Table 8: Vitamins content of the different ice mixes.

Ice cream		Vitamins ppm								
		Thiamine (B1)	Riboflavin (B2)	Niacin (B3)	Pantothenic	Pyridoxine (B6)	Folic Acid	Bitotin	Vitamin A	Vitamin E
control	A	0.03 ^{CD}	0.023 ^{B}	0.113 ^{E}	0.05 ^{D}	0.015 ^{D}	0.021 ^{A}	0.35 ^{C}	0.03 ^{DE}	0.05 ^{BC}
	B	0.04 ^{BCD}	0.024 ^{B}	0.118 ^{DE}	0.076 ^{CD}	0.016 ^{D}	0.023 ^{A}	0.357 ^{C}	0.035 ^{CDE}	0.053 ^{BC}
	C	0.05 ^{ABCD}	0.025 ^{B}	0.119 ^{DE}	0.093 ^{CD}	0.048 ^{CD}	0.025 ^{A}	0.398 ^{AB}	0.043 ^{CDE}	0.075 ^{BC}
White corn	A	0.042 ^{ABCD}	0.03 ^{B}	0.239 ^{BCDE}	0.369 ^{BC}	0.278 ^{BC}	0.031 ^{A}	0.4 ^{AB}	0.056 ^{BCDE}	0.12 ^{ABC}
	B	0.049 ^{ABCD}	0.032 ^{B}	0.295 ^{BCDE}	0.501 ^{AB}	0.384 ^{AB}	0.037 ^{A}	0.402 ^{AB}	0.072 ^{ABCD}	0.168 ^{AB}
	C	0.061 ^{AB}	0.037 ^{B}	0.379 ^{ABC}	0.699 ^{A}	0.543 ^{A}	0.046 ^{A}	0.404 ^{AB}	0.096 ^{AB}	0.24 ^{A}
Yellow corn	A	0.03 ^{CD}	0.025 ^{B}	0.187 ^{CDE}	0.075 ^{CD}	0.017 ^{D}	0.016 ^{A}	0.4 ^{AB}	0.061 ^{ABCDE}	0.125 ^{ABC}
	B	0.033 ^{BCD}	0.026 ^{B}	0.222 ^{BCDE}	0.099 ^{CD}	0.019 ^{D}	0.017 ^{A}	0.402 ^{AB}	0.079 ^{ABC}	0.175 ^{AB}
	C	0.038 ^{BCD}	0.028 ^{B}	0.276 ^{BCDE}	0.111 ^{CD}	0.022 ^{D}	0.018 ^{A}	0.405 ^{AB}	0.106 ^{A}	0.25 ^{A}
Sorghum	A	0.046 ^{ABCD}	0.03 ^{B}	0.239 ^{BCD}	0.369 ^{CD}	0.278 ^{CD}	0.031 ^{A}	0.4 ^{AB}	0.056 ^{E}	0.12 ^{C}
	B	0.055 ^{ABC}	0.038 ^{B}	0.437 ^{AB}	0.127 ^{CD}	0.054 ^{CD}	0.017 ^{A}	0.42 ^{AB}	0.017 ^{E}	0.015 ^{C}
	C	0.069 ^{A}	0.04 ^{B}	0.583 ^{A}	0.165 ^{CD}	0.072 ^{CD}	0.018 ^{A}	0.425 ^{A}	0.018 ^{E}	0.016 ^{C}
Oats	A	0.026 ^{D}	0.023 ^{B}	0.103 ^{E}	0.046 ^{D}	0.072 ^{CD}	0.017 ^{A}	0.396 ^{B}	0.014 ^{E}	0.001 ^{C}
	B	0.028 ^{CD}	0.024 ^{B}	0.105 ^{E}	0.049 ^{D}	0.096 ^{CD}	0.018 ^{A}	0.397 ^{AB}	0.015 ^{E}	0.002 ^{C}
	C	0.03 ^{CD}	0.245 ^{A}	0.108 ^{E}	0.053 ^{D}	0.132 ^{CD}	0.019 ^{A}	0.399 ^{AB}	0.016 ^{E}	0.003 ^{C}

A: added 0.5% powder grains, B: added 0.7% powder grains, C: added 1% powder grains.
Means with same letter are not significantly different.

Table (9): Amino Acids content of the different ice mixes

Ice cream		Amino Acids ppm																
		Aspartic	Alanine	Arginine	Cystine	Glutamic	Glycine	Leucine	Lysine	Methionine	Histidine	Isoleucine	Phenylalanine	Proline	Serine	Threonine	Tyrosine	Valine
control	A	0.34^{BCD}	0.15^{BCD}	0.11^{D}	0.04^{A}	0.81^{EF}	0.094^{A}	0.44^{AB}	0.25^{AB}	0.07^{BC}	0.15^{A}	0.24^{BCD}	0.25^{AB}	0.43^{ABC}	0.21^{B}	0.19^{BC}	0.21^{ABC}	0.30^{EF}
	B	0.37^{BCD}	0.16^{BC}	0.12^{CD}	0.05^{A}	0.87^{DE}	0.10^{A}	0.45^{AB}	0.26^{AB}	0.08^{BC}	0.16^{A}	0.25^{ABC}	0.26^{AB}	0.45^{ABC}	0.22^{AB}	0.20^{BC}	0.24^{AB}	0.31_{DEF}
	C	0.40^{AB}	0.17^{AB}	0.14^{BC}	0.06^{A}	0.99^{B}	0.11^{A}	0.46^{AB}	0.28^{AB}	0.09^{AB}	0.17^{A}	0.26^{AB}	0.31^{A}	0.46^{ABC}	0.22^{AB}	0.21^{B}	0.26^{A}	0.36_{ABCD}
White corn	A	0.31^{D}	0.14^{CD}	0.13^{BCD}	0.04^{A}	0.93^{BC}	0.094^{A}	0.44^{AB}	0.25^{AB}	0.07^{BC}	0.16^{A}	0.23^{CD}	0.25^{AB}	0.44^{ABC}	0.24^{AB}	0.19^{BC}	0.22^{ABC}	0.29^{EF}
	B	0.38^{ABC}	0.17^{AB}	0.14^{BC}	0.05^{A}	0.96^{BC}	0.11^{A}	0.47^{AB}	0.26^{AB}	0.08^{BC}	0.17^{A}	0.26^{AB}	0.26^{AB}	0.45^{ABC}	0.25^{AB}	0.20^{BC}	0.23^{AB}	0.34_{BCDE}
	C	0.44^{A}	0.19^{A}	0.15^{AB}	0.06^{A}	0.99^{B}	0.12^{A}	0.50^{A}	0.27^{AB}	0.09^{AB}	0.18^{A}	0.27^{A}	0.27^{AB}	0.48^{A}	0.28^{A}	0.21^{B}	0.24^{AB}	0.37_{ABC}
Yellow corn	A	0.34^{BCD}	0.14^{CD}	0.11^{D}	0.04^{A}	0.76^{FG}	0.097^{A}	0.42^{B}	0.22^{B}	0.06^{C}	0.15^{A}	0.23^{CD}	0.22^{B}	0.41^{BC}	0.22^{AB}	0.19^{BC}	0.18^{BC}	0.29^{EF}
	B	0.35^{BCD}	0.15^{BCD}	0.12^{CD}	0.05^{A}	0.82^{E}	0.10^{A}	0.43^{B}	0.24^{AB}	0.07^{BC}	0.16^{A}	0.24^{BCD}	0.23^{B}	0.43^{ABC}	0.22^{AB}	0.21^{B}	0.19^{BC}	0.33_{CDE}
	C	0.37^{BCD}	0.16^{BC}	0.14^{BC}	0.06^{A}	0.97^{BC}	0.11^{A}	0.44^{AB}	0.27^{AB}	0.09^{AB}	0.17^{A}	0.25^{ABC}	0.26^{AB}	0.47^{AB}	0.22^{AB}	0.24^{A}	0.23^{AB}	0.34_{BCDE}
Sorghum	A	0.33^{CD}	0.15^{BCD}	0.13^{BCD}	0.04^{A}	0.74^{G}	0.097^{A}	0.43^{B}	0.22^{B}	0.06^{C}	0.15^{A}	0.24^{BCD}	0.22^{B}	0.41^{BC}	0.20^{B}	0.18^{C}	0.16^{C}	0.31_{DEF}
	B	0.34^{BCD}	0.16^{BC}	0.15^{AB}	0.05^{A}	0.85^{E}	0.10^{A}	0.45^{AB}	0.24^{AB}	0.07^{BC}	0.16^{A}	0.25^{ABC}	0.24^{B}	0.44^{ABC}	0.23^{AB}	0.20^{BC}	0.21^{ABC}	0.33_{CDE}
	C	0.39^{ABC}	0.17^{AB}	0.17^{A}	0.06^{A}	1.08^{A}	0.11^{A}	0.46^{AB}	0.30^{A}	0.09^{AB}	0.18^{A}	0.26^{AB}	0.27^{AB}	0.48^{A}	0.25^{AB}	0.21^{B}	0.24^{AB}	0.34_{BCDE}
Oats	A	0.33^{CD}	0.13^{D}	0.11^{D}	0.04^{A}	0.82^{E}	0.091^{A}	0.41^{B}	0.22^{B}	0.07^{BC}	0.15^{A}	0.22^{D}	0.21^{B}	0.40^{C}	0.20^{B}	0.18^{C}	0.20^{ABC}	0.27^{F}
	B	0.34^{BCD}	0.15^{BCD}	0.13^{BCD}	0.05^{A}	0.84^{E}	0.095^{A}	0.43^{B}	0.24^{AB}	0.09^{AB}	0.16^{A}	0.24^{BCD}	0.25^{AB}	0.42^{ABC}	0.21^{B}	0.19^{BC}	0.22^{ABC}	0.39^{AB}
	C	0.35^{BCD}	0.16^{BC}	0.14^{BC}	0.06^{A}	0.92^{CD}	0.10^{A}	0.44^{AB}	0.27^{AB}	0.11^{A}	0.17^{A}	0.25^{ABC}	0.26^{AB}	0.43^{ABC}	0.22^{AB}	0.20^{BC}	0.24^{AB}	0.40^{A}

A: added 0.5% powder grains, B: added 0.7% powder grains, C: added 1% powder grains.
Means with same letter are not significantly different

Physical attributes of formulated ice creams mixes:-
Over-run:

Overrun is the industrial calculation of the air added to frozen dessert products, and it is calculated as the percentage increase in volume of mix that occurs as a result of the air addition, i.e., air volume/mix volume. It makes the ice cream smooth and reduces crystal size. Overrun percentage in the present study ranged from 30.50 to 35.40 for mix A (0.5% added), 33.00 to 39.2% for mix B (0.7% added) and 35.30 to 46.70 for mix C (1% added). Fig (1) shows the effect of add whole meal grains on overrun. Oats mixes gave the highest overrun, then sorghum, yellow corn, and white corn .Control was the lowest value of overrun. Oats mixes contained the highest protein concentration. Vidisha and Kumar 2013, Rosalina et al., 2004, Goff and Hartel , 2013 found that increase the protein content in ice creams decreased ice crystal size and increased the over run.

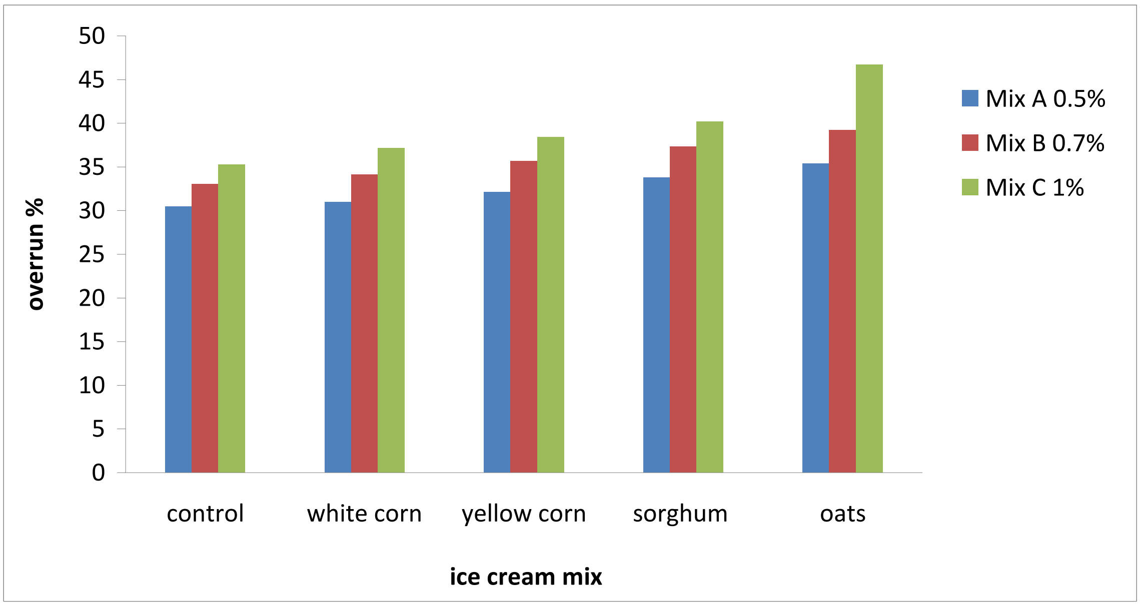

Fig (1): Overrun % of ice cream mix prepared using different whole mill grains.

Melting rate% :

Results in fig 2 shows that in all mixes melting resistance increased as the concentration of the whole mill grains increased, significantly. The highest value for melting resistance was obtained for control and the lowest value was oats. Results showed mix A had the highest value of melting rate % then mix B then mix C. Dietary fibers also showed an increase in the melting of ice cream. In similar study, the use of fibers improved melting properties, but failed to increase overrun of ice cream (Tiwari et al., 2015) and Dervisoglu and Yazici. (2006)). Sakurai et al. (1996) found that ice creams with low overruns melted quickly, whereas ice creams with high overruns began to melt slowly and had a good melting resistance. This slower melting rate in the ice creams with high overruns was attributed to a reduced rate of heat transfer due to a larger volume of air but may also be due to the more tortuous path through which the melting fluid must flow (Hartel et al., 2003).

The melt-down rate of ice cream is affected by many factors, including the amount of air incorporated, the nature of the ice crystals and the network of fat globules formed during freezing. These results agree with result obtained by Marshall, et al., 2003, Goff and Hartel , 2013 and Salem et al., 2016).

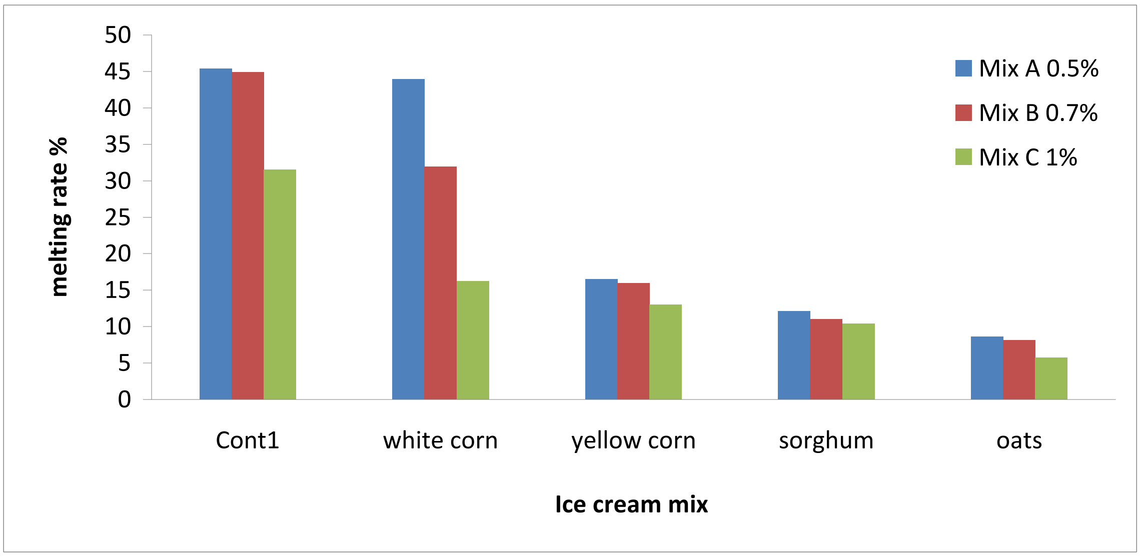

Fig. (2): Melting rate % of ice cream mix prepared using different whole mill grains.

The effect of type and concentration of whole mill grains on viscosity of ice cream mix:

Ice cream mixes exhibit non-Newtonian pseudo plastic behavior, meaning that there is a nonlinear relationship between shear stress and shear rate, with the apparent viscosity decreasing with increasing shear rate. The pseudo plasticity or shear thinning behavior has been related to the increased alignment of constituent molecules of the system (Farhoosh and Riazi,2007). Generally, the power law model is used to fit the rheological properties of the ice cream mix (Kaya and Tekin, 2001): $\tau = K\gamma^n$ (Goff and Sahagian,1996).

Where τ is the shear stress (Pa), K is the consistency index (Pa.sn), $\gamma^{\cdot}$ is the shear rate (s−1), and n is flow behavior index (dimensionless). The values n and K are important rheological properties of fluid foods, because the flow of these foods is characterized in terms of these quantities (Rincon et al., 2006). The smaller the n value, the greater the departure from Newtonian behavior and, hence, the greater the pseudo plasticity. The consistency index, which is considered to be a measure of the viscous nature of the food, increases with stabilizer concentration (Bahram Parvar, et al., 2010). The flow behavior curve showing non-Newtonian liquid behavior of tested sample in Fig (3, 4, 5). The results reported shows that κ value was increased and n value was decreased in the both cases of modified and unmodified ice cream. From the results, the parameter n equals to 0.55 and a κ value of 3688. It is known that in Newtonian fluids the n is equal to 1. The coefficient of determination, R^2, is 0.90 for tested samples indicating the appropriateness of the power law model to describe the flow properties of the sample at 0.5% additive (Fig.3).

Increasing the concentration of rate of additive to 0.7% shows a κ value of 4621.5 and n value of 0.45 (Fig.4). The coefficient of determination, R^2, is 0.96. The apparent viscosity was gradually increased with increasing rate of additive (Fig.4).

Increasing the concentration of rate of additive to 1% changed the flow behavior of the samples (Fig.5). The n value became 0.38, κ value of 5543.4, the coefficient of determination, R^2, is 0.97 and the fluid changed to non- Newtonian behavior. It has been reported that non- Newtonian behavior became important when the flow behavior index (n) is less than 0.6 (Muller et al., 1994). The value of flow behavior index was less than 1, indicating the pseudo plastic nature (shear thinning) of the ice cream sample. The effect of viscosity was discussed on the basis of the following points: First, by a higher level of blocked lysyl residues, which increase the net negative charge of the protein, and second by a larger distribution of hydrophilic residues bound at the surface of the protein, which may favor water-protein interactions and weaken, by steric effects, the electrostatic attraction forces between the protein subunits (Baniel et al., 1992) probably because of the repulsive effects induced by the added carbohydrate. For a provision of a high viscosity and good mouth feel, a low n value would be required (Marcotte et al., 2001).

Gomez-Diaz and Navaza (2003) related the increase of κ values to the increase of water binding capacity. Wanchoo et al., (1996), reported that the coefficient κ is a strong function of the concentration of the solution, whereas n does not have a strong dependency on the concentration of the polymeric solutions. The occurrences have been explained as induction of the electrostatic repulsion by functional group that tends to keep the molecules in an extended from, thus producing a high viscous solution and thus the κ values increased (Onweluzo et al., 1994).

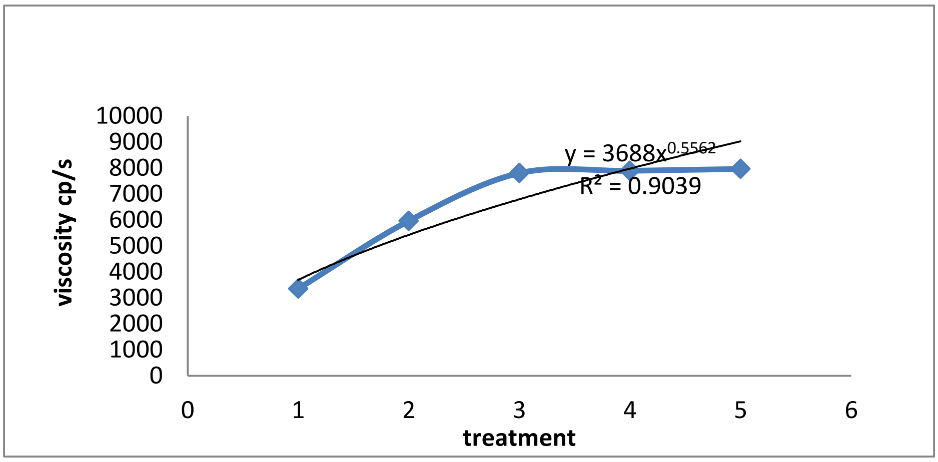

Fig (3): Viscosity of ice cream with different milled grains at 0.5%

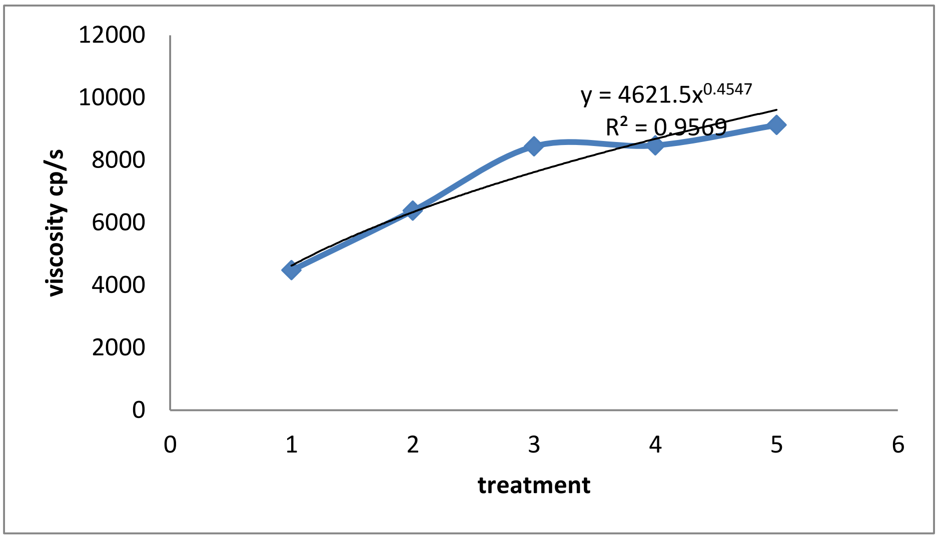

Fig (4): Viscosity of ice cream with different milled grains at 0.7%

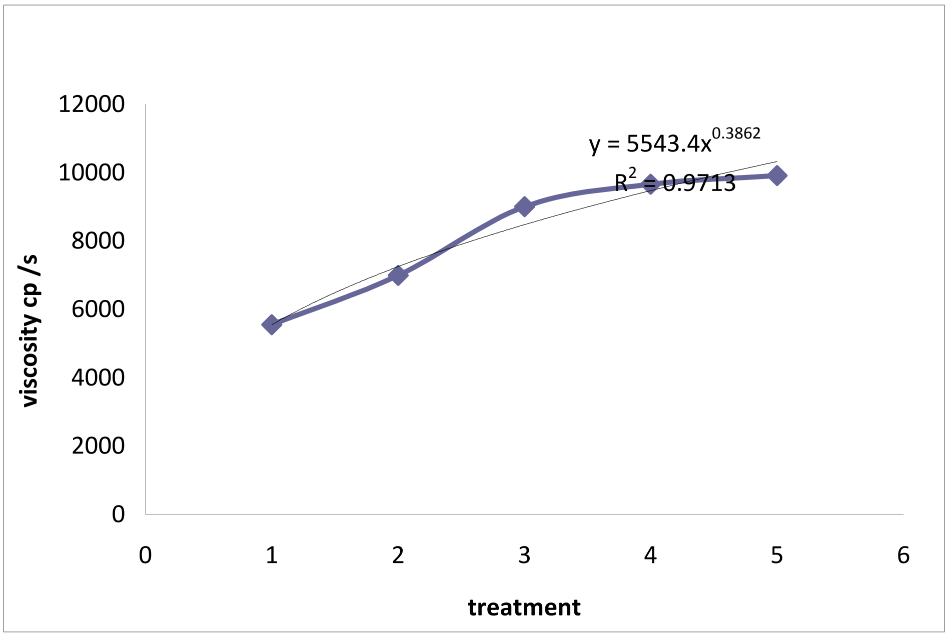

Fig (5): Viscosity of ice cream with different milled grains at 1%

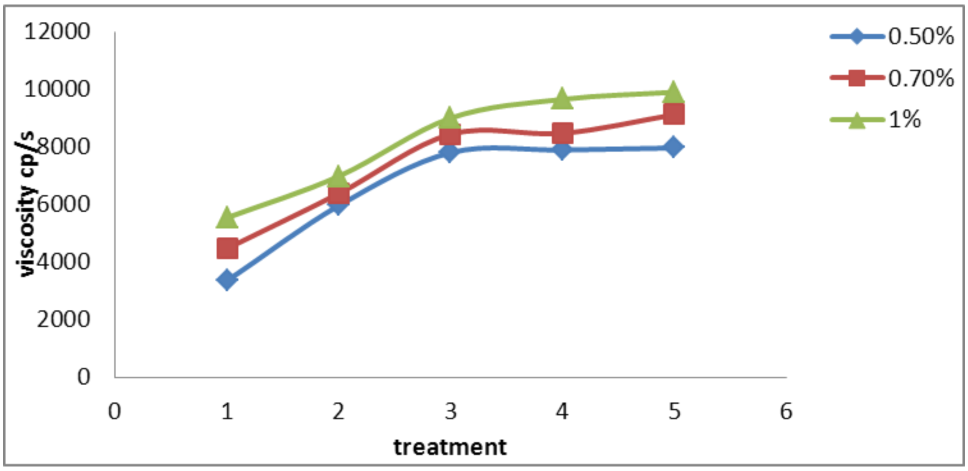

Fig (6): Viscosity of ice cream with different milled grains at 0.5-0.7-1.00%.

As seen in Figures 3 to 6, ice cream under the same experimental conditions and shear rates can be graded in order of increasing apparent viscosity as a result of changing both of kind of carbohydrate and concentration of protein: modified samples (oats; sorghum; white corn; yellow corn) and unmodified control samples. These high values of viscosity could be due to the ability of starch and oat to improve network of ice cream, which constrains the serum areas and, thus, leads to increased viscosity Salem et al., (2016) so undoubtedly increase in quantity of stabilizers, result in increase in viscosity (Igoe, 1979, Muse and Hartel, 2004).

Viscosity, which is one of the most important rheological properties of ice cream mix and the unfrozen portion of ice cream, is influenced by mix composition (mainly stabilizer and protein), type and quality of the ingredients, processing and handling of the mix, concentration (total solid content), and temperature (Marshall, et al., 2003) .The viscosity of ice cream mix is set through mix composition, particularly stabilizer content and level (Kus, et al., 2005).

Goff and Davidson (1994) reported that the flow behavior index (*n*) of ice cream mixes is around 0.7, although other investigators have found values from 0.37 to 0.98. Values of flow behavior index and consistency index of some ice cream mixes containing stabilizers previous studies have shown that an increase in concentration and decrease in temperature increases pseudo plasticity (decreases *n* values).

The effects of stabilizers on mechanical and stress relaxation properties of ice cream mix and sugar solutions containing hydrocolloids have also been investigated. Thermo mechanical analysis indicated that these materials decrease the rate of thermal deformation, increase apparent viscosity, and decrease compliance at −26◦C in frozen 20% sucrose solutions (proposed as model ice cream mixes). Stabilizers also decreased the molecular relaxation properties (Goff and Sahagian, 1996, Herrera, et al., 2007) and increased storage (elastic component) and loss moduli (viscous component) in ice cream mixes compared to unstabilized mixes of the same composition.

Sensory evaluation of ice cream mixes prepared using different whole meal grains

Results of sensory evaluation of ice cream mixes prepared using different whole meal grains at 0.5, 0.7 and 1% are shown in Table (10). The highly significant effect of appearance was observed in (mix C) ice cream for sorghum and oats in all samples. For body and texture highest mean score was with oats at mix A, C and white corn at mix B ,C then the lowest was control mix B and C. The statistical analysis for color was significantly differences between all ice cream making from which ranged from 8.0 to 14%. The highest value of color (14) was obtained by (mix C) white corn ice cream whereas (mix A) yellow corn got the lowest score (8.0). Maximum flavor and quality score (39.4) was obtained by mix B with oats. With respect to general acceptability of ice cream mixes , the highest score (93.4) was obtained by (mix C oats) ice cream and thus regarded as more acceptable than other ice cream mixtures while lowest score (70.5) was obtained by mix C. These results are parallel with Akalın, et al., (2008) and Dervisoglu and Yazici, (2006).

Table 10: Sensory evaluation of different ice cream mixes.

Ice cream mixes		Appearance 10%	Body and Texture 35%	Flavor 40%	Color 15%	General acceptability 100%
control	A	7.8^{B}	29.5^{AB}	31.7^{BCD}	10.0^{CDE}	79.0^{CDEF}
	B	8.2^{B}	26.0^{C}	29.8^{CD}	10.0^{CDE}	74.0^{EF}
	C	7.5^{B}	25.8^{C}	28.2^{D}	9.0^{DE}	70.5^{F}
White corn	A	8.2^{B}	26.7^{BC}	33.0^{BC}	10.0^{CDE}	77.9^{DEF}
	B	8.5^{B}	31.5^{A}	32.9^{BC}	11.0^{BCD}	83.9^{BCD}
	C	8.4^{B}	31.9^{A}	33.8^{BC}	14.0^{A}	88.1^{ABC}
Yellow corn	A	7.9^{B}	28.9^{ABC}	32.1^{BCD}	8.0^{E}	76.9^{DEF}
	B	7.5^{B}	27.4^{BC}	32.5^{BC}	12.0^{ABC}	79.9^{CDE}
	C	8.0^{B}	28.7^{ABC}	30.5^{CD}	12.0^{ABC}	79.2^{CDEF}
Sorghum	A	8.6^{B}	29.9^{AB}	32.0^{BCD}	9.0^{DE}	79.5^{CDEF}
	B	8.4^{B}	29.6^{AB}	33.1^{BC}	13.0^{AB}	84.1^{BCD}
	C	14.0^{A}	28.9^{ABC}	35.6^{B}	11.0^{BCD}	89.5^{AB}
Oats	A	8.8^{B}	32.0^{A}	32.2^{BC}	12.0^{ABC}	85.0^{ABCD}
	B	7.9^{B}	27.8^{BC}	39.4^{A}	13.0^{AB}	86.1^{ABCD}
	C	14.0^{A}	31.1^{A}	35.1^{B}	13.0^{AB}	93.4^{A}

A: added 0.5% powder grains, B: added 0.7% powder grains, C: added 1% powder grains.

Means with same letter are not significantly different.

CONCLUSION

The results of this study show that addition of whole meal of grains improves the physico-chemical and sensory properties of ice cream. Also ice cream produced by addition of 1% oats has the most overall sensory characteristics followed by 0.7 and 0.5%.

Thus we recommend to use oats at 1% to produce acceptable ice cream mixes acceptable for the consumers and of high nutritional value.

REFERENCES

AACC, (2000). American association of cereal chemists, Approved method of the AACC 10th ed., vol. 1, AACC, St Paul, MN.

Akintayo, I. and Sedgo, J. (2001). Towards sustainable sorghum production and utilization in West and Central Africa; Akintayo I.; Sedgo J. Eds.; ASRN/ICRISAT, 19-22 April 1999, Lomé, Togo. ISBN 92-9066-4330-9. p. 162.

Akalın, A.S., Karagözlü, C. and Ünal, G. (2008). Rheological Properties of Reduced-Fat and Low-Fat Ice Cream Containing Whey Protein Isolate and Inulin. European Food Research and Technology, 227, 889-895.

Arbuckle.W.S. (1986). Ice Cream, Fourth Edition.Van Nostrand Reinhold., New York.

Anglani, C. (1998). Sorghum for human food: a review. Plant Foods Hum. Nutr. 52: 85-89.

A.O.A.C., (2005). Association of Official Analytical Chemists. Official Methods of Analysis. 18th Ed. Published by A.O.A.C. W.Horwitz. North Frederick, U.S.A.

Arbuckle, W.S. (1986). Ice cream, IV, Ed. The Avi Pub. Co., New York, USA. Awika, J. M. and Rooney, L. W., (2004). Sorghum phytochemicals and their potential impact on human health, Phytochemistry, vol. 65, pp.1199–1221.

Baniel, A.; D. Caer; B. Colas and J. Gueguen (1992). Functional Properties of Glycosylated Derivatives of the 11S Storage Protein from Pea (Pisum sativum L.). J. Agric. Food Chem, 40: 200- 205.

BahramParvar, M.; Razavi, S.M.A.; Haddad Khodaparast, M.H.(2010). Rheological characterization and sensory evaluation of typical soft ice cream made with selected food hydrocolloids. Food Science and Technology International, 16(1), 79–88.

Banu, C., (2000). Aditivi şi ingrediente pentru industria alimentară, Editura Tehnică, Bucureşti.

Benz, Bruce F. (2005). Archaeological evidence of teosinte domestication from Guilá Naquitz, Oaxaca. Proceedings of the National Academy of Sciences (National Academy of Sciences of the United States of America) 98 (4): 2104–2106.

Chow, K.C. (2000). Fatty acids in Foods and their Health Implications. Marcel Decker, Inc. New York.

Cody, T.L., A. Olabi, A.G. Pettingell, P.S. Tong, and J.H. Walker. (2007). Evaluation of rice flour for use in vanilla ice cream. Journal of Dairy Science 90: 4575-4585.

David, C.L.,(1977). Laboratory Guide in Dairy Chemistry Practicals. FAO Regional Dairy Development and Training Centre for Asia and Pacific. Dairy Training and Research Institute, University of Philippines, Loss Banos College, Laguma, Philippines.

Dervisoglu, M., and F. Yazici. (2006). The effect of citrus fibre on the physical, chemical and sensory properties of ice cream. Food Science and Technology International 12: 159-164.

Elahi, A.T.M.M.E., S. Habab, M.M. Rahman, G.I. Rahman and M.J.U. Bhuiyan, (2002). Sanitary quality of commercially produced ice cream sold in the retrial stores. Pak. J. of Nutr., 1(2): 93-94.

ES, (1986). Egyptian Standard of wheat grains. Egyptian Organization for Standardization and Quality Control, No. 1601, and its modification No. 2/2002. Arab Republic of Egypt.

FAO, (1995). Food and Agriculture Organization FAO Database, Accessed on: 2009, www.fao.org.

FAO/IAEA. (2001). Manual on the application of the HACCP system in mycotoxin prevention and Control. FAO Food and Nutrition Paper 73, Food and Agriculutre Organization / International Atomic Energy Agency, Rome.

FAO, (2005). Food and Agriculture Organization FAO Statistics Database. Accessed on; Feb. 14, 2005; Available at: http://a pps.fao.org/fastali.

FAO, (2009). Food and Agriculture Organization FAO Database, Accessed on: 2009, www.fao.org.

Feng, T., Z. B. Gu and Z. Y. Jin (2007). Chemical composition and some rheological properties of Mesona Blumes gum. Food Sci. and Technol. International, 13: 55–61.

Farhoosh, R.; Riazi, A.(2007). A compositional study on two types of salep in Iran and their rheological properties as a function of concentration and temperature. Food Hydrocolloids, 21, 660–666. Frozen Yogurt. How Products Are Made. Volume 2. (http://www.madehow.com/Volume-2/Frozen-Yogurt.html.

Fulcher, R.G. and Miller, S.S., (1993). Oat Bran. Cereal Chemistry Book, (3), 318–323.

Gelroth, J. and Ranhotra, G.S. (2001). Food Uses of Fiber. In: Sungsoo Cho, S. and Dreher, M.S., Eds., Handbook ofDietary Fiber, Taylor and Francis, New York, 345-452.

Gohari A., A., (2005). Effect of data syrup asa substitute for sugar on the physicochemical andsensory properties of soft ice cream, Iranian Food Sci. Technol. Res. J., 1(2): 23-31 (In Persion).

Goff, H.D., Sahagian, M.E. (1996). Freezing of dairy products. In Freezing Effects on Food Quality; Jeremiah, L.E., Ed.; Marcel Dekker: New York, 299–335.

Goff, H.D.; Sahagian, M.E.(1996). Freezing of dairy products. In Freezing Effects on Food Quality; Jeremiah, L.E., Ed.; Marcel Dekker: New York, 299–335.

Goff, H.D.; Davidson, V.J. (1994). Controlling the viscosity of ice cream mixes at pasteurization temperatures. Modern Dairy, 73, 12–14.

Goff, H. D. (1997). Colloidal aspects of ice cream - a review. Int. Dairy. J., 7(6-7): 363-373.

Goff, H.D. and R. W. Hartel. (2013). Ice Cream, 7th Edn. Springer. Varelag, New York.

Gomez-Diaz, D. and J. M. Navaza (2003). Rheology of aqueous solutions of food additives effect of concentration, temperature and blending. J. Food Engineering, 56: 387–392.

Grundy, S.M. (1997).What is the desirable ratio of saturated, polyunsaturated, and monounsaturated fatty acids in the diet. Am. J. Clin. Nutr. 66(suppl): 988S.

Guinard, J.X., C. Liitle, C. Marty and T.R. Palchakz, (1994). Effect of Sugar and Acid on the Acceptability of Frozen Yogurt to a Student Population. J. Dairy Sci., 77: 1232-1238.

Hartel,R. W.,M. Muse, and R. Sofjan (2003). Effects of structural attributes on hardness and melting rate of ice cream. In Proceedings of the 2nd IDF Ice Cream Symposium, Thessoliniki, Greece. (in press)

Herrera, M.L.; M'Cann, J.I.; Ferrero, C.; Hagiwara, T.; Zaritzky, N.E.; Hartel, R.W. (2007). Thermal, mechanical, and molecular relaxation properties of frozen sucrose and fructose solutions containing hydrocolloids. Food Biophysics, 2, 20–28.

Herald, T. J., Aramouni, F. M. and Abu- Ghoush, M. H. (2008). Comparison Study of Egg Yolks and Egg Alternatives in French Vanilla Ice Cream, J. Text. Stud., 39: 284- 295.

Kaya, S.; Tekin, A.R. (2001). The effect of salep content on the rheological characteristics of a typical ice cream mix. Journal of Food Engineering, 47, 59–62.

Igoe, S. Robert, (1979). Compositions for stabilizing soft serve and hard frozen yogurt. United States Patent 4178390.

Kilara, A.; Chandan, R.C. (2008). Ice cream and frozen desserts. In Dairy Processing & Quality Assurance; Chandan, R.C.; Kilara, A.; Shah, N., Eds.; Wiley-Blackwell: New Delhi, India, 2008; 364–365.

Keeney, P.G. (1982). Development of frozen emulsions. Food Technol. 36(11): 65-70.

Kus, S.; Altan, A.; Kaya, A. (2005). Rheological behavior and time-dependent characterization of ice cream mix with different salep content. Journal of Texture Studies, 36, 273–288.

Kuntz, L.A., (1995). Freez/thaw-stability: keeping your assets frozen. Food Prod. Design 4: 11.

Lasztity, Radomir (1999). The Chemistry of Cereal Proteins. Akademiai Kiado (English).

Marcotte, M.; A. R. Taherian and H. S. Ramaswamy (2001). Rheological properties of selected hydrocolloids as a function of concentration and temperature. Food Res. International, 34: 695–704.

Marshall, R.T. and W.S. Arbuckle, (1996). Ice Cream. Fifth Edition. New York: Chapman &Hall, International Thomson Publishing.

Marshall, R.T.; Goff, H.D.; Hartel, R.W. (2003). Ice Cream, 6th ed.; Kluwer Academic/Plenum Publishers: New York.

Ministry of Health of Ukraine, (2001). Instruction guidelines Procedure and frequency of alimentary raw materials and food products control according to safety indices, No. 137.

Molkentin, J. (1999). Bioactive lipids naturally occuring in bovine milk. Nahrung 43(3):185-189.

Muhammet, D. (2006). Influence of hazelnut flour and skin addition on the physical, chemical and sensory properties of vanilla ice cream. International Journal of Food Science and Technology 41: 657-661.

Muller, F.L.and J.P., Villon, (1994). On the behaviour of non-Newtonian liquids in collinear ohmic heaters. In: Proceedings of the 10 th International Heat Transfer Conference. Freezing, Melting, Internal Forces Convection and Heat Exchangers, Vol. 4. Brighton, UK, PP.285-290.

Nagarajan, S., (2005). Quality Characteristics of Indian Wheat, Quality and basic sciences, Vol. 4. Issue 9, Pages 79-86.

Newton, I.S. (1996). Long chain fatty acids in health and nutrition. J. Food Lipids. 3:233-249.

Onweluzo, J. C.; Z. A. Obanu and K. C. Onuoha (1994). Viscosity studies on the flour of some lesser known tropical legumes. Nigerian Food J., 12: 1–10.

Riba, S.; Mokrane, F.; Mathieu, A.; Lebrihi, F and Sabaou, N., (2008). Mycoflora and ochratoxin A producing strains of Aspergillus in Algerian wheat. International Journal of Food Microbiology, Volume 122, Issues 1-2, Pages 85-92.

Rincon, F.; Leon de Pinto, G.; Beltran, O. (2006). Behavior of a mixture of Acacia glomerosa, Enterolobium cyclocarpum and Hymenaea courbaryl gums in ice cream preparation. FoodScience and Technology International, 12(1), 13–17.

Roney, J., Winter, (2009). The Beginnings of Maize Agriculture. Archaeology Southwest 23 (1): 4.

Rosalina, P., Sofian., Hartel, W. Richard, 2004. Effects of overrun on structural and physical characteristics of ice cream. Int. Dairy j., 14(3): 255-262.

Sakurai, K., Kokubo, S., Hakamata, K., Tomita, M. and Yoshida, S. (1996). Effect of Production Conditions on Ice Cream Melting Rate and Hardness. Milchwissenchaft, 51: 451–454.

Salem, S.A., Hamad, E.M. and Ashoush, I.S. (2016). Effect of Partial Fat Replacement by Whey Protein, Oat, Wheat Germ and Modified Starch on Sensory Properties, Viscosity and Antioxidant Activity of Reduced Fat Ice Cream. Food and Nutrition Sciences, 7, 397-404.

Samson , R. A.; Hoekstra, E. S. ;Frisrad , J.C. and Borg, O. F. (1995) Introduction to Food Borne Fungal Handbook, Fourth edition.

Soukoulis, C., D. Lebesi, and C. Tzia. (2009). Enrichment of ice cream with dietary fibre: Effects on rheological properties, ice crystallisation and glass transition phenomena. Food Chemistry 115: 665-671.

Southward, C.R. (1985). Manufacture and application of edible casein products. 1-Manufacture and properties (Review) New zealand. J. Dairy Sci. and Technol., 20: 19.

SAS, (1999). SAS / Stat. User's Guide: statistics, system for windows, version 4.10 (releasa 6.12 TS level 0020), SAS Inst., Inc. Cary, North Carolina, USA.

Tarkashv and, Yadolah, (2005). Ice cream. first print. Ata publisher, Tehran (in persion).

Tiwari, A., Sharma, H.K., Kumar, N. and Kaur, M. (2015). The Effect of Inulin as a Fat Replacer on the Quality of Low-Fat Ice Cream. International Journal of Dairy Technology, 68, 374-380.

Tungland, B.C. and Meyer, D. (2002). Non-Digestible Oligo and Polysaccharides (Dietary Fibre): Their Physiology and Role in Human Health and Food. Comprehensive Reviews in Food Science and Food Safety, 1, 73-92.

USDA, (1995). United Stats Department of Agriculture. Grain Inspection Handbook I. Grain Inspection, Packers and Stockyards Administration ,Federal Grain Inspection Service Probe Sampling, Washington, D.C. 20090-6454.

USDA, (1999). United Stats Department of Agriculture. Moisture Handbook Grain Inspection, Packers and Stockyards Administration 1400 Independence Ave., S. W. Washington, D.C. 20250-3600.

USDA, (2002). United Stats Department of Agriculture. Equipments Handbook. Grain Inspection, Packers and Stockyards Administration,1400 Independence Ave., S.W. Washington, D.C. 20250-3600.

USDA, (2006). United Stats Department of Agriculture. Grain Inspection Handbook II Grain Inspection, Packers and Stockyards Administration, Federal Grain Inspection Service.

Vallabhaneni, R and Wurtzel, ET, (2009). "Timing and biosynthetic potential for carotenoid accumulation in genetically diverse germplasm of maize". Plant Physiol 150 (2): 562–72.

Wanchoo, R. K.; S. K. Sharma and R. Bansal (1996). Rheological parameters of some water-soluble polymers. Journal of Polymer Materials, 13: 49-55.

Wood, P.J. and M. U. Beer, (1998). Functional Foods, Biochemical & Processing Aspects. Technomic Publication Company. Inc. Lancaster, 1-37.

Institute of Medicine (2011) Dietary Reference Intakes (DRIs): estimated average requirements. Food and Nutrition Board, Institute of Medicine, National Academies, Washington, DC.

Vidisha, T. and A. Kumar (2013). Development of High Protein Ice-Cream Using Milk Protein Concentrate. Journal Of Environmental Science, Toxicology And Food Technology ,Volume 6, Issue 5 (Sep. - Oct.), PP 71-74.

الخواص الفيزوكيميائية والحسية لاستخدام مطحون الحبوب الكاملة فى مخلوط الايس كريم

جيهان بسطامى على *، تامر توفيق السيسى*، ميرفت سيد حسن*

***المركز الاقليمى للأغذيه والأعلاف – مركز البحوث الزراعية**

دراسات عديدة تمت لزيادة القيمة الغذائية للايس كريم وهدف البحث الحالى هو انتاج ايس كريم صحى لتغيير الخواص الحسية لمخلوط الايس كريم . وقد وجد ان اضافة مطحون الحبوب الكاملة قد ادى الى زيادة المواد الصلبة الكلية والبروتين والرماد والكربوهيدرات خاصة مخاليط الشوفان. ايضا اعطت مخاليط الشوفان أعلى قيم فى الريع اللزوجة للناتج كما اظهرت مخاليط الايس كريم المحتوية على الشوغان افضل النتائج فى التقييم الحسى لذلك توصى الدراسة استخدام مخاليط الحبوب الكاملة فى تصنيع الايس كريم خاصة الشوفان لتحسين صفات المنتج ورفع قيمته التغذوية والعلاجية.