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Production of cocoa flavored soymilk ice cream

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Abstract: The aim of this study was to investigate production of cocoa ice cream by using soymilk. In this study the effect of substituting soymilk instead of skim milk (the ratios of 0:100, 25:75, 50:50, 75:25 and 100:0 soymilk to skim milk) was evaluated on chemical, physical and sensory properties of ice cream. The results showed that by increasing the substitution of soymilk the total solids, protein, pH, fat, overrun and viscosity of mixture increased but acidity and solids non-fat decreased significantly in all samples ($p< 0.0001$), while have no significant effect on amount of sucrose samples. All samples showed psuedoplastic behavior and viscosity of ice cream samples decreased with increasing shear rate. Finally, it was found that the viscosity of ice cream is kind of Herschel Bulkley. The results of sensory evaluation showed that adding cocoa powder (1 %) in the formulation could completely remove the beany flavor. Also soymilk replacement up to 50% does not have significant effect on flavor, texture, color and overall acceptability. According to the results, the best ratio in terms of chemical, physical and organoleptic properties is 50:50 ratio of soymilk to skim milk.

Key words: *Cocoa powder; Ice cream; Soymilk*

1. Introduction

Soybean is a rich source of vegetable protein and inexpensive food. Soy-based products may have some adventages to consumers due to their hypolipidemic, anticholesterolemic and antiatherogenic properties as well as due to reduced allergenicity. It also has isoflavones, which can reduce the risk of most hormone-associated health disorders (Favaro Trindade *et al*., 2001). Soymilk is derived from soybean. It can be used as a suitable alternative for cow's milk in the production of dairy products such as ice cream (Bisla et al., 2012). Protein content of soymilk and cow's milk is similar (3.5-4.0%) and their amino acid pattern is fairly close except that soymilk is deficient in sulfur containing amino acids. Soy milk has about 60 to 90 % nutritional value of cow's milk and with adding small amounts of methionine to soy milk it has equivalent nutritional value to cow's milk (Abdullah *et al.*, 2003). Some studies have shown that soy milk protein causes the maintenance of calcium in the body and decreases hypercalciuria, however its calcium content is lower in comparison with dairy milk (Riaz, 2006). Soy protein provides some functional properties such as water-holding, binding and emulsifying properties. Therefore, using soy protein may effect on the quality of food (Akesowan, 2009). The most important health effects of soy milk protein in production of ice cream are to decrease osteoporosis, risks of several types of cancers, blood pressure and cardiovascular disease (Akitha Devi et al., 2009; Akesowan, 2009). The most important characteristic of soy ice cream is that it has no cholesterol and it does not only contain a low rate of saturated fatty acids, but it has unsaturated fatty acids (linoleic acid, linolenic acid). Consumption of soy ice cream instead of regular ice cream causes a decrease of saturated fat intake, and also an increase in soy protein intake (Zhang et al., 2005; Akesowan, 2009; Bisla et al., 2012; Wangcharoen, 2012). The amount of calorie in soy ice cream is at least 77 percentage of calories in regular ice cream (Khetarpaul and Goyal, 2008; Laan and Truelsen, 2009; Akesowan, 2009; Bisla et al., 2012). Moreover, soy ice cream is lactose free and has high digestibility. It can be a suitable alternative for cow's milk, especially for people who are allergic to cow's milk, and have lactose intolerance. It is also suitable and recommended for diabetic people (Wangcharoen, 2008; Laan and Truelsen, 2009; Bisla et al., 2012).

Using sesame oil can be desirable in producing soy ice cream. Sesame oil has a compound called Sesamol that cause resistance of this oil against of oxidation and also contains lignan targeted with antioxidant property and vitamin E (Elleuch et al., 2006; Sankar et al., 2006). In addition, sesame oil contains unsaturated fatty acids such as Oleic acid and Linoleic acid (Blommers, 2002; Marangell, 2003).

The use of cocoa powder in soymilk ice cream production can be suitable because it removes beany flavor of soymilk and improves its organoleptic quality. The aim of this study was to produce cocoa flavored ice cream by using soymilk.

2. Materials and methods

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Materials were used in this study included pasteurized skim milk (Milk Factory Pak Ara Sanandaj), sterilized soy milk (ACE CANNING CORP made in Malaysia), nonfat dried milk (Arya Rama Tehran company), cream 30% fat, pasteurized and homogenized, sugar, carboxy methyl cellulose CMC (made in Denmark), palsgaard (made in Denmark), sesame oil and cocoa poeder.

2.1. Production of the ice cream

For producing ice cream, different ratios of soy milk were substituted with skim milk in 5 levels (0, 25, 50, 75, and 100 %) to achieve appropriate formulation and all the samples were produced in three replications.

All formulatins were considered on the basis of 64.6% of milk (which were substituted in different ratios of soy milk to skim milk), sugar (14.6 %), dried milk (5.8 %), sesame oil (3.9 %), cream 30% fat (10.5 %), palsgaard (0.48%), CMC (0.12 %) and cocoa powder (1 %).

Liquid ingredients (skim milk and soy milk, etc.) were mixed and heated up to 25 °C. Next, dry ingredients were slowly added and stirred to the liquid ingredients in order to prevent clumping. Adding must be terminated before the temperature reaches to 40°C. After dissolving all powder ingredients, the temperature was brought to 45 °C so cream and oil that had been previously heated were gradually added to the mixture and stirred slowly (Marshall and Arbuckle, 1996; Marshall *et al.,* 2003; Goff, 2006; Michael Dennis Sharp, 2009). The next step was homogenization and pasteurization. A two-stage homogenization was applied on ice cream mixture at 70 °C and 150 atm. HTST pasteurization was performed in holding tubes at 80 to 82 °C for 25 seconds. Then the cooling process was performed on ice cream mixture immediately after pasteurization (with water) below 5 °C (Marshall and Goff, 2003; Marshall *et al*., 2003; Michael Dennis sharp, 2009). Next stage was aging the mix that was performed in a special tank. The mixture was maintained in less than 5 °C for 8 hours in special aging tanks. Also at this time the ice cream mixture frequently and gently was stirred in the tank of aging. The next stage was freezing. When the ice cream mixture was pumped from special tanks of aging with temperatures around 5 °C or less into the freezer tank, it was aerated and frozen. Ice cream samples were frozen with overrun about 85 percent. At freezing stage, the temperature was about minus 30 °C, in 30-60 seconds, the pressure inside the tank was usually 5 atm and rotation speed of stirrer was 200 rpm. The output temperature of ice cream was minus 5 °C. Then product was sent to forming and packaging units and was filled in 50 grams disposable containers of plastic. Hardening of ice cream at special tunnels and at temperatures of -38 to -45 °C was performed in 20 minutes. In the next step samples were kept in freezers with temperatures around -18 °C (Marshall and Arbuckle, 1996; Marshall et al., 2003; Goff, 2006; Michael Dennis Sharp, 2009).

2.2. Chemical analysis

Total solids, total sugar, protein, fat, pH and acidity of samples were determined in accordance with AOAC methods (AOAC, 2005).

2.3. Physical analysis

Viscosity of samples was determined by a Brookfield viscometer (model DV-II+Pro, Brookfield engineering laboratories, Inc, Ma, USA). The samples were taken after a period of aging (for 8 hour at temperature of 4 °C) with spindle number 4, 42 rpm, and at 14±1ºC (Marshall and Arbuckle, 1996; Akesowan, 2009).

The overrun value was determined according to the method described by Whelan et al., (2008).

2.4. Sensory Evaluation

15 trained panelists evaluated the sensory properties of ice cream samples. Taste, odor, body/texture, color and overall acceptability of the samples were evaluated (Clarke, 2004).

2.5. Statistical Analysis

Variance analysis of results of physical and chemical tests of ice cream samples was performed using SAS9 software in a completely randomized one-way format. Also sensory evaluation results of samples were analyzed by variance analysis using Minitab software and data mean was compared with Duncan's multiple range tests to analyze significant differences between treatments. The curves and charts of results were drawn by Excel software.

3. Results and discussion

3.1. The impact of different levels of soy milk substituting on chemical characteristics of ice cream

The effect of different levels of soy milk substituting on chemical characteristics of ice cream is shown in Table 1. Results showed that different levels of substitution of soy milk have a significant effect ($p<0.0001$) on total solids content of the samples so that sample containing 100% soy milk had the highest amount of total solids and the lowest amount of total solids was related to the sample containing 100% skim milk. The results indicate that with increasing amounts of soy milk, the content of total solids of ice cream increases because the total solids of soy milk (9.2 percent) is higher than skim milk (9%). The findings of this study are in agreement with the results of Razavi et al., (2001) and Abdullah et al., (2003). These researchers

showed that the total solids are more in samples containing high amounts of soy milk.

Moreover, the results showed that different ratios of soy milk substituting have significant effect ($p<0.0001$) on content of solids nonfat of the samples and sample containing 100% skim milk has the highest amount of SNF (Table 1). So increased SNF in these samples are the because of that solids nonfat of soy milk (7.5 percent) are lower than skim milk (8.9 percent). Also soy milk is lactose-free and skim milk has lactose.

According to Table 1 different ratios of soy milk substituting with skim milk have significant effect ($p<0.0001$) on fat content of the samples. As with increasing amounts of soy milk, the content of fat of ice cream increases and the sample containing 100% soy milk has the highest amount of fat. Because fat content of soy milk (1.7%) is higher than fat content of skim milk (0.1%). Similarly Razavi et al., (2001) and Abdullah et al., (2003) said that samples containing skim milk have the lowest fat compared with samples containing soy milk, that their findings are consistent with the results obtained in this study.

Levels of different of soy milk substituting have significant effect ($p<0.0001$) on protein content of the samples (Table 1). So that with increasing levels of soy milk, the content of protein increases because protein content of soy milk (3.6%) is higher than protein content of skim milk (3.4 %). Abdullah et al., (2003) and Bisla et al., (2012) reported similar results. Moreover, in a similar study Gracas Pereira et al., (2011) reported that adding extracts of soy milk instead of skim milk cause increasing content of protein mixture and this is due to the high content of soy protein extract.

Table 1: Chemical properties of Ice cream samples containing different ratios of soy milk to skim milk (mean ± Standard deviation)

Properties	Ratios of soy milk to skim milk 0:100	25:75	50:50	75:25	100:0	Mean-square
Total solid(%)	34.005±0.004^{e}	34.035 ±0.004^{d}	34.068 ±0.004^{c}	34.097±0.003^{b}	34.129 ±0.001^{a}	0.00721021**
Solids nonfat(%)	11.925 ± 0.007^{a}	11.787± 0.007^{b}	11.561± 0.011^{c}	11.341± 0.004^{d}	11.126± 0.004^{e}	0.31517747**
Fat(%)	6.896 ± 0.152^{e}	7.11 ± 0.028^{d}	7.28 ± 0.011^{c}	7.596±0.020^{b}	7.810± 0.01^{a}	0.40202667**
Protein(%)	4.272± 0.001^{e}	4.305±0.001^{d}	4.33±0.0005^{c}	4.370± 0.001^{b}	4.394±0.002^{a}	0.00721101**
Sucrose(%)	14.597±0.002^{a}	14.604±0.003^{a}	14.600±0.001^{a}	14.601±0.003^{a}	14.604±0.520^{a}	0.00002510^{ns}
pH	6.433±0.004^{e}	6.506±0.008^{d}	6.655± 0.004^{c}	6.736±0.0052^{b}	6.817±0.006^{a}	0.07578783**
Acidity(%)	0.201± 0.005^{a}	0.186±0.002^{b}	0.170± 0.001^{c}	0.153± 0.001^{d}	0.137± 0.001^{e}	0.00193710**

ns and ** respectively non-significant ($p>0.05$) and significant ($p<0.0001$).

The numbers in each row with the same words don't have significant difference according to Duncan's test ($p> 0.05$).

The numbers in each row with dissimilar words have significant difference according to Duncan's test ($p<0.0001$).

According to Table 1, the effect of different ratios of soy milk substituting with skim milk is not significant ($p>0.05$) on sucrose content of the samples so that with increasing levels of soy milk substituting, a significant difference is not observed in sucrose content, because soy milk contains soluble and non-soluble carbohydrates (including dietary fiber). Soluble carbohydrates mainly include raffinose and Stachyose, and also contain very small amounts of sucrose, glucose and arabinose, which soluble carbohydrates constitute10% of soy milk. Insoluble carbohydrates include cellulose, hemicellulose and pectin (Riaz, 2006). Due to the sugars in soy milk, are mainly types of raffinose, stachyose and insoluble carbohydrates, so increasing soy milk substitution has no effect on sucrose amount.

Moreover, results showed that different levels of soy milk substituting with skim milk have significant effect ($p<0.0001$) on pH and acidity of samples (Table1). As increasing levels of soy milk substitution, pH increases and acidity decreases. Also the sample containing 100% soy milk had the highest amount of pH and the lowest acidity was related to the sample containing 100% skim milk. Because pH of soy milk is about 7 (Onuorah et al., 2007) and is more compared to skim milk that slightly has an acidic pH about 6.5. For this reason, acidity of soymilk ice cream is lower than skim milk ice cream. Similarly Sutar et al. (2010) and Gracas Pereira et al. (2011) reported that with replacing skim milk with soy milk extract, pH of ice cream mixture increases. Their results are in parallel with the findings of this study.

3.2. The impact of different levels of soy milk substituting on physical characteristics of ice cream

The effect of different levels of soy milk substituting on physical characteristics of ice cream is shown in Table 2. The results showed that different levels of soy milk substituting with skim milk have significant effect ($p<0.0001$) on overrun of the samples so that with increasing levels of soy milk, overrun increases. Abdullah et al., (2003)

showed that with increasing total solid overrun increases. These researchers reported that highest amount of total solids can be observed in samples containing the highest amount of soy milk. Their results are perfectly matched with the findings of this study. Other researchers have proved that overrun is affected by the fat content as increasing fat content, overrun increases. Also samples containing the highest amount of solids nonfat have the lowest overrun because fat content is less in samples containing skim milk, in addition since fat effects on overrun of samples so overrun of sample containing 100% skim milk is lower than other samples (Zhang and Goff, 2005; Gohari Ardabili et al., 2005; Goff, 2006).

Akesowan (2009) reported that the ice cream samples with 25% and 50% SPI substitution have higher overrun than the control sample. It is probably due to foaming capacity of SPI leading to enhanced air bubbles, resulting in excess volume of the frozen sample (Martınez et al., 2009; Michael Dennis Sharp, 2009). Also many researchers have been reported the effect of protein on viscosity increase, because when viscosity increases, overrun increases too. Their results are similar with findings of this study (Akin, 2007; Moeenfard and Mazaheri Tehrani, 2008). Reports from other researchers showed that viscosity increase creates a greater overrun, a higher level of micro dispersion and stabilization of the air bubbles (Gracas Pereira et al., 2011) that all these findings are in parallel with the results of this study.

Table 2: Physical properties of Ice cream samples containing different ratios of soy milk to skim milk (mean ± Standard deviation)

Properties	Ratios of soy milk to skim milk 0:100	25:75	50:50	75:25	100:0	Mean-square
Overrun(%)	85.0125± 0.013^{e}	85.094± 0.007^{d}	85.169± 0.012^{c}	85.244± 0.008^{b}	85.324 ± 0.005^{a}	0.04484102**
Viscosity (Centi-Poise)	4568.33±12.583^{e}	5090.66 ±10.066^{d}	5498.33±7.637^{c}	6098.33±12.583^{b}	6654 ±16.037^{a}	2018784.567**

ns and ** respectively non-significant (p>0.05) and significant (p <0.0001).

The numbers in each row with the same words don't have significant difference according to Duncan's test (p> 0.05).

The numbers in each row with dissimilar words have significant difference according to Duncan's test (p<0.0001).

Also, results showed that different levels of soy milk substituting with skim milk have significant effect (p<0.0001) on viscosity of the samples so that ice creams sample containing 100% soy milk had the highest viscosity. The results indicated that with increasing levels of soy milk, viscosity of ice cream increases, too. Other researchers stated that ice cream samples containing soy milk have more fat and when fat increases, total solids content increases and when the total solids increases viscosity of ice cream mixture increases. These findings are consistent with the results obtained from this study (Razavi et al., 2001; Marshall et al., 2003; Clarke, 2004; Zhang and Goff, 2005; Goff, 2006; Bisla et al., 2012).

Akesowan (2009) showed that the addition of soy protein isolates (SPI) increases viscosity of the ice cream samples (p <0.05), this may be attributable to the high water-holding and binding capacity of SPI, causing the formation of a gel matrix which in turn results in a more stable product and is for modify the feature of ice cream. Some researchers demonstrated that viscosity increase of ice cream mixture containing soy milk is due to higher content of soy protein and capacity of soy protein for interaction with water. Soy proteins have higher water holding capacity, this ability is one of the most important functional properties of soy products (Roccia et al., 2009; Akesowan, 2009; Gracas Pereira et al., 2011). The results of these researchers are similar to the findings of this study.

In order to recognize the fluidity of ice cream, viscosity of the samples were measured at 14 ±1 °C with spindle no. 4 (spindle 4) and at speeds of 10, 15, 20, 25, 30, 35, 40, 41, 42, 45, 50, 60, 70, 80, 90 and 100 rpm, and according to the obtained results, all samples had psuedoplastic behavior. Moreover, viscosity of ice cream samples decreased with increasing shear rate (rpm). The flow behavior index (n) in all of the samples were lower than 1 (between 0.53 and 0.69), which shows a shear thinning behavior of samples (pseudoplastic). In fluid type of shear thinning (pseudoplastic) the flow behavior index (n) is in the range of 0<n<1. (n=1 Newtonian fluid, n<1 Pseudoplastic fluid, n>1 Dilatant). Because with substituting soy milk in ice cream, the amount of pseudoplasticity (or shear thinning) increases; due to the presence of high amounts of fiber that its reason is the increase of total solids and forming a network of hydrated cellulose and hemicelluloses (Soukoulis *et al.*, 2009). Since it needs an initial stress and also works like a shear thinning fluid, so the fluid behavior is similar to Herschel Bulkley.

The changes in viscosity and shear stress against shear rate were represented pseudoplastic behavior of most mixtures, apparent viscosity decreased with increasing shear rate. Overall viscosity of shear thinning fluid decreases with increasing shear rate (rpm). Moreover, in the reports of other researchers, flow behavior of ice cream mixture is

described as well as pseudoplastic. The results of this study are corresponded with the findings of other researchers (Soukoulis et al., 2008; Soukoulis et al., 2010; Gracas Pereira et al., 2011).

Gracas Pereira et al., (2011) have demonstrated that increasing the soy extract content in the formulation of ice cream causes the mix to deviate greater pseudoplasticity. Also the flow behavior indexes (n) were obtained between 0.62 and 0.71, flow behavior was described as pseudoplastic. The results of above researchers are similar to findings of this study.

3.3. Sensory characteristics of ice cream samples

The effect of different levels of soy milk substituting on sensory characteristics of ice cream is shown in Table 3. Results showed that different levels of replacement ratios of soy milk with skim milk have a significant effect ($p<0.0001$) on taste, odor, texture, color and overall acceptability of the samples. So that sample containing 100% skim milk has the highest score of taste, odor, texture, color and overall acceptability and samples containing 25% and 50% soy milk are also appropriate and desired samples without beany flavor, without texture inappropriate and without dark colors. Also the difference between the samples are not significant and can be easily substituted with soy milk up to 50%, without significant changes in taste, odor, texture, color and overall acceptability of ice cream sample. Significant differences ($p< 0.05$) were observed between samples containing 50% and 75% soy milk. The sample containing 75% soy milk has some beany taste and odor, some coarse and thick in texture, some dark color that related to soy milk and had less overall acceptability. The sample with 100% soy milk had the lowest scores of taste, flavor, texture color and overall acceptance.

Since soy milk has beany flavor with increasing levels of soy milk the score of taste decreases. Volatile and non-volatile compounds of soybean have considerable effect. The volatile compounds are responsible for the grassy flavor and beany flavor, while the non-volatile components originate astringent flavor and bitter flavor. Other researchers have also proved simultaneously with increasing soy milk in formulation of samples, the score of taste decreases (Yuan and Chang, 2007; Villegas et al., 2009; Gracas Pereira et al., 2011). Similarly Laan and Truelsen (2009) claimed that the highest score of flavor of ice cream related to ratios of 50 to 50 of soy milk and cow's milk. Other researchers have concluded that using desirable flavors can provide up to 50 percent of SNF of ice cream from soy milk (Akesowan, 2009; Bisla et al., 2012). Results of these researchers are similar with the findings of this survey.

Table 3: Sensory properties of ice cream samples containing different ratios of soy milk to skim milk (mean ± standard deviation)

Properties	Ratios of soy milk to skim milk 0:100	25:75	50:50	75:25	100:0	Mean-square
Taste	4.00±0.000[a]	3.60 ±0.507[b]	3.33 ±0.488[b]	2.26±0.457[c]	1.40 ±0.507[d]	17.013**
Odor	4.00±0.000[a]	3.60 ±0.507[b]	3.46± 0.516[b]	2.27± 0.46[c]	1.20± 0.414[d]	19.920**
Texture	4.00±0.000[a]	3.73 ± 0.457[a]	3.73 ± 0.457[a]	2.60±0.507[b]	1.46± 0.516[c]	16.987**
Color	4.00±0.000[a]	3.53±0.516[b]	3.40±0.507[b]	2.13± 0.3511[c]	1.13±0.351[d]	20.820**
Overall acceptability	4.00±0.000[a]	3.53 ±0.516[b]	3.40±0.507[b]	2.33±0.488[c]	1.47 ±0.5167[d]	15.847**

ns and ** respectively non-significant ($p>0.05$) and significant ($p<0.0001$).

The numbers in each row with the same words don't have significant difference according to Duncan's test ($p> 0.05$).

Similarly, some researchers reported that as soy milk increases, the desirability and homogeneity of texture significantly decrease, because difference in solids non-fat (SNF) in soy milk with skim milk in terms of protein kind , lactose and sugars cause creation difference in the texture of samples (Akesowan, 2009). Also other researchers demonstrated that sample 50:50 creates the highest consistency in ice cream, this shows that soy milk and cow's milk together have a synergistic effect and cause created more tightly and stronger texture. Also soy milk has beneficial effects on the texture, such as creating more overrun in ice cream (Abdullah et al., 2003; Laan and Truelsen, 2009). Their results are similar with the findings of this study.

Also some researchers showed that as soy milk increases the desirability and score of color decrease. Because samples containing soy milk have more brown color (Abdullah et al., 2003; Akesowan, 2009; Laan and Truelsen , 2009). Moreover, the adding soy milk would increase amine compounds, which react with aldehydes via Maillard reaction to form dark pigments (melanoidins), for this reasons samples containing high amounts of soy milk are darker (Akesowan, 2009). The findings of these

researchers are aligned with the results obtained from this study.

Laan and Truelsen (2009) indicated that the highest scores of taste, flavor, color, mouth feel, texture and overall acceptance related to the sample containing equal ratios of soy milk and cow's milk. Other researchers have also reached similar results (Abdullah et al., 2003; Akesowan, 2009) that their findings are corresponded with the results of this research.

4. Conclusion

We concluded that substitution of soy milk with different ratios has significantly affected ($p< 0.0001$) on content of total solids, solids nonfat, protein, fat, acidity, pH, overrun and viscosity of ice cream samples whereas it had no significant effect on the amount of sucrose of samples. The sample containing 50% soy milk and 50% skim milk was selected as the most desirable sample. So that this sample in terms of content of total solids, solids nonfat, protein, fat, acidity, pH was absolutely appropriate. In addition its fat is mostly unsaturated. Also the results of sensory evaluation showed that, different ratio of substitution of soymilk had significant effects on taste flavor, texture, color and overall acceptability of samples ($p< 0.0001$). Finally the sample contains 50% soy milk and 50% skim milk was selected as the most desirable sample in terms of sensory properties. Adding cocoa powder completely removed beany flavor of soymilk, and ice cream had quite appropriate overall acceptance.

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