Effect of frozen-storage on sensory quality of three types of low-fat goat milk ice creams

C. McGhee, K. P. Bastola*, B. Davis, and Y.W. Park

Georgia Small Ruminant Research & Extension Center, Fort Valley State University, Fort Valley, GA 31030

Abstract

Three types of low-fat soft-serve goat milk ice creams were manufactured using whole milk (3.64% fat), 2% fat and skim (0.71% fat) goat milk, and stored at -18ºC for 0, 2, 4, 8 weeks to study the effect of extended frozen-storage on sensory properties of the caprine products. A commercial powdered vanilla flavor pre-mix containing 2.5% fat (Alpha Freeze, Tampa, FL, USA) was formulated into the 3 types of goat milk base for manufacture of the ice creams. Eight membered sensory panel evaluated the sensory properties of the experimental caprine milk ice creams. Panelists assessed flavor, body and texture, and color and appearance characteristics of the goat ice cream products using the ADSA Collegiate Dairy Products Evaluation Ice Cream scorecard. The results showed that, for the two main factors, fat type did not have any influence on sensory properties, while storage period significantly affected the flavors of cooked (P<0.01), sweetness (P<0.05), freshness (P<0.05), rancidity (P<0.05), whey (P<0.05) and oxidized (P<0.05), but not for acid flavor. The type x storage interaction did not affect the sensory quality. The overall acceptability of the three types of low-fat goat ice creams slightly declined as storage period advanced. Among body and texture properties, only two characteristics, sogginess and fluffiness, had shown significant (P<0.05) differences among four different storage periods. The 2 weeks frozen-stored ice cream samples showed the highest scores of all flavor traits. This may indicate that the 2 weeks frozen goat ice creams were better in flavor characteristics compared to the fresh soft serve ice creams. For batch effect, the batch 3 had significantly (P<0.01) higher rancidity value than the batches 1 and 2. It was concluded that sensory qualities of the three types of low-fat goat milk ice creams were still acceptable by the sensory panel after 8 weeks frozen-storage.

Introduction

Ice cream is one of the main frozen desserts, made mainly from bovine milk, while it can be made from other species milk including caprine milk. Frozen dessert market is predominantly ice cream market (Arbuckle, 1986). In 2009, ice cream market amounted to 1.52 billion gallons (5.75 billion liters) (USDA, 2012). It comprised 86.7% of the total volume of all frozen desserts. The rest of the market primarily consists of frozen yogurt, water/fruit ices, and sherbet (Kilara and Chandan, 2013).

Although ice cream is a popular food around the world, high fat foods are discouraged, since dietary fat has been implicated with coronary heart diseases, diabetes and other health problems (WHO, 2011; Nouira et al., 2011). Thus, consumption of reduced or low fat dairy products has been increasingly popular among health-conscientious consumers in recent years (Thayer, 1992; Johnson et al., 2009). The sales of light ice cream have been increased by 9% in 1997, while the sales of both low fat and fat free had declined (Markgraf, 1997). To meet this new consumer trend, the dairy industry has developed a variety of low-fat and fat-free ice cream products (Giese, 1996; Marshall et al., 2003), while traditional ice creams typically contain 10-16% fat.

The storage stability of dairy products including ice creams can be affected by storage time, temperature and chemical composition of the products (Day, 1960; Jin and Park, 1995; Park, 2001 Carunchia Whetstine et al., 2003). Positive correlations have been found between lipolyzed flavor, fat acidity and short chain free fatty acid contents (Berger, 1990; Drake et al., 1995; Carunchia Whetstine et al., 2003; Velez et al., 2010).

Compared with traditional ice creams, the low-fat ice creams have problems of low flavor and low textural qualities. such as coarseness and iciness, crumbly body, shrinkage and flavor defects in dairy foods including ice cream products (Drake et al., 1995; Marshall and Arbuckle, 1996; Johnson et al., 2008). This challenge in working with low fat ice creams is attributed to the fact that the fat globule network would either be disrupted or absent and this could seriously impact the texture of the product (Aime et al., 2001), and the overall acceptability of the products would be decreased.

Even though the effect of extended storage on sensory quality of low-fat or fat free bovine milk ice cream products have been studied, little information has been available for the effect of frozen-storage on sensory characteristics of low-fat goat milk ice creams.

Objectives

To study the effect of extended frozen-storage (at -18ºC) on sensory properties of three types of low-fat caprine milk ice creams during 0, 2, 4, 8 weeks storage.

Material and Methods

1. Experimental Design:

a. The experiment was conducted in a 3 x 3 x 4 factorial arrangement.
b. Three batches of the goat milk ice creams were made using skim, 2%, and whole goat fluid milk formulated with a commercial ice cream mix containing 0.25% fat.
c. All manufactured experimental goat ice creams were stored -18ºC in a freezer for 0, 2, 4, 6 and 8 weeks for evaluation of fatty acids during the storage.

2. Preparation of fluid goat milk and ice cream pre-mix:

a. The caprine milk used was a bulk tank milk collected from the late lactation milking goat herd consisted of Saanen, Alpine and Nubian breeds at the Georgia Small Ruminant Research and Extension Center, Fort Valley State University, Fort Valley, Georgia, USA.
b. The vanilla flavor powdered ice cream pre-mix was commercially purchased, which was composed of sugar, corn syrup solids, coconut oil, natural flavor, sodium caseinate, sodium and potassium phosphate, guar gum, mono and diglycerides, xanthan gum, and soy lecithin.

2. Manufacturing procedure of goat milk ice creams:

a. The raw whole goat milk was pasteurized by heating the milk to 115º for 30 min, using a portable table top pasteurizer (Hoegger 54M-5, Fayetteville, AR, USA), and cool to 4ºC.
b. For skim milk and 2% fat milk ice cream making, cream was separated from the whole goat milk using a cream separator (Milky Electric Cream Separator;125 L/h, Austria).
c. For standardization of 2% milk, an accurately measured volume of cream was added to one gallon of skim milk by using the Pearson Square method for %fat calculation.
d. Upon pasteurization, 3 pounds Alpha Freezz Awesome Vanilla ice cream mix (Tampa, FL) was added to 1 gallon each of the 3 type of milk(skim, 2% and whole), and thoroughly mixed.
e. The mixed ice cream milk was poured in 2 separate tanks in the Sani Serv ice cream machine (A5223P, Mooresville, USA), was frozen and agitated until the soft serve ice cream is made.
f. The fresh ice creams were filled in 8 ounce Styrofoam cups, and stored at -18ºC for 8 weeks, until sensory and chemical analyses.

3. Chemical analysis of nutrients:

a. Moisture; Moisture was determined by oven drying at 105ºC using AOAC (1990) method.
b Ash; Ash content was assayed by dry ashing in a muffle furnace at 550ºC (AOAC, 1990).
c. Fat; Fat content was determined by Babcock method (AOAC, 1990).
d. Protein: Protein content was analyzed using a carbon/nitrogen analyzer (Vario MAX CN Elementar Americas, Inc. Mt. Laurel, NJ, USA).

4. Sensory Evaluation:

a. An 8 member sensory panel at College of Agriculture, Family Sciences and Technology at Fort Valley State University, Fort Valley evaluated sensory properties of goat milk ice cream.
b. Panelists assessed the flavor, body and texture, and color and appearance properties of the ice cream samples on a 10-point and 5-point intensity hedonic scale using the USDA scorecard (1976) and ADSA Collegiate Dairy Products Evaluation Ice Cream scorecard.
c. Standard for ratings of all sensory descriptor languages, lexicon of flavor and the score card for training for sensory scoring was done according to Carunchia Whetstine and Drake (2006).

5. Statistical Analysis:

Experimental data were analyzed for analysis of variance, correlation coefficients and Duncan's multiple mean comparison by the GLM procedure of SAS program (2000).

Results

Table 1. Summary of basic nutrient compositions (%) of three types of low-fat goat milk ice creams manufactured with commercial ice cream mix.

Ice cream	Fat		Protein		Ash		Carbohydrate		Total solids	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Skim milk	1.87	0.40	2.87	0.15	1.54	0.05	24.81	0.12	32.11	0.40
2% milk	3.84	0.15	2.80	0.16	1.58	0.18	25.94	0.06	34.16	1.70
Whole milk	5.31	0.57	2.90	0.24	1.58	0.08	23.47	0.12	33.28	1.70

Figure 6. Comparison of changes in mean overall acceptability scores of three types of goat milk ice creams during 8 weeks frozen-storage.

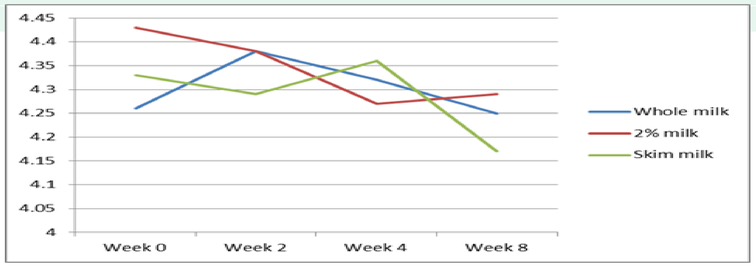


Table 2. Effects of main factors and interactions on flavor characteristics of the three types of low fat goat milk ice creams.[a]

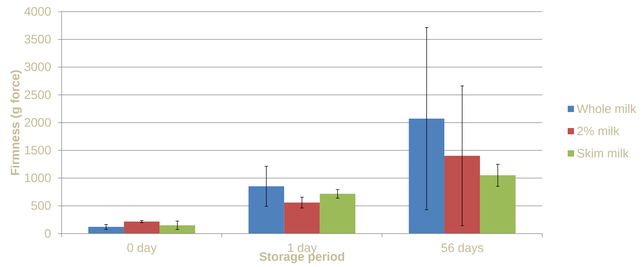
	Cooked	Sweetness	Freshness	Rancid	Whey	Acid	Oxidized
Batch	0.83	0.03	1.74	4.52*	1.19	1.00	2.56
Type	0.12	0.15	0.18	0.57	0.42	0.03	0.35
Storage	6.00**	3.57*	2.13*	2.84*	1.94*	0.59	2.74*
Type x storage	0.34	0.96	0.40	1.01	0.24	0.58	0.37

*Significant P<0.05; **Significant P<0.05

Table 3. Mean Body/Texture characteristics scores of three different types of low-fat goat milk ice creams during 8 week storage period by the sensory panel.

	Coarse/Icy		Crumbly		Fluffy		Gummy		Sandy		Soggy		Weak Body	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Whole Milk ice cream														
Week 0	4.63	0.13	4.75	0.13	4.58	0.07	4.71	0.14	4.58	0.26	4.29	0.47	3.92	0.79
Week 2	4.29	0.26	4.67	0.07	4.58	0.36	4.75	0.22	4.71	0.07	4.58	0.26	4.54	0.19
Week 4	4.25	0.13	4.54	0.26	4.45	0.07	4.75	0.22	4.63	0.13	4.63	0.13	4.50	0.66
Week 8	4.25	0.33	4.21	0.19	4.58	0.07	4.50	0.22	4.46	0.29	4.46	0.14	4.38	0.45
2 % Milk ice cream														
Week 0	4.42	0.19	4.67	0.07	4.46	0.19	4.63	0.25	4.46	0.07	4.33	0.38	4.38	0.63
Week 2	4.67	0.26	4.54	0.19	4.67	0.31	4.67	0.07	4.75	0.22	4.63	0.13	4.63	0.00
Week 4	4.38	0.22	4.50	0.22	4.33	0.14	4.67	0.14	4.63	0.13	4.63	0.13	4.67	0.26
Week 8	4.50	0.33	4.38	0.22	4.75	0.22	4.75	0.13	4.54	0.07	4.50	0.25	4.38	0.13
Skim Milk ice cream														
Week 0	4.38	0.00	4.46	0.29	4.54	0.14	4.54	0.26	4.54	0.19	4.33	0.19	4.38	0.33
Week 2	4.38	0.43	4.58	0.19	4.54	0.19	4.50	0.13	4.33	0.07	4.58	0.29	4.29	0.19
Week 4	4.50	0.38	4.63	0.33	4.42	0.26	4.71	0.07	4.50	0.13	4.71	0.19	4.50	0.22
Week 8	4.46	0.14	4.67	0.07	4.71	0.19	4.54	0.40	4.66	0.19	4.54	0.29	4.50	0.33

Figure 2. Comparison of firmness of 3 types of goat milk ice creams during three different frozen-storage periods.



Conclusion

1. **The flavors of the low-fat goat ice creams were significantly influenced by storage period in cooked, sweetness, freshness, rancidity, whey and oxidized flavors, but not in acid flavor.**
2. **Among body and texture properties, sogginess and fluffiness were the only two properties affected by the storage periods.**
3. **Although there was a slight decrease in overall acceptability of the three experimental low-fat goat ice creams during 8 weeks storage, textural and sensory qualities of the 3 types of low-fat goat milk ice creams were acceptable.**

References

1. Aime, D.B., S.D. Arntfield, L.J. Malcolmson and D. Ryland. 2001. Textural analysis of fat reduced vanilla ice cream products. Food Res. International. 34:237.
2. Arbuckle, W.S. 1986. Ice Cream, Van Nostrand Reinhold Publ. New York. 4th Ed.
3. Day, E.A. 1960. Autoxidation of milk lipids. J. Dairy Sci. 43:1064.
4. Drake, M.A., W. Herrett, T.D. Boylston, B.G. Swanson. 1995. Sensory evaluation of reduced fat cheeses. J. Food Sci. 60: 898-901.
5. Kilara, A. and R.C. Chandan. 2013. Frozen Dairy Products. In: Milk and dairy products in human nutrition. Y.W. Park and G.F.W. Haenlein, eds. Wiley-Blackwell Publishers. Pp. 435-457.
6. Markgraf, S. 1997. Annual ice cream erport: indulgence supreme. Dair Foods. 99 (3):82-84.
7. Nouira, W., Y.W. Park, Z. Guler and T.H. Terrill. 2011. Comparison of free fatty acid composition between low-fat and full-fat goat milk cheeses stored for 3 months under refrigeration. Open J. Ani. Sci. 2: 17-23.
8. Park, Y.W. 2001. Proteolysis and lipolysis of goat milk cheese. J. Dairy Sci. 84(E. Suppl.):E84-E92.
9. Thayer, A.M. 1992. Food Additives. Chemical Engineering News 70: 26.
10. USDA. 1976. Judging and scoring milk and cheese farmer's bulletin No. 2259. United State Dept. of Agriculture, Washinton, DC.
11. USDA. 2012. National Agriculture Statistics Service. U.S. Department of Agriculture. 16 July 2012. http://www.idfa.org/news--views/media-kits/ice-cream/ice-cream-sales-and-trends/
12. Velez, M.A., M.C. Perotti, I.V. Wolf, E.R. Hynes, and C.A. Zalazar. 2010. Influence of milk pretreatment on production of free fatty acids and volatile compounds in hard cheeses: Heat treatment and mechanical agitation. J. Dairy Sci. 93:4545-4554
13. WHO. 2010. World Health Statistics. Global health indicator tables and footnotes part 2. http://www.who.int/whosis/whostat/2010/en/.