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Sensory Evaluation and Physical Characteristics of Chocolate Using Goat's Milk

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Abstract: This study was carried out to determine the physicochemical properties of goat milk chocolate based on colour, hardness, glossiness and fat bloom. The sensory evaluation of the chocolate was analysed at immediately after processing and at three months' storage. Nine formulations of goat milk chocolate were formulated (namely S1 to S9). The results showed the lightness of the samples had increased when percentage of milk fat (8.4%) and total fat (36.4%) increased. The lowest of total fat (28.6%) caused more hardness for sample S1 that had significantly harder texture ($p<0.05$) compared to other samples. Higher percentage of goat milk fat was able to retain glossiness at a longer period as long as fat bloom was inhibited. Results of sensory evaluation showed no significant difference for all attributes using the hedonic test. However significant differences ($p<0.05$) were found for colour, sweetness and texture attributes in the scoring test. In storage study, significant differences ($p<0.05$) were found for colour and texture attributes for storage at room temperature (27°C). As for storage at 16°C with relative humidity 50%, significant differences ($p<0.05$) were noted for colour, rancidity, texture and overall acceptance. In conclusion, the outcome of this research revealed that goat's milk as an ingredient for chocolate caused hardness in chocolate texture compared to cow's milk. It is advisable to determine the Solid Fat Content (SFC) to ensure suitability of fat melting properties. Formulation S3 and S5 were most accepted by trained and consumer panellists respectively.

Key words: Chocolate, goat milk, physicochemical properties, sensory evaluation

Introduction

Milk is one of the most important ingredients in chocolate production. Milk fat, which is formed directly from milk, gives softness to chocolate, improves texture and prevents blooming. Besides providing nutritional values, milk fat also improves viscosity, increase shelf life and play an important role in taste, colour and texture (Shukla, 1994). Milk fat is obtained from ruminant animals such as cows and goats.

The use of goat's milk as cow's milk substitute is new in the chocolate making industry. However the use of goat milk in cosmetic industry is well known. In this study, physical characteristics of goat milk chocolate were identified through various parameters to determine acceptance of modified milk chocolate with goat's milk substitute.

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The fat contents of goat's milk have many special characteristics compared to cow's milk. Goat's milk aids digestion and absorption of fat in the intestines, due to smaller fat globules and more short-chained fatty acids. Goat's milk also has more calcium, vitamin B_6, vitamin A, sodium and niacin compared to cow's milk (Haenlein, 1999). Goat's milk serves as alternative dairy choice to children and individuals suffering from diarrhoea, asthma, vomiting and headache which is associated with cow's milk allergy (Haenlein, 1984, 1992; Park, 1991). One of the most significant differences between cow's milk and goat's milk is in the composition and structure of fats. The average size of goat's milk fat globules is about 2.0 µm as compared to 2.5-3.5 µm for cow's milk fat. The smaller sized fat globules provide better dispersion and a more homogenous mixture of fat in milk (Haenlein, 1984, 1992). Moreover, goat milk has longer transit time in the intestines and this increased amino acid absorption in the intestines (Chandan *et al*., 1992).

Goat milk has been approved as cow milk substitute for those with cow milk allergy (Park, 1994). However, goat milk cannot be substituted with cow's milk entirely because the price of goat milk is more expensive and the supply is very limited. Goat milk is an appropriate substitute for cow milk and soymilk because it has sufficient calcium to prevent hypertension, osteoporosis and bone related disease. Moreover goat milk consists of 13% more calcium than cow milk. Besides having more short-chained fatty acids, goat milk fat also contains low arotic acid, which is important in coronary heart disease prevention (Haenlein, 1992). Comparison of nutrient composition between cow milk and goat milk showed vast differences. Goat milk contained 13% more calcium, 25% more vitamin B, 47% more vitamin A, 134% more potassium and 350% more niacin. Goat milk also has higher amount of chloride, copper, manganese and 27% more selenium (Haenlein, 1999).

Chocolate acceptance is evaluated based on product appearance, colour, glossiness and uniformity of surface. This includes texture; flavour and level of mouth feel (Weyland, 1999). These unique characteristics play important roles in the development of the chocolate industry.

Materials and Methods

Sample Preparation and Evaluation

This study was conducted in November 2004 and was conducted over a period of four months. The main ingredients used in this project were goat's milk powder, cocoa fat, cocoa liquor, sugar, salt and lecithin. In this study, 9 formulations (S1-S9) were formed utilizing statistics ratio X1 and X2 (Table 1). Milk chocolate was prepared by mixing the dry and wet ingredients at Hobart Mixer with medium speed. The samples were refined using refiner (Pascall 3 roll) until the particle size reached 20-25 um. Once refining, the samples were transferred to the conching process at 60°C for 4 h using Pascall Runner Mill conche. After four hours, the complete milk chocolates were tempered on marble slab until chocolate reaches a temperature of 35°C. The tempered chocolates were dispersed into the moulds and the filled moulds were placed in the cooling cabinet (18°C) for three hours. Storage studies were conducted for three months and during the duration, assessment of glossiness and fat bloom formations were conducted. During the 3 month storage, samples were kept at three different temperatures and relative humidity conditions until further evaluation.

Physical analysis was conducted on parameters such as colour, texture and blooming. Colour was measured using Colormeter Minolta Chromameter Model Cr-100 (Japan). Texture was measured using Texture method (Steven Farnell QTS 25 Texture Analyse), obtained hardness of the products in each formulation. The glossiness was measured using Pro Glass Version 1.0 Model PRO-3 and PRO-6, Hunter Associates Laboratory (Virginia, USA). Bloom formation were carried out according to the

Table 1: Ingredients (%) used in goat milk recipe

	Samples								
Ingredients (%)	S1	S2	S3	S4	S5	S6	S7	S8	S9
Cocoa liquor	24.7	21.7	18.7	21.7	18.7	15.7	15.7	15.7	12.7
Goat milk	22.0	22.0	22.0	25.0	25.0	25	28.0	28.0	28.0
Cocoa butter	22.0	25.0	28.0	22.0	25.0	28	22.0	25.0	28.0
Sugar	30.8	30.8	30.8	30.8	30.8	30.8	30.8	30.8	30.8
Lecithin	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Vanilla	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Salt	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Total solid	100	100	100	100	100	100	100	100	100

method by Sabariah and Ali (1996) where visual evaluations of chocolate surface were carried out and scores were given, as follows; 1- unacceptable (complete bloom); 2- just acceptable (trace a bloom); 3- fair (surface dull, no bloom); 4- good (slightly dull, no bloom); 5- excellent (glossy, no bloom).

Sensory Evaluation

Descriptive sensory evaluation (scoring test) of the chocolate products by trained panellists from Malaysian Palm Oil Board (MPOB) was conducted. A total of 10 panellists participated. The scoring test was conducted twice on all formulations. A commercial cow milk chocolate product was also added for comparison. The attributes evaluated were colour, foreign odour, rancid taste, sweetness, texture, waxy mouth feel and overall acceptance of the products. Four best formulations were chosen and a consumer test (hedonic test) was conducted. In this second part of the sensory evaluation, 70 untrained panellists, who comprised of university students, participated. Attributes assessed were the same as the scoring test with the addition of bitterness attribute to replace rancid taste.

Results and Discussion

Hardness

Results on physical properties indicated S1 formulation was significantly harder ($p<0.05$) than to other samples (Fig. 1). This is because the percentage of goat milk fat and cocoa fat is very low. Moreover, the percentage of total fat content was the lowest (28.6%) as compared to other samples. According to Beesley (1977), higher mixture of cocoa liquor and milk crystallization willcause chocolate product to be harder. The hardness of commercial sample (600 N) however was significantly lower ($p<0.05$) then other samples. The low values for hardness indicated faster melting in the mouth and uniformity without sandy feel. This is because the smaller the particle size, better viscosity is obtained during melting. Talbot (1995) stated that milk fat has higher softness than cocoa fat and addition of milk fat will reduce Solid Fat Content (SFC) in a chocolate product. This is because the SFC influences the hardness characteristic of the product at a specific temperature whereby higher SFC will produce harder chocolate products.

Goat milk's and cocoa butter, which have substantially different fatty acids compositions, would show more pronounced eutectic behaviour. In general, the more dissimilar the fatty acid composition of two blended fats, the melting point depression will be stronger whilst the fat blend will be softer (Beekett, 2002). Incompatibility occurs between the two blended fats, (CB/GMF triglycerides). However, a new liquid phase will appear resulting in the softening of the chocolate layer. According to Dimick and Manning (1987), an increase in the amount of liquid phase produces softer chocolate. Figure 1 showed, sample S3 and S4 formulations did not differ significantly in terms of softness.

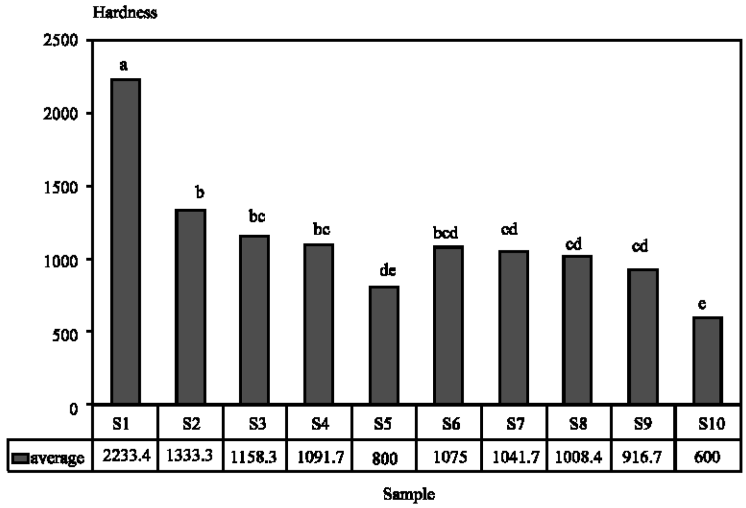

Fig. 1: Means hardness[1] of goat milk chocolate

[1] Determined with a Steven Farnell QTS 25 texture analyser

[a,b,c,d] means with different superscripts indicate significant differences ($p<0.05$)

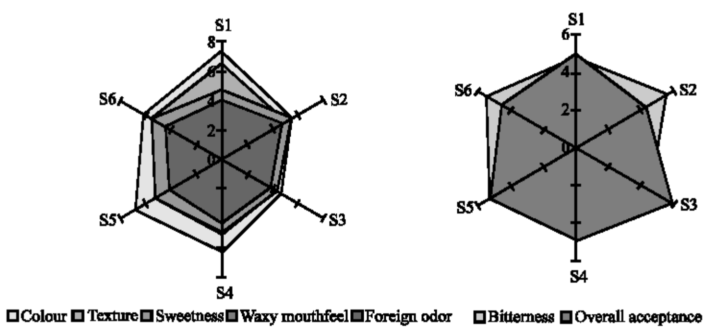

Fig. 2: Results from scoring test (portrayed in spider web)

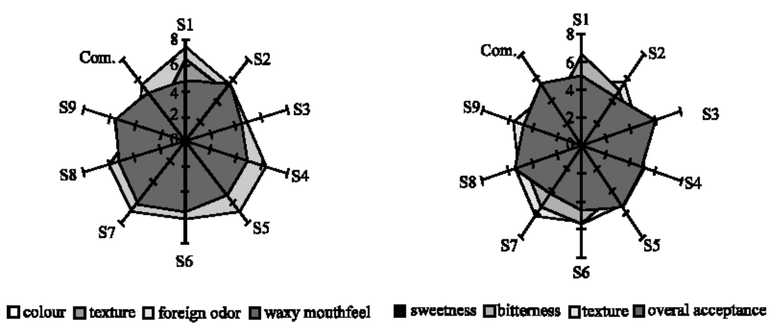

Fig. 3: Results from hedonic test (portrayed in spider web)

Similar finding was also noted for S7, S8 and S9 formulations. However, samples S1, S2, S5, S6 and the commercial product were significantly different ($p<0.05$). Overall observation indicated chocolate produced from goat milk is harder than the commercial cow milk chocolate.

Sensory Evaluation

Results showed S1 was assessed to be the darkest (mean score 7.4) compared to the commercial product with mean score of 5.5. Sample S9 was found to be the lightest in colour due to higher percentage of milk and cocoa fat (Fig. 2). Based on hedonic test, panellists found the most suitable chocolate colour was for commercial sample with mean score of 6.6. However no significant differences were noted for hardness attribute for all samples (Fig. 3). All goat milk chocolate samples were not found with prominent foreign odour. The best accepted samples were still the commercial samples both by the panellists in the descriptive and hedonic tests.

As for sweetness attribute, sample S3 was found to have lowest sweetness score of 3.9 and sample S7 indicates highest mean score of 5.7, while commercial samples had a mean score of 3.9 for sweetness attribute. In the hedonic test, the consumers rated highest mean score for sweetness for S8 sample. However no significant differences were found. Even though the percentage of sugar in each sample is the same, the difference in the content of fat composition gave differences sweetness (Chia, 2000).

Sample S7 had the highest rancid taste with a mean score of 6.6 while the lowest score was for sample S3 (mean score of 4.4). No significant differences were noted in all samples for rancid taste. As for hedonic test, rancid taste attribute was replaced with bitterness. Sample S3 was rated having highest bitterness score. In both sensory tests, sample S7 was noted to have highest waxy mouth feel (Fig. 2 and 3). According to Minson (1994), waxy taste is formed when there is a significant level of fat solid at body temperature. Thus, fat is unable to melt in the mouth and gives waxy mouth feel.

Sample S1 has the highest score of texture (6.6) and the commercial sample has the lowest score (3.0). Significant difference ($p<0.05$) was noted for commercial sample compared to all other samples. As for the hedonic test, the most accepted sample in terms of texture was S8 (Fig. 3). According to Beesley (1977), texture is not only related to moisture content and fat sold proportion, but also controlled by the particle size of cocoa during production. Uniformity of chocolate particle size is important because this can influence the texture of the final product.

As for overall acceptance attribute, sample S3 was most accepted by the descriptive evaluation panellists followed by the commercial sample. As for the consumer panellists, preference was for sample S5, S3 and followed by the commercial sample. However no significant differences were noted. Sample S7 and S4 were least liked by both trained and consumer panellists with mean score of 4.2 and 5.3, respectively.

Colour

The lightness of S7, S8, S9 and the commercial product were higher than other samples. The percentage of goat milk add to formulation (8.4%) gave higher values for lightness. The S9 sample had highest level of lightness value was due to the highest percentage of goat milk fat and cocoa fat in the formulation. The lightness of the commercial product was significantly different ($p<0.05$) from all other samples. It also had the lowest intensity (b) value followed by S2 formulation. However S3 formulation had the highest intensity value (Table 2).

Glossiness Changes in the Chocolate Surfaces

Table 3 shows that the glossiness value increased significantly ($p < 0.05$) in chocolate stored at 27°C compared to chocolates stored at 16°C and controlled humidity at 50%. Overall observation

Table 2: Colour intensity of goat milk chocolate samples

	Colour[1]		
Samples	Lightness (L)	Hue (a)	Intensity (b)
S1	39.93^{bcd}	7.66^{a-c}	7.14^{bc}
S2	37.12^{b}	7.08^{c}	6.18^{c}
S3	38.36^{cd}	7.70^{a-c}	8.89^{ab}
S4	39.50^{b-d}	8.23^{ab}	7.88^{ab}
S5	38.20^{cd}	7.84^{a-c}	8.84^{ab}
S6	39.17^{b-d}	7.40^{bc}	9.20^{a}
S7	41.10^{a-d}	7.76^{a-c}	7.61^{a-c}
S8	43.27^{ab}	8.32^{ab}	6.78^{bc}
S9	44.90^{a}	8.55^{a}	8.01^{ab}
Commercial	41.79^{a-c}	8.35^{ab}	6.08^{c}

L, a and b were determined with Minolta Chromameter Model Cr-100 (Japan) ^{a,b,c,d} means with different superscripts indicate significant differences ($p<0.05$)

Table 3: Mean sample glossiness* during storage study at room temperature 27°C

	Samples									
Week	S1	S2	S3	S4	S5	S6	S7	S8	S9	Com
Initial	20.06	13.52	13.83	12.9	13.3	14.98	12.9	12.56	14.51	20.79
1	17.38	17.7	16.28	15.65	13.74	18.34	16.09	18.41	23.41	26.72
3	19.59	14.44	17.45	12.59	13.39	15.48	12.41	12.93	12.68	13.84
5	15.26	12.64	13.62	16.10	15.99	13.08	12.53	17.05	16.92	14.75
7	16.70	14.97	15.76	16.52	14.77	16.38	16.53	16.39	15.32	16.41
9	14.59	13.40	12.51	13.67	13.43	12.52	14.11	14.61	12.28	15.21
11	15.38	15.50	14.79	14.88	13.23	14.14	14.8	16.57	17.51	14.24

*Glossiness were determined using Pro Glass V1.0 Model PRO-3 and PRO-6

Table 4: Sample glossiness* during storage study at temperature 16°C

	Samples									
Week	S1	S2	S3	S4	S5	S6	S7	S8	S9	Com
1	10.47	10.18	8.97	11.3	10.62	12.16	12.94	12.68	11.71	12.5
3	20.42	16.21	16.98	21.4	16.66	17.90	13.70	19.21	16.07	18.62
5	19.50	15.35	10.90	7.37	8.75	11.08	7.83	14.88	14.85	13.95
7	18.51	16.23	14.22	18.46	12.86	13.88	14.32	12.32	14.46	13.95
9	16.28	14.95	14.05	13.14	12.87	12.79	13.71	11.36	12.36	13.12
11	16.02	14.71	13.99	17.07	17.40	15.21	15.36	13.60	15.26	14.64

*Glossiness were determined using Pro Glass V1.0 Model PRO-3 and PRO-6

Table 5: Sample glossiness* during storage study at relative humidity 50% (26.5°C)

	Samples									
Week	S1	S2	S3	S4	S5	S6	S7	S8	S9	Com
1	2.65	3.19	1.85	4.21	3.6	4.37	7.71	8.57	7.76	8.18
3	7.98	6.21	8.05	6.83	7.54	6.30	8.29	6.58	8.90	8.16
5	16.40	15.10	12.86	16372	17.33	13.26	12.62	15.17	12.11	10.92
7	24.01	15.15	14.00	12.70	14.28	14.21	16.36	17.26	17.04	17.16
9	12.62	14.87	11.57	12.50	12.41	11.41	13.16	14.46	14.00	15.77
11	14.22	13.04	11.53	13.21	15.22	13.32	14.28	15.31	13.01	12.81

* Glossiness were determined using Pro Glass V1.0 Model PRO-3 and PRO-6

showed, the glossiness of chocolate was not stabile and not uniform at the different storage conditions (Table 3 to 5) compared to that of the original commercial chocolate bar. This is due to the arrangement

Table 6: Fat blooms formation on milk chocolate during storage study at room temperature (27°C)

	Samples*									
Week	S1	S2	S3	S4	S5	S6	S7	S8	S9	Com
1	5	5	5	5	5	5	5	5	5	5
3	5	5	5	5	5	5	5	5	5	5
5	5	4	5	5	5	5	5	5	5	5
7	4	4	4	4	4	5	5	5	5	5
9	4	4	4	4	4	4	4	4	5	5
11	4	4	4	4	4	4	4	4	4	5

* 1, unacceptable (complete bloom); 2, just acceptable (trace a bloom); 3, fair (surface dull, no bloom; 4, good (slightly dull, no bloom; 5, excellent (glossy, no bloom)

Table 7: Fat blooms formation on milk chocolate during storage study at temperature 16°C*

	Samples									
Week	S1	S2	S3	S4	S5	S6	S7	S8	S9	Com
1	5	5	5	5	5	5	5	5	5	5
3	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	4	4	5	5	5
7	3	3	3	4	4	4	4	4	5	4
9	3	3	3	4	4	3	4	4	5	4
11	3	3	3	4	4	3	4	4	5	4

* 1, unacceptable (complete bloom); 2, just acceptable (trace a bloom); 3, fair (surface dull, no bloom; 4, good (slightly dull, no bloom; 5, excellent (glossy, no bloom)

Table 8: Fat blooms formation on milk chocolate during storage study at relative humidity 50% (26.5°C)

	Samples*									
Week	S1	S2	S3	S4	S5	S6	S7	S8	S9	Com
1	5	5	5	5	5	5	5	5	5	5
3	5	5	5	5	5	5	5	5	5	5
5	4	5	5	5	5	5	5	5	5	5
7	4	4	4	4	4	4	4	4	5	5
9	3	3	3	4	4	4	4	4	5	5
11	3	3	3	4	4	4	4	4	4	5

* 1, unacceptable (complete bloom); 2, just acceptable (trace a bloom); 3, fair (surface dull, no bloom; 4, good (slightly dull, no bloom; 5, excellent (glossy, no bloom)

of double bond of fatty acids in chocolate (chain packing). The arrangement will performed to get a stabile packing of triacylglycerol in chocolates (Talbot, 1995). The commercial chocolate had more shine on the surface during storage at 27°C in the first week. However it was not significantly different when compared to the others samples. Moreover, our experience indicates that glossiness of goat milk's chocolate may show an increasing glossiness value during storage period. Evidently, the low glossiness was due to sample preparation and the absence of tempering, which was not considered as a variable in this study.

Bloom Formation

Table 6 to 8 showed the effect of storage temperature at 27, 16°C and RH at 50% on the bloom cycle of the chocolate layer. No bloom was observed at all during the storage temperature; at 16 and 26.5°C, the onset of the bloom was observed after seven week, which took around four cycles to bloom. The bloom was found to be due to recrystallization of the goat milk fat and cocoa butter triglycerides mixture (Nazaruddin *et al*., 2005). Goat milk fat crystallizes out in β form because it is usually contaminated with other unsaturated glycerides from cocoa butter. At 27°C, possibility of fat migration increases into the chocolate layer as time increases until equilibrium. Shukla (1994) have studied the action of 10% olive oil on the polymorphic behaviour of cocoa butter and have found that the transformation rates were markedly increased by an increase in liquid content; bloom is more likely to occur when the chocolate is stored at relatively high temperature (25±32°C) (Talbot, 1995).

Conclusions

The utilization of goat milk increases the hardness of chocolate samples compared to cow milk chocolate (commercial sample). Sample S3 was most accepted by the trained panellists followed by commercial samples. As for consumer panellists, sample S5 and S3 were most accepted. Good correlations were found between hardness, colour and gloss value to the storage conditions of goat milk chocolate. Further research is needed to relate the eutectic and polymorphism behaviour of goat milk into the production of chocolate.

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