Original Article

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Nutritional Values and Stability of Goat Milk Tablets

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Abstract

Spray dried goat milk was prepared and compressed into tablets by wet granulation method. Goat Milk tablets were placed in plastic bottles and aluminium-laminated pouches and stored at both room temperature and accelerated storage conditions (45±2 ^{o}C, 90% relative humidity). The storage stability of goat milk tablets in terms of quality parameters for the major constituents (fat, protein, lactose and solids-not-fat), fat-soluble vitamins (A, E) and water-soluble vitamins (folic acid, B_1) was studied in both containers. The magnitude of change of these nutritional parameters after storage at both conditions for 90 days were not significantly different ($P>0.05$).

Key words: goat milk tablets, stability, aluminium-laminated pouches, vitamins

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INTRODUCTION

In recent years, goat milk and its products have become more popular. The nutritional advantage of goat milk compared to cow milk has been attributed to the small size of fat globules. This is one of the proposed reasons for the easy digestion of goat milk[1]. Goat milk has identified as an alternative for infants and adults who are sensitive or allergic to cow milk[2]. Goat milk contains more calcium, phosphorous, potassium, magnesium, chloride and selenium, in addition, goat milk has higher amount of vitamins A and D than cow milk. On the other hand, goat milk has lower sodium and sulfur contents than cow milk[3]. At present, the production of goat milk in Thailand is increasing but it still could not attract more consumers due to its undesirable goaty odour. Goat milk can be processed into different products, including goat fluid milk, powder, yogurt and cheese[4]. In Thailand, UHT and pasteurized goat milk and yogurt are available commercially. However, goat milk powder is not yet commercially available. Goat milk tablet can probably be an interesting alternative to produce because it is easy to consume and to prepare in a small package. Besides, the goaty odour can be masked by adding various flavouring agents. The objectives of this study were to produce goat milk tablets and to study the effect of plastic bottles and aluminium-laminated pouches on nutritional values and stability of goat milk tablets.

MATERIALS AND METHODS

Preparation of goat milk tablets

Pasteurized goat milk was concentrated to 30% of total solid in a vacuum evaporator. Then it was spray-dried at the inlet air temperature of 180±2°C and the outlet air temperature of 90±5°C with the feeding rate at 7-10 rpm. The main ingredients of goat milk tablets were 60% w/w spray dried goat milk powder, 16% w/w lactose, 17% w/w sucrose and 0.86% w/w magnesium stearate (MgSt). Spray-dried goat milk powder, lactose and magnesium stearate were passed through a 120-mesh screen. Sucrose syrup was prepared at a concentration of 65% w/v to be used as a binder solution. Spray dried goat milk powder and lactose were mixed and granulated by gradual addition of the binder solution in a planetary mixer. The damp mass was passed through a 14-mesh screen and dried in a hot air oven at 50°C for 3 hours. After that, 8.6 g of magnesium stearate was added to the granules and it was continuously mixed for 5 min in a tumbling mixer. The tablets were compressed on a single punch tablet machine, using 16-mm toolings. The targeted tablet weight was set at 1 g.

Evaluation of tablets properties

Weight variation

Weight variation test was determined by weighing 20 tablets, individually, calculating the average weight and comparing the individual tablet weight to the average.

Thickness and hardness

Twenty goat milk tablets were sampled and determined for thickness (mm), and hardness (kg) using an electronic thickness/hardness tester (Pharma test® Model DTB 311, Pharmatest, Germany).

Friability

Twenty goat milk tablets were brushed to remove dust and then weighed (W_1). The tablet samples were placed in a Roches friabilator (Pharma test® Model PTFR-A, Pharmatest, Germany) at the rotating speed of 25 rpm. After 4 min, the tablets were removed, dedusted and weighed again (W_2). The friability value (F%) of tablet was calculated from the different weight of goat milk tablet, before and after rotating, using the following equation:

$$F\% = [(W_1 - W_2)/ W_1] \times 100$$

Storage of goat milk tablet samples

Goat milk tablets were separately packed in high density polyethylene plastic bottles and aluminum-laminated

polyethylene pouches and then stored at room temperature and accelerated conditions (45°C and 90% relative humidity). The samples were taken for analysis after 0, 15, 30, 45, 60, 75, and 90 days of storage.

Analysis of composition of milk samples

The goat milk tablets were ground to powder. Approximately 3.0 g of powder was accurately weighed and 30 mL of distilled water was then added and mixed until complete homogenization. Prior to the analysis, the samples were preheated to 40°C in order to liquify the fat. Air was incorporated to the samples by vigorous mixing just before analysis by MilkoScan (N.Foss Electric, Denmark). Each milk sample was analysed in duplicates.

Analysis of vitamins

The method of Zahar and Smith[5], with slightly modification, was used for the determinations of vitamins A and E. Goat milk tablets were finely powdered. Four grams of powder sample was reconstituted with 8 ml of double-distilled water. It was then immersed in warm water (40°C), and mixed until complete homogenization. Two milliliters of reconstituted sample was transferred to a centrifuge tube. Five milliliters of 0.1% (w/v) ascorbic acid and 2 mL of 50% (w/v) potassium hydroxide solution were added. The mixture was again stirred for 1 min and placed in a water bath at 80°C for 20 min. It was then cooled and placed in an ice water bath. Twenty milliliters of 0.01% (w/v) of butylated hydroxytoluene in diethyl ether and petroleum ether (1:1) were added. The mixture was vortexed for 1 min and centrifuged at 3,500 *g* for 15 min to aid solvent separation. The 10 ml of clear organic top layer was removed and evaporated to dryness under nitrogen. The extract was reconstituted with 1 mL of methanol (HPLC grade) and then filtered with a 0.45-µm nylon filter before injection into HPLC.

The HPLC equipment (Shimadzu corporation, Kyoto, Japan) consisted of a Liquid Chromatograph LC-10 AD, Communication Bus Model CBM-10A, UV-Visible Detector SPD-10A and Data processing (class LC-10). The separation was performed on a ODS-2 HYPERSIL C18 Column 250 x4.6 mm, 5 µm. (Thermo, USA). Manual injection was carried out using a Rheodyne model 7725 injector with a 20- µL loop. The mobile phase used for separation of vitamins described by Joanna Karpińska *et al*[6] with slightly modification to a mixture of methanol- *n*-hexane (90:10, v/v) at a flow rate 1.0 mL/min. The UV detection was performed at 295 nm.

The same equipment and column were used for the separation of vitamin B_1 and folic acid, as for vitamins A and E. The mobile phase was modified from that of Albalá-Hurtado *et al*[7]. It contained 5 mM sodium 1-heptane-sulfonate, 0.5% triethylamine, 2.5% glacial acetic acid, pH 3.8 and 10% methanol. The flow rate was 1 ml/min. The UV detection was operated at 265 nm. Goat milk tablets were finely powdered. Four grams of powder sample was reconstituted with 8 ml of double-distilled water. The mixture was then immersed in warm water (40°C), and mixed until complete homogenization. Four milliliters of reconstituted sample was transferred to a centrifuge tube. Then 3 mL of 1% (w/v) meta-phosphoric acid was added. The mixture was thoroughly vortexed for 1 min and centrifuged at 3,500*g* for 10 min to separate the two phases. After that, 2 ml of 1% (w/v) meta-phosphoric was added to the solid residue obtained. It was mixed thoroughly for 1 min and centrifuged. The two acid extracts were combined in a 10-mL volumetric flask and adjusted to volume with double-distilled water. The samples were filtered through 0.45-µm membranes prior to HPLC analysis.

Statistical analysis

The data for the components in milk samples were analyzed using t-test with the 95% confidence interval ($p < 0.05$). The factors included in the models were material (high-density polyethylene plastic bottle and aluminium-laminated pouch) and storage time (0, 15, 30, 45, 60 and 90 days).

RESULTS AND DISCUSSION

Production of goat milk tablets

The physical appearances of goat milk tablets, which were prepared by wet granulation method, were canary yellow with shiny and smooth surface. The photograph of goat milk tablet is shown in Figure 1. The average weight of goat milk tablets was 1.0394±0.01 g and the weight variation met the requirement of USP 24[8]. The thickness and hardness of the tablets were 4.497±0.07 mm and 5.75±0.67 kg, respectively. Additionally, the friability of tablet sample was 0.36 % which met the requirement of USP 24 which stated that the friability of tablet should not be more than 1%[8].

Analysis of compositions of milk samples

The compositions of goat milk tablets were analyzed using MilkoScan. The contents of fat, protein, lactose, and solid-not-fat which stored at room temperature and accelerated conditions (45 °C and 90% relative humidity) in plastic bottles and aluminium laminated pouches are shown in Tables 1 and 2. At both storage condition, room temperature storage and accelerated storage, the contents of fat, protein, lactose, and solids-not-fat were unchanged after storage in both containers for 90 days. The milk contents of goat milk tablets stored in plastic bottles were comparable to those of tablets stored in aluminium-laminated pouches.

Analysis of vitamins

As shown in Table 3, the initial contents of vitamins A and E were 0.0780 and 0.1000 µg/g, respectively. Vitamin E content was unchanged after storage for 90 days in both type of containers. After storage for 90 days, the decreases of vitamin A, 1.73% and 1.19% in plastic bottles and aluminium-laminated pouches, respectively, were not statistically significant ($p > 0.05$). Thus, vitamin A and vitamin contents could be considered constant throughout the 90 days of storage at room temperature in both containers. The results agreed with those reported in a previous study of the stability of powder infant milk which was stored at 20 and 30°C[9]. After 90 days at accelerated condition storage**,** the decreasing of vitamins A and E contents of goat milk tablets in plastic bottles and in aluminium laminated pouches was not significantly different ($P > 0.05$). The results are given in Table 4. Change of contents of vitamins A and E in goat milk tablets during accelerated storage are shown in Figures 2 and 3, respectively.

Folic acid and vitamin B_1 contents of goat milk tablets tablets during storage in plastic bottles and in aluminium laminated pouches at room temperature are shown in Table 5. After storage in both containers at room temperature for 90 days, no change was found in the contents of folic acid and vitamin B_1 in goat milk tablets. The results agreed with those reported in a previous study of the stability of powder infant milk which storage at 20 and 30°C[9]**.** After 90 days of storage at accelerated storage condition, the folic acid content of goat milk tablets kept in plastic bottles and aluminium-laminated pouches decreased to 74.95 and 51.90%, respectively. The vitamin B_1 content decreased to 57.51 and 41.34% after 90 days of storage for goat milk tablets kept in plastic bottles and aluminium-laminated pouches, respectively. Vitamin B_1 and folic acid contents of goat milk tablets after storage in plastic bottles and aluminium-laminated pouches at 0, 15, 30, 45, 60, 75 and 90 days in accelerated storage condition are shown in Table 6. The decreasing of folic acid and vitamin B_1 in plastic bottles and in aluminium-laminated pouches was not significantly different ($P > 0.05$). The change contents of folic acid and vitamin B_1 in goat milk tablets during accelerated storage are shown in Figures 4 and 5, respectively.

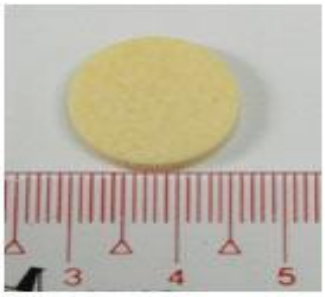

Figure 1 Goat milk tablet

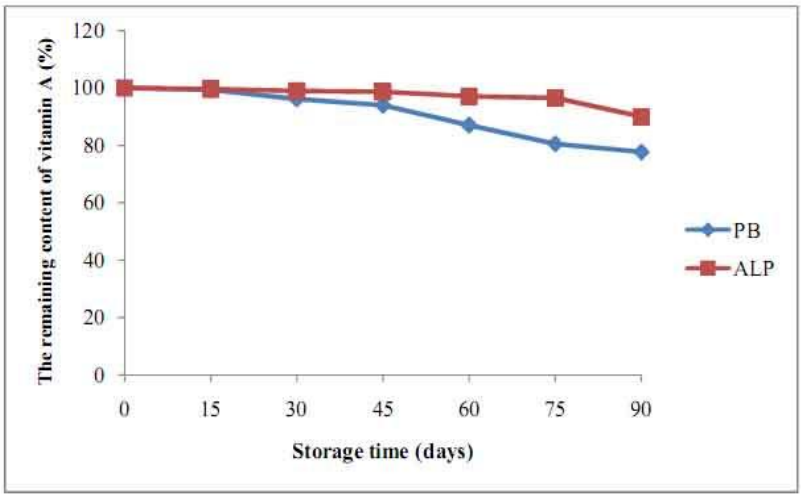

Figure 2 The remaining content of vitamin A in goat milk tablets during storage at accelerated conditions (45 °C and 90% relative humidity) in plastic bottles and aluminium laminated pouches (PB = Plastic bottle, ALP = Aluminium-laminated pouch)

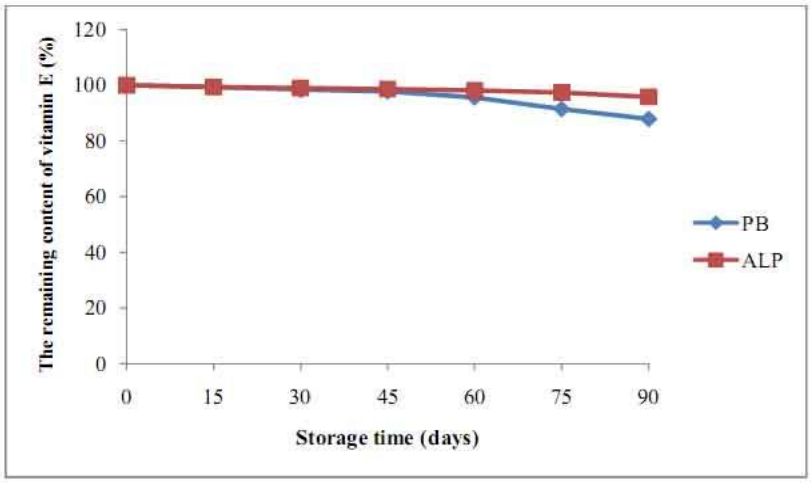

Figure 3 The remaining content of vitamin E content in goat milk tablets during storage at accelerated conditions (45 °C and 90% relative humidity) in plastic bottles and aluminium laminated pouches (PB = Plastic bottle, ALP = Aluminium-laminated pouch)

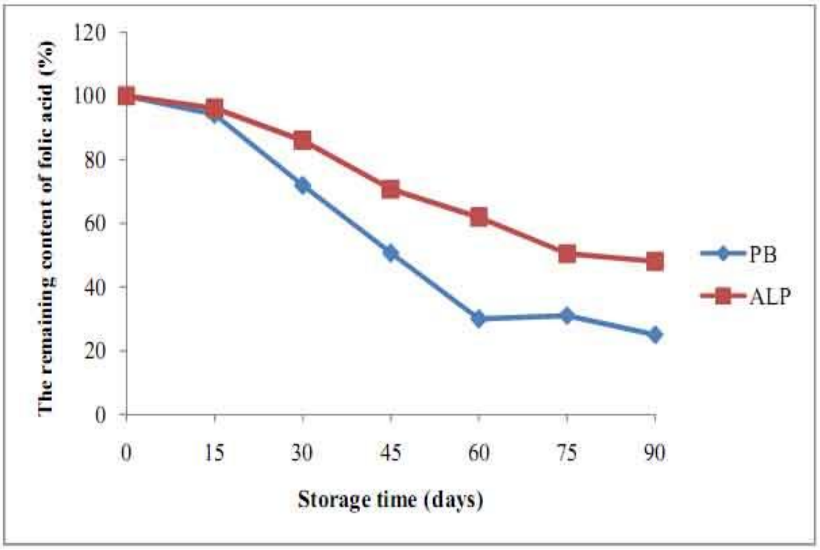

Figure 4 The remaining content of folic acid content in goat milk tablets during storage at accelerated conditions (45 °C and 90% relative humidity) in plastic bottles and aluminium laminated pouches (PB = Plastic bottle, ALP = Aluminium-laminated pouch)

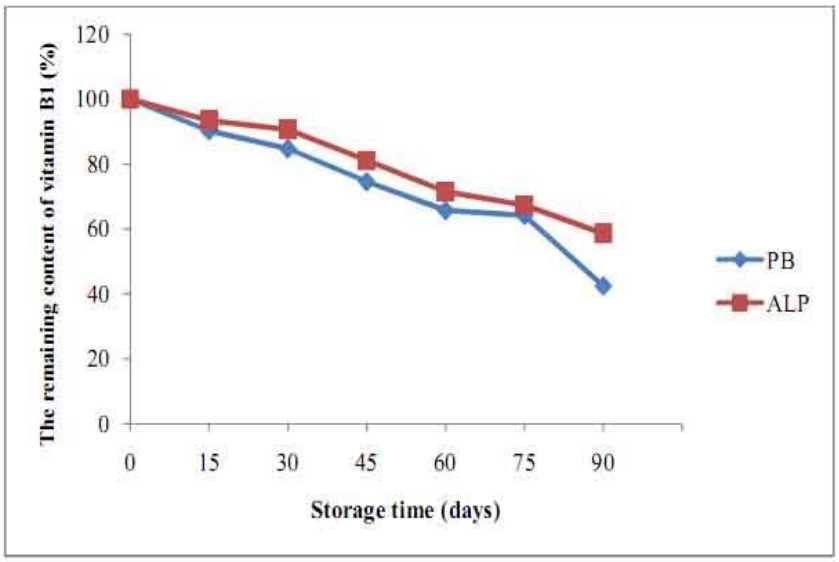

Figure 5 The remaining content of vitamin B_1 content in goat milk tablets during storage at accelerated conditions (45 °C and 90% relative humidity) in plastic bottles and aluminium laminated pouches (PB = Plastic bottle, ALP = Aluminium-laminated pouch)

Table 1. Compositions of goat milk tablets during storage in two different containers at room temperature (n=2)

Storage of time (days)	Plastic bottle				Aluminium-laminated pouch			
	Content (g/100g)				Content (g/100g)			
	Fat	Protein	Lactose	Solid-not-fat	Fat	Protein	Lactose	Solid-not-fat
0	60.21±0.34	47.06±0.42	145.94±2.07	214.66±0.73	60.21±0.34	47.06±0.42	145.94±2.07	214.66±0.73
30	59.83±0.47	47.58±0.36	145.67±1.18	213.75±4.36	60.50±0.24	47.17±0.23	149.75±0.60	214.34±3.06
60	59.16±0.66	47.84±0.23	146.17±1.65	214.33±0.71	60.92±0.12	47.75±0.11	148.58±0.12	214.83±2.36
90	59.67±0.23	47.75±0.11	146.58±0.35	214.00±0.47	59.16±0.23	47.83±00	148.91±0.35	214.42±0.35

Table 2. Compositions of goat milk tablets during storage in two different containers at accelerated conditions (45^{o}C and 90% relative humidity) (n=2)

Storage of time (days)	Plastic bottle				Aluminium-laminated pouch			
	Content (g/100g)				Content (g/100g)			
	Fat	Protein	Lactose	Solid-not-fat	Fat	Protein	Lactose	Solid-not-fat
0	60.21±0.34	47.06±0.42	145.94±2.07	214.66±0.73	60.21±0.34	47.06±0.41	145.94±2.07	214.66±0.73
30	60.42±0.36	48.50±0.95	145.75±0.60	214.25±1.77	60.25±0.35	48.42±0.35	148.67±2.12	214.92±2.24
60	60.66±0.47	48.17±0.71	143.92±0.59	215.83±0.23	60.25±0.59	49.17±0.47	147.33±0.24	216.42±2.10
90	59.50±0.40	47.67±0.71	145.58±0.35	215.49±2.36	59.83±0.24	48.42±0.35	147.59±0.87	214.00±0.94

Table 3. Vitamins A and E contents of goat milk tablets during storage in plastic bottles and Aluminium-laminated pouches at room temperature (n=3)

Storage time(days)	Content of vitamin A (µg/g)		Content of vitamin E (µg/g)	
	Plastic bottle	Aluminium - laminated pouch	Plastic bottle	Aluminium - laminated pouch
0	0.0780	0.0780	0.1000	0.1000
15	0.0777	0.0778	0.1000	0.1003
30	0.0773	0.0777	0.1001	0.1000
45	0.0771	0.0777	0.1000	0.1000
60	0.0766	0.0772	0.1000	0.1001
75	0.0769	0.0771	0.0999	0.1001
90	0.0767	0.0771	0.1000	0.1002

Table 4. Vitamins A and E contents of goat milk tablets during storage in plastic bottles and aluminium-laminated pouches at accelerated condition (45°C and 90% relative humidity) (n=3)

Storage time(days)	Content of vitamin A (µg/g)		Content of vitamin E (µg/g)	
	Plastic bottle	Aluminium - laminated pouch	Plastic bottle	Aluminium - laminated pouch
0	0.0780	0.0780	0.1000	0.1000
15	0.0775	0.0777	0.0994	0.0994
30	0.0750	0.0772	0.0984	0.0990
45	0.0733	0.0770	0.0978	0.0986
60	0.0679	0.0757	0.0956	0.0981
75	0.0628	0.0753	0.0915	0.0974
90	0.0606	0.0702	0.0879	0.0958

Table 5. Folic acid and vitamin B_1 contents of goat milk tablets during storage in plastic bottles and aluminium-laminated pouches at room temperature (n=3)

Storage time(days)	Content of folic acid (µg/g)		Content of vitamin B_1 (µg/g)	
	Plastic bottle	Aluminium - laminated pouch	Plastic bottle	Aluminium - laminated pouch
0	0.0499	0.0499	0.0779	0.0779
15	0.0500	0.0497	0.0780	0.0779
30	0.0498	0.0498	0.0778	0.0780
45	0.0496	0.0496	0.0775	0.0773
60	0.0497	0.0497	0.0770	0.0772
75	0.0498	0.0497	0.0770	0.0773
90	0.0492	0.0494	0.0769	0.0770

Table 6. Folic acid and vitamin B_1 contents of goat milk tablets during storage in plastic bottles and aluminium-laminated pouches at accelerated conditions (45°C and 90% relative humidity) (n=3)

Storage time(days)	Content of folic acid (µg/g)		Content of vitamin B_1 (µg/g)	
	Plastic bottle	Aluminium - laminated pouch	Plastic bottle	Aluminium - laminated pouch
0	0.0499	0.0499	0.0779	0.0779
15	0.0470	0.0480	0.0703	0.0728
30	0.0359	0.0429	0.0660	0.0706
45	0.0253	0.0353	0.0581	0.0632
60	0.0150	0.0309	0.0512	0.0557
75	0.0155	0.0252	0.0500	0.0525
90	0.0125	0.0240	0.0331	0.0457

CONCLUSION

The study of the effects of plastic bottles and aluminium-laminated pouches which stored at room temperature demonstrated that all of nutrients, fat, protein, lactose, solids-not-fat, vitamin A, E, B_1 and folic acid contents, showed no significant changes ($P>0.05$). Fat, protein, lactose, solids-not-fat contents in goat milk tablets which were kept in plastic bottles and aluminium-laminated pouches and stored at accelerated condition did not change while vitamins A, E, B_1 and folic acid contents in both containers decreased. According to the results, it could be suggested that aluminium-laminated pouches and plastic bottles were comparable in term of protection from vitamin A, E, B_1 and folic acid loss.

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