Raw Goat Milk Qualities from Thai Muslim Farms in Ayuthaya Province, Thailand, A Field Study

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Abstract: In Thailand, dairy goat farms are associated with Muslim communities where the big cluster is in the central and southern parts of the country. The purpose of the paper is to survey the relation of farm management and feeding of 6 Thai Muslim farms in Ayuthaya province with the goat milk quality as mainly focused on the chemical and physical properties, fatty acids compositions, and volatile compounds affecting odor and flavor. Most farms feed their goats with natural grass and silage mixed with soybean meal but some farms may add commercial concentrate feeding and white popinac leaves (*Leucaena leucocephala* de Wit) in each feeding meal. Our survey indicated the variation in goat milk quality which includes the intense off flavor and odor and fatty acid composition is influenced by insufficient feeding nutrition and poor farm management by some Muslim families. The neglected farm hygiene maybe one of the factors causing the unpleasant odor of goat milk. Percentage of fat and total solid, and specific gravity of goat milk from 6 farms were remarkably followed the standard values of Thai Agricultural Standard, whereas percentage of protein and solid not fat (SNF), and freezing point were graded as sub-standard. The improvement of feeding stuff through high nutrition for dairy goats and proper farm management are recommended for these 6 small Muslim farms which will be the prototype farming for upgrade goat milk to the standard in all categories turning back higher income for small Muslim families in Ayuthaya province.

Keywords: Goat milk, Thai Muslim farm

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Introduction

Goats (*Capra hircus*) have the ability to adapt to harsh climates, the environment and flexible feeding behavior that make them easy to take care of and grow faster than cows and other economic ruminants. Goats have a higher capacity than other farms raised ruminants to effectively convert some feed sources into milk and meat (Dacan and Silanikove, 2018). In Thailand, goat raising has long been associated with Thai Muslim communities. The dairy goat sector is relatively new and small compared to the meat goats. However, the number and popularity of dairy goats have slightly increased from the last decade (Nakavisut and Anothaisinthawee, 2014).

Thai Muslim dairy goat farms are widespread across the country but a big cluster is distributed in the southern and central parts of the country. Muslim goat farms usually succeed to family and have traditional management. Saanen is the most popular breed of goats reared because of its high milk yield (Nakavisut and Anothaisinthawee, 2014). The average farm size of the Muslim community in the central part of Thailand is around 7-20 goat/farm. Most farms feed their goats with natural grass and silage with soybean meal and commercial concentrate diet. Some farms allow goats to graze outdoors and roam freely around the house. Most farms rear goats in stalls of the house where the floor is made of wooden slats and elevated high from the ground. The modern farms are divided into stalls for feeding, breeding and milking.

Goat milk differs from cow and human milk in both composition and nutritional properties. Goat milk provides a great excess of calcium, vitamin B6 and vitamin A compared to cow milk. Goat milk and other goat-derived products also contain several bioactive compounds that might be useful in patients suffering from a variety of chronic diseases. Thereby, goat milk has been recommended for people who have a problem with lactose tolerance and are sensitive or allergic to cow milk. The health benefits, composition and nutritive value of goat milk has been reviewed by Getaneh *et al*. (2016) and Lima *et al*. (2017).

In Thailand, goat milk is mostly the product from Muslim farms and usually sold to specific consumers with health concerns. Goat milk is more expensive than cow milk because of lower productivity, seasonal variations and small farm size. However, the weakness of goat milk produced from Thai Muslim farms is its smell, which is unacceptable to many consumers. With reference to our survey of the goat milk quality received from Thai Muslim farms in Ayuthaya province, located in the central part of Thailand, a variation of inferior odor from none to high intensive scent was found. Most people appear to reject the goat milk with altered odor, as the variation could be derived from many factors including climate, diets, or farm management (Chilliard *et al*., 2003). The top three reasons that Thai consumers had for not buying and drinking goat milk were its taste, goaty flavor, and high price (Nakavisut and Anothaisinthawee, 2014).

This paper aims at studying the dairy goat farms of Muslim community in Ayuthaya province regarding feeding and farm husbandry relating to the physical and chemical properties as well as the scent of goat milk. It is very important to understand other aspects affecting goat milk quality including odor and sanitation. This will help Muslim farmers improve their goat milk product quality to meet consumer needs and would expand their market to other health consumer groups.

Materials and Methods

Background information on dairy goat farm management of Muslim farms

The goat farms (Farm A, B, C, D, E, F) of the Muslim community in Ayuthaya are closed farms and feed their goats with natural grass and silage mixed with soybean meal but sometimes may add commercial concentrate diet supplemented with white popinac leaves (*Leucaena leucocephala* de Wit) and para grass (*Brachiaria mutica* Forsk, Stapf) in each diet meal. Only farm A allows goats to graze outside and roam freely around the house while other farms rear goats in stalls of the house. The 6 Muslim farm houses are slightly different where the floor is made up of wooden slats and are elevated high up from the ground to keep goats away from dirt, moisture, droppings and parasite worms. All farms have routinely practiced vaccination of their goats against foot and mouth disease (FMD) and a deworming program according to the recommendation by the Department of Livestock Development (DLD).

Some farmhouses are divided into stalls for feeding, breeding, and milking. They usually milk a goat in the morning and in the evening. For the sanitation of milking the breast is cleaned before stripping. Milk is stripped into a narrow necked clean plastic bottle and then poured into a plastic bag. The plastic bags are stored at 4°C before selling. Most farms usually sell raw goat milk to consumers except farm A, which boils the raw goat milk for 15 minutes before bottling and selling it to consumers (Table 1).

Table 1 Background information on the dairy goat farms at Ayuthaya province

Background information	Farm A	Farm B	Farm C	Farm D	Farm E	Farm F
Area	1600 m^2	1600 m^2	1600 m^2	224 m^2	50 m^2	1600 m^2
Number of goat	Male 1 head Female 29 heads Baby goat 9 heads	Male 1 head Female 7 heads Baby goat 8 heads	Male 10 heads Female 50 heads Baby goat 10 heads	Male 8 heads Female 34 heads Baby goat 15 heads	Male 7 heads Female 7 heads Baby goat 8 heads	Male 8 heads Female 30 heads Baby goat 42 heads
Farm	Closed farm	Closed farm	Closed farm	Closed farm	Closed farm	Closed farm
Goat breed	Saanen	Saanen	Saanen	Saanen	Saanen	Saanen
Feeding	Napier grass, concentrates supplemented with soy bean and minerals	Fermented para grass and concentrates, supplemented with soy bean and minerals	Fresh grass supplemented with soy bean	Fresh grass and Napier grass supplemented with soy bean and Leucaena forage	Silage and para grass (Brachiaria mutica Forsk, Stapf)	Fresh Pangola grasss, supplemented with Leucaena forage, soy bean
Feeding time	Morning - Evening	Morning - Evening	Morning - Evening	Morning - Evening	Morning - Evening	Morning - Evening
Health management	Vaccination against foot and mouth disease (FMD) and deworming program	Vaccination against foot and mouth disease (FMD) and deworming program	Vaccination against foot and mouth disease (FMD) and deworming program	Vaccination against foot and mouth disease (FMD) and deworming program	Vaccination against foot and mouth disease (FMD) and deworming program	Vaccination against foot and mouth disease (FMD) deworming program
The practice of cleaning the stall	Wiping and washing the stall with clean water every morning and evening	Wiping and washing the stall with clean water once a week	Wiping the stall every day, no washing with water.	Wiping and washing the stall with clean water sometimes, the accumulation of dung and waste is noticeable	Wiping and washing the stall with antiseptic water once a month so the accumulation of dung and waste is noticeable	Wiping and washing the stall with antiseptic water once a week
Time for milking	In the morning (7.00 am)	In the evening (5.00 pm)	In the evening (5.00 pm)	In the morning (7.00 am)	In the morning (7.00 am)	In the morning (7.00 am)
Average milk yield per head	1.5 kg	1.5 kg – 2 kg	1.5 kg	1 kg –1.5 kg	1 kg – 1.2 kg	1.2 kg – 2 kg
The practice of raw goat milk	- Pasteurizing raw goat milk then packing in plastic bag and freezing - Selling frozen raw goat milk in plastic bag.	- Packing raw goat milk in plastic bag then chilling at 4°C - Selling chilled raw goat milk in plastic bag.	- Packing raw goat milk in plastic bag then chilling at 4°C - Selling chilled raw goat milk in	- Packing raw goat milk in plastic bottle then chilling at 4°C - Selling chilled raw goat milk in plastic bottle.	- Packing raw goat milk in plastic bottle then chilling at 4o – 8 °C - Selling chilled raw goat milk in plastic bottle.	- Packing raw goat milk in plastic bottle then chilling at 4°C - Selling chilled raw goat milk in plastic bottle.
Average income per month	9,000 baht	7,000 baht	9,000 baht	7,000 baht	5,000 baht	9,000 baht

Results and Discussion

The physical and chemical properties of goat milk

Our results in (table 2) indicated that the fat content of the goat milk from the 6 farms met the standard value (>3.2%) according to the first Thai agricultural commodity and food standard for raw goat milk in September, 2008 (Thai Agricultural Standard, 2008). The average percentage of milk fat is a variable component, often ranging of 3.0% - 6.0% (Getaneh *et al.*, 2016).

The quality and quantity of feeds, genetics, season and stage of lactation all influence the average percentage of goat milk fat. Due to the smaller size of fat globules found in goat milk than in cow milk, it provides a better dispersion and a more homogeneous mixture of fat in the milk, indicating the creaming ability of goat milk and smooth texture in goat milk products compared to cow milk and its products.

Table 2 The composition of raw goat milk from 6 Muslim farms

Farm Sample	Fat (%)	Solid Not fat, (SNF) (%)	Total Solid (%)	Protein (%)	Freezing Point (FP) (^{o}C)	Lactose (%)	Specific Gravity
Farm A	3.72 ± 1.17	7.47 ± 0.13	13.28 ± 5.17	3.89 ± 0.42	-0.379 ± 0.07	2.90 ± 0.58	1.032 ± 0.0006
Farm B	3.25 ± 1.94	7.22 ± 0.12	13.25 ± 0.55	3.02 ± 0.07	-0.330 ± 0.02	2.50 ± 0.45	1.028 ± 0.0057
Farm C	3.98 ± 1.11	8.66 ± 0.26	14.35 ± 2.59	3.19 ± 0.13	-0.403 ± 0.99	2.92 ± 0.88	1.031 ± 0.0349
Farm D	3.25 ± 1.47	7.23 ± 0.19	13.57 ± 0.17	3.49 ± 0.20	-0.322 ± 0.75	2.41 ± 0.74	1.026 ± 0.0851
Farm E	3.41 ± 1.71	7.87 ± 0.25	13.36 ± 1.64	3.68 ± 0.08	-0.352 ± 0.81	2.48 ± 0.11	1.029 ± 0.0054
Farm F	3.64 ± 1.83	7.95 ± 0.22	13.90 ± 2.21	3.49 ± 0.35	-0.365 ± 0.13	2.68 ± 0.95	1.030 ± 0.0055
Standard values (Thai Agricultural Standard, TAS 6006-2008)	≥3.25-3.5	≥8.25	11.7 - 12	≥3.7	≤-0.520	-	≥1.028

The solid not fat (SNF) values of goat milk from 5 farms were below the standard value of 8.5%. However, the SNF in milk from farm C was 8.66% which was accepted in the standard value (Thai Agricultural Standard, 2008). The total solid content in milk samples from all farms was between 13.25% and 14.35%, which was higher than the standard value, thus graded as premium by this aspect. The total solid content was mainly composed of protein content, fat content, minerals and other components. The increase in concentration of protein and fat in subsequent stages of lactation had a direct effect on the content of total solids and SNF (Strzałkowska *et al*., 2009).

The relative percentage of protein in goat milk from 5 farms was below the standard value of 3.7%. Only the milk sample from farm A contained protein content of 3.8% which is graded as premium according to TAS standard (Thai Agricultural Standard, 2008). This may be related to Farm A feeding their goats with concentrates and soybean and minerals as supplement, while other farms did not usually feed concentrates to their goats. It is therefore recommended to add more feedstuff to account for such high proteins in their feed diet. Regarding to family income, feedstuff which has an influence on increasing the total protein content and must be available at the farm location in the Muslim community is of interest. Goetsch (2019) found that byproducts high in ruminally degradable fiber could be substituted for cereal grains without appreciable effects. The mixture of byproducts such as tomato fruits, citrus pulps, brewer's grain and brewer yeast in the feed diet had numerous positive effects such as N balance, increasing milk total protein and casein concentrations.

The total protein content in goat milk varies from 2.6 % to 4.1 %. The main group of proteins in milk composition among ruminants is casein. The difference in casein fractions in goat milk is accounted to the soft curd – forming properties of goat milk as well as its better digestibility and the lower frequency of allergic reaction in children (Lima *et al*., 2017).

Lactose is the main carbohydrate in milk. Our survey revealed little variation in the lactose content of the goat milk samples among all farms, which ranged from 2.40% - 2.9%. Despite the lack of an established standard value of lactose content in goat milk the percentage of lactose content in the goat milk from all farms was rather low compared to published information currently available on the lactose content which is 4.08% - 4.60%. (Getaneh *et al*., 2016; Lima *et al*., 2017). Our finding may be helpful for those farms to look for the appropriate approach to increase the lactose content in their milk, with the consequence of increasing the SNF to the standard value. Goat milk lactose is often largely increased by dietary plant oil supplementation in contrast to cow milk (Lima *et al*., 2017). The percentage of lactose content in goat and cow milk is much lower than in human milk.

The freezing point (FP) indicated the adulteration of the milk with water. The FP value corresponded to the SNF content. According to the standard value, the FP should be -0.520°C or lower. The FP of the goat milk from the 6 farms was in the range between -0.403°C and -0.322°C, which was higher than the standard value. This may imply an accidental adulteration with water occurred due to poor system drainage during milk production. Adding extraneous water to milk whether accidentally or intentionally, dilutes salt, lactose, protein, and other milk component concentrations thereby compromising milk quality (Rosenman and Gary, 2010). Park *et al*. (2007) reported that the FP for goat milk to range between -0.540°C and -0.570°C, while Strzalkowskam *et al.* (2009) reported much lower of FP to -0.609°C and -0.596°C. Such low values for the FP may be related to the fact that the concentration of individual milk components increased with the progress of lactation. The breed of goat may influence the variation of FP values in the goat milk (Antunac *et al*., 2001). The specific gravity of the goat milk from all farms were in the range of the standard value (1.028 g/mL–1.032 g/mL at 20°C).

The physical and chemical compositions of the goat milk from the 6 farms were fairly similar to those found by Ceballos *et al*. (2009) and Park et al. (2007). According to our survey, the goat milk quality varied among farms depending on feed supply and management which is in agreement with Wasiksiri *et al*. (2010) who revealed that the variation on general farm management and the mixture of feeding stuff which affected the goat milk quality from lower Southern Thailand. Factors that cause variation in goat milk compositions are genetics, goat age, stage of lactation, daily variation (between morning and evening), season, environment condition, locality, parity, type of diet, udder health, and processing (Park *et al*., 2007; Getaneh *et al*., 2016).

The composition of mineral (mg/100 g milk) in raw goat milk from 6 farms

(table 3) shows the content of Ca, Fe, Zn, and Cu of goat milk from 6 Muslim farms. There was a slightly variation in these mineral contents among the 6 farms. The range of those changes depends on many factors. It was noticed that the concentration of macro-minerals may not

fluctuate much, but they vary depending on the breed, diet, individual animal, stage of lactation, status of udder health, and month and year of study (Park, 2009; Strzałkowska *et al*., 2009). However, it is important to know that the goat feed may have a substantial effect on the mineral contents of the milk (Zenene *et al*., 2014).

Table 3 The composition of minerals (mg/100 g milk) in raw goat milk from 6 Muslim farms

Farm	Calcium	Fe	Zn	Cu
Farm A	134.81 ± 5.33	0.09 ± 0.03	0.26 ± 0.02	0.01 ± 0.01
Farm B	140.40 ± 3.30	0.12 ± 0.62	0.39 ± 0.02	0.02 ± 0.01
Farm C	139.10 ± 1.20	0.08 ± 0.02	0.31 ± 0.02	0.02 ± 0.01
Farm D	133.60 ± 9.83	0.09 ± 0.17	0.40 ± 0.20	0.02 ± 0.01
Farm E	140.79 ± 7.21	0.10 ± 0.44	0.31 ± 0.37	0.02 ± 0.03
Farm F	138.59 ± 7.63	0.07 ± 0.12	0.33 ± 0.05	0.01 ± 0.02
Goat milk[*1]	134	0.07	0.56	0.05
Sheep milk[*1]	193	0.08	0.57	0.04
Cow milk[*1]	122	0.08	0.53	0.06
Human[*1]	33	0.20	0.38	0.06
Goat milk[*2]	130.28 ± 2.26	0.06 ± 0.00	0.320 ± 0.03	0.040 ± 0.001
Cow milk[*2]	119.90 ± 0.69	0.07 ± 0.020	0.380 ± 0.00	0.017 ± 0.0016
Human[*2]	32.36 ± 0.70	0.053 ± 0.004	0.165 ± 0.02	0.050 ± 0.004

[*1]Park et al. (2007); [*2]Soliman (2005)

According to our survey, the values of mineral content in raw goat milk from Muslim farms were in agreement with those from other authors (Soliman, 2005; Park, 2009). Calcium is of importance for building up the bone structure, and is found in goat milk almost 4 times higher than in human milk. Zamberlin *et al*. (2011) reported the content of Ca in goat milk was 106 mg/100 g milk – 192 mg/100 g which was approximate to that found in sheep milk (136 mg/100 g milk – 200 mg/100 g milk) but higher than in cow milk (107 mg/100 g milk - 133 mg/100 g milk). The goat milk improves Fe metabolism, favoring the recovery of Fe-deficiency anaemia. Goat milk is therefore recommended in the diet of people who suffer nutritional Fe deficiency anaemia (Díaz-Castro *et al*., 2015). Copper is also needed for various enzyme functions. It affects the metabolism of iron and oxygen and also the cell defense against free radicals. The copper content of milk of sheep and goat was found to be about the same as that for cows. Soliman (2005) found that human milk had significantly lower content of Zn while cow and goat milk had somewhat comparable levels. Zinc (Zn) is an essential component of more than 200 enzymes involved in digestion, metabolism, reproduction and wound healing (World Health Organization, 1996). The copper content of sheep and goat milk was found to be about the same as that for cow milk (Soliman, 2005).

The composition of fatty acids in raw goat milk from 6 farms

Results in (table 4) showed that the fatty acids of the goat milk from 6 Muslim farms were composed mainly of medium chains of 5 fatty acids, (C10:0, C14:0, C16:0, C18:0, C18:1) which made up nearly 80% of all fatty acids. The level of saturated fatty acids (SFAs) of the goat milk from 5 farms was approximately 50 %– 64% of the total fatty acids, except for farm F which had the highest level of SFA at 93%. The most abundant fatty acids (FA) in the milk fat of goats from all farms was palmitic (C16:0), followed by oleic (C18:1), stearic (C18:0), capric (C10:0), and myristic (C14:0) acids. Likewise, the amount of polyunsaturated fatty acids (PUFA) in goat milk ranges from 2% to 6%, whereas the amount of saturated fatty acids (SFAs) ranges from 53% to 72%, whereas the remainder of fatty acids is represented by monounsaturated fatty acids (MUFA), usually from 26% to 42% (Kouřmská, 2014). The presence of relatively high levels of these medium chain fatty acids in goat milk fat when released as free fatty acids by enzyme lipase could be responsible for its inferior flavors (Kompan and Komprej, 2012). This was confirmed by results of sensory evaluation on the goat milk obtained from farm F showing rather off-aroma and flavor which may be related to the high content of SFA in their milk (Table 6).

Table 4 The composition of fatty acids (expressed as peak area) in raw goat milk from 6 Muslim farms

Type of fatty acid	Farm A	Farm B	Farm C	Farm D	Farm E	Farm F
C8:0 (Caprylic)	51.09 ± 0.012	76.58 ± 0.019	46.60± 0.020	55.63 ± 0.009	72.07 ± 0.021	63.18 ± 0.010
C10:0 (Capric)	204.04 ± 0.012	279.46 ± 0.073	181.93± 0.074	191.63 ± 0.064	289.64 ± 0.083	243.58 ± 0.047
C12:0 (Lauric)	119.72 ± 0.023	138.04 ± 0.045	97.44± 0.032	97.49 ± 0.035	163.03 ± 0.045	150.23 ± 0.039
C14:0 (Myristic)	337.01 ± 0.055	327.90 ± 0.089	277.80± 0.081	259.86 ± 0.078	423.22 ± 0.117	417.27 ± 0.069
C16:0 (Palmitic)	961.92 ± 0.105	925.09 ± 0.173	892.44± 0.237	902.86 ± 0.120	1015.28 ± 0.220	1236.13 ± 0.051
C18:0 (Stearic)	423.61 ± 0.074	502.96 ± 0.040	474.29± 0.081	592.66 ± 0.232	480.49 ± 0.086	990.83 ± 0.106
C18:1 (Oleic)	538.73 ± 0.072	751.44 ± 0.095	648.73± 0.065	924.01 ± 0.275	621.57 ± 0.058	97.56 ± 0.002
C18:2 (Linoleic)	39.71 ± 0.002	128.19 ± 0.013	119.79± 0.041	84.13 ± 0.018	98.33 ± 0.013	5.73 ± 0.001
C18:3 (Linolenic)	9.61 ± 0.001	12.09 ± 0.001	14.93± 0.004	14.66 ± 0.002	13.42 ± 0.002	12.11 ± 0.003
C20:0 (Arachidonic)	7.84 ± 0.001	8.49 ± 0.001	7.06± 0.005	6.53 ± 0.002	6.28 ± 0.004	9.27 ± 0.001
C22:0 (Behenic)	1.70 ± 0.0004	2.27 ± 0.0004	2.81± 0.001	1.51 ± 0.0004	1.42 ± 0.0004	2.23 ± 0.006
C22:1 (Eucic)	0.99 ± 0.0002	2.03 ± 0.0001	3.07± 0.001	1.13 ± 0.0001	0.96 ± 0.001	1.37 ± 0.001
Total SFA	2,106.93 ± 0.28 (64%)	2,260.79 ± 0.44 (55.8%)	1980.37 ± 0.53 (55.7%)	2,108.17 ± 0.54 (50.7%)	2451.4 ± 0.58 (62.5%)	3112.7 ± 0.33 (93%)
Total UFA	588.04 ± 0.075 (17.9%)	893.75 ± 0.11 (22.0%)	786.52 ± 0.11 (22.1%)	1,023.93 ± 0.30 (24.6%)	734.28 ± 0.07 (18.7%)	116.77 ± 0.01 (3.5%)
Total MUFA	538.72 ± 0.072 (16%)	753.47 ± 0.10 (18.6%)	651.80 ± 0.07 (18.3%)	925.14 ± 0.75 (22%)	622.53 ± 0.59 (15.8%)	98.93 ± 0.003 (3%)
Total PUFA	49.32 ± 0.003 (1.5%)	140.28 ± 0.01 (3.5%)	134.72 ± 0.05 (3.8%)	98.79 ± 0.02 (2.3%)	111.75 ± 0.02 (2.8%)	17.84 ± 0.003 (0.53%)
Total fatty acid	3284.08	4047.50	3553.41	4155.85	3919.56	3346.24

Table 5 Volatile compounds (expressed as percentages based on the peak area) in raw goat milk from 6 Muslim farms in Ayuthaya province

Volatile compound	Farm A	Farm B	Farm C	Farm D	Farm E	Farm F
2-Heptenal, (E) -	-	-	-	0.063 ± 0.00	-	-
2,4-Decadienal, (E,E) -	-	-	-	0.52 ± 0.025	-	-
4-Methyl octanoic acid	-	-	-	0.05 ± 0.00	0.034 ± 0.01	-
4-Ethyl octanoic acid	-	-	-	0.01 ± 0.11	0.01 ± 0.02	-
Tridecanal	-	2.51 ± 0.83	2.52 ± 0.63	0.353 ± 0.01	2.44 ± 0.46	2.5 ± 0.51
Tetradecanal	3.63 ± 0.45	3.65 ± 0.97	-	0.57 ± 0.84	3.62 ± 0.52	3.51 ± 0.56
8-Heptadecene	-	0.44 ± 0.01	-	0.12 ± 0.01	-	0.98 ± 0.08
2-Pentadecanone	8.16 ± 1.56	7.58 ± 2.49	7.82 ± 1.98	2.07 ± 3.6	8.69 ± 2.20	10.20 ± 5.40
Pentadecanal -	11.86 ±2.71	12.20 ± 5.19	11.59 ± 3.34	2.31 ± 3.59	13.06 ± 3.12	-
3-Octadecene, (E) -	-	0.65 ± 0.01	1.12 ± 0.47	-	-	1.16 ± 0.37
5-Octadecene, (E) -	1.61 ± 0.00	-	-	-	-	-
Hexadecenal	-	-	-	0.12 ± 0.01	-	-
7-Hexadecenal, (Z) -	-	-	-	0.043 ± 0.01	-	1.36 ± 0.46
Cis-9-Hexadecenal	-	-	-	-	-	8.02 ± 4.60
Hexadecanoic acid, methyl ester	-		-	0.41 ± 0.11	-	3.59 ± 2.31
n-Hexadecanoic acid	4.09 ± 4.03	4.41 ± 0.00	13.16 ± 0.25	11.49 ± 7.38	9.83 ± 7.38	15.75 ± 0.65
1- Octadecenoic acid	-	-	-	-	4.05 ± 3.01	-
7-Octadecenoic acid, methyl ester	-	-	2.79 ± 0.01	-	-	-
8-Octadecenoic acid, methyl ester	9.59 ± 6.93	-	-	0.86 ± 0.035	-	-
9- Octadecenoic acid, methyl ester	5.70 ± 0.00	-	3.44 ± 0.01	-	4.48 ± 0.33	
9,12-Octadecadienoic acid (Z,Z) -, methyl ester	-	-	-	1.62 ± 0.31	-	2.35 ± 0.01
13-Octadecenal, (Z) -	-	-	-	0.42 ± 0.12	-	-
Oleic Acid	-	-	-	34.45 ±2.96	-	6.54 ± 0.88
Octadecanoic acid	-	-	-	2.53 ± 0.042	-	-
Cis-Vaccenic acid	-	-	-	0.087 ± 0.08	-	-
Hexanedioic acid, bis (2-ethylhexyl) ester	-	-	-	0.95 ± 0.27	-	-
9,17-Octadecadienal, (Z) -	-	-	-	0.31 ± 0.30	-	-
Methyl stearate	2.07 ± 0.00	-	0.89 ± 0.01	-	-	-

Table 6 Sensory evaluation score (1-5: 1 = the weakest unpleasant flavor intensity; 5 = the strongest unpleasant flavor intensity; n = 30 persons) of pasteurized goat milk from 6 Muslim farms

Farm	Sensory score	Description
Farm A	$1.1^{a*} \pm 1.2$	Unpleasant aroma and flavor was slightly detected
Farm B	$1.1^{a} \pm 1.2$	Unpleasant aroma and flavor was slightly detected
Farm C	$0.8^{a} \pm 0.6$	Unpleasant aroma and flavor was slightly detected
Farm D	$2.7^{b} \pm 1.0$	Intensive unpleasant aroma and flavor was remarkably detected
Farm E	$2.3^{b} \pm 0.7$	Intensive unpleasant aroma and flavor was remarkably detected
Farm F	$1.7^{ab} \pm 1.0$	unpleasant aroma and flavor was remarkably detected

*Different letters in the same column indicate statistically significant difference ($p<0.05$)

A high concentration of C6:0 (caproic), C8:0 (caprylic), and C10:0 (capric) is dominant SFA in goat and sheep milk compared to cow's milk, which cause a specific aroma in milk of these small ruminants. These medium chain triglycerides comprise 15% of the total of goat milk compared to only 5% in cow milk. It has been understood that these three compounds cause off–flavor and aroma in goat milk that is improperly handled (Getaneh *et al*., 2016). On the other hand, these fatty acids may have health promoting effects on human health by inhibiting bacterial and viral growth as well as dissolving cholesterol deposits (Markiewicz-Keszycka *et al*., 2013). The content of MUFA in goat milk from 5 farms was in the range of 15% - 22% which was in agreement with Strzałkowska *et al*. (2009) who reported the share of MUFA in sheep and goat milk to be about 20% - 35%. Among the MUFA group, the oleic acid (C18:1) is characterized by the highest content. The C18:1, a neutral fatty acid has no effect on the concentration of serum cholesterol. Cow milk is the richest source of oleic acid (24%) while its content in goat and sheep milk is on average of 18% of all fatty acids (Markiewicz-Keszycka *et al*., 2013).

The C18:2 is an essential fatty acid which cannot be synthesized in the human body and decreases the concentration of serum cholesterol. The content of C18:2 of goat milk from all farms varied in range of about 0.17%-3.37%. The goat milk obtained from farm A, and farm F showed the lowest content of C18:2, which was about 1.21% and 0.17% respectively, whereas for other farms the content of C18:2 was about 2% to 3%.

Fat composition in goat milk is important, and is related to the nutritional, physical, and acceptable sensory quality of the processed products from the goat milk. According to the result of fatty acid composition of milk from farm F, diet, management of farm and goats themselves, for example age and fertility, may affect the remarkable different fatty acid contents of milk comparing to the other 5 farms.

Research on the effects of dietary inclusion of various sources of fat and oil on milk yield and fatty acid composition is being given increased attention. According to Kouřimská *et al*. (2014) the addition of algae also increased the nutritional quality of goat's milk There was a positive change in the ratio of SFA:MUFA:PUFA in terms of reducing the proportion of saturated fatty acids, as well as a change in the ratio of n-6 and n-3 PUFAs. Inglingstad *et al*. (2017) revealed effects of grapeseed oil in diet of Norwegian

dairy goats on levels of total fat and polyunsaturated FA as well as lower lipoprotein lipase activity in milk that positively affected flavor score. Ingvortová *et al.* (2013) investigated the effects of flaxseed supplementation administered to lactating goats on their milk fatty acid content. Flaxseed supplementation to lactating goats has a positive effect on increasing conjugated linoleic acid (CLA) in milk fat along with an increase in the content of MUFA and PUFA of milk fat in an experimental group. Goetsch (2019) addressed the recent research of feeding practices and the nutrition of lactating dairy goats. Dietary feedstuffs including concentrate, by-products, fibrous feedstuffs, fat and oils, dietary additives, and plant secondary metabolites are all responsible for the goat milk quality.

The composition of volatile compounds in raw goat milk from 6 Muslim farms in Ayuthaya Province

It has been understood that the goat aroma is related to the increase in fatty acids, especially C 6:0 to C9:0 and the branch chain of fatty acid C9 and C10 (methyl-C8 and ethyl-C8). Our survey found that goat milk from all farms contained free fatty acid (C8:0) and the concentration of this fatty acid was high in farms B, E, and F.

Goat milk samples were collected from 6 farms and the volatile compounds were analyzed by GC-Mass according to the method described previously (Kang *et al*., 2013). We found 4-methyloctanoic acid and 4-ethyloctanoic acid at low concentrations in raw goat milk from farms D and E (Table 5) which are responsible for the aroma of "goaty/waxy" and "goaty' (Poveda *et al*., 2008). In contrary, it was found that 4-ethyloctanoic acid, 3-methylindole (skatol) and one unknown compound, known as RI 2715 showed highest intensities in all raw milks (Siefarth and Buettner, 2014).

Octadecanoic acid and 1-octadecenoic acid at high concentrations of 2.53% and 4.05% (based on the total peak area) were found in the raw goat milk from farms D and E, respectively, which is responsible for the "oil / fatty" aroma. The 9, 12 octadecadienoic acid and octadecanoic acid are well-known causes of off-flavor in Korean native black goat meat (Kang *et al*., 2013). The volatile compound of 2, 4-decadienal, (E, E) which was detected in the milk fat of farm D is the major compound that contributes to the "fried" aroma similar to cheese products made from goat milk as confirmed by Carunchiawhetstine *et al*. (2003).

Aldehyde compounds and ester compounds are found in raw milk goat which are 2-heptanal, tridecanal, tetradecanal, 2-pentadecanone, pentadecanal, hexadecanal, 7-hexadecenal, hexadecanoic acid, methyl ester, 7-octadecenoic acid, methyl ester, 8-octadecenoic acid, methyl ester, 9-octadecenoic acid, and methyl ester, for example (Figure 1 and 2). These compounds are in high concentration in the raw goat milk from farm D and E in comparison to the goat milk from other farms. This result is related to the sensory evaluation shown that goat milk from farm D and farm E were the most unaccepted on aroma and flavor by consumers (Table 6). Evidence shows that these volatile compounds, hexadecanoic acid methyl ester and 9, 12-octadecadienoic acid methyl ester is the compound found in Leucaena forage (Salem *et al*., 2011). This investigation may support our detection of hexadecanoic methyl ester in the goat milk from farm D and farm F as related to the supplemental feed diet with Leucaena forage fresh grass.

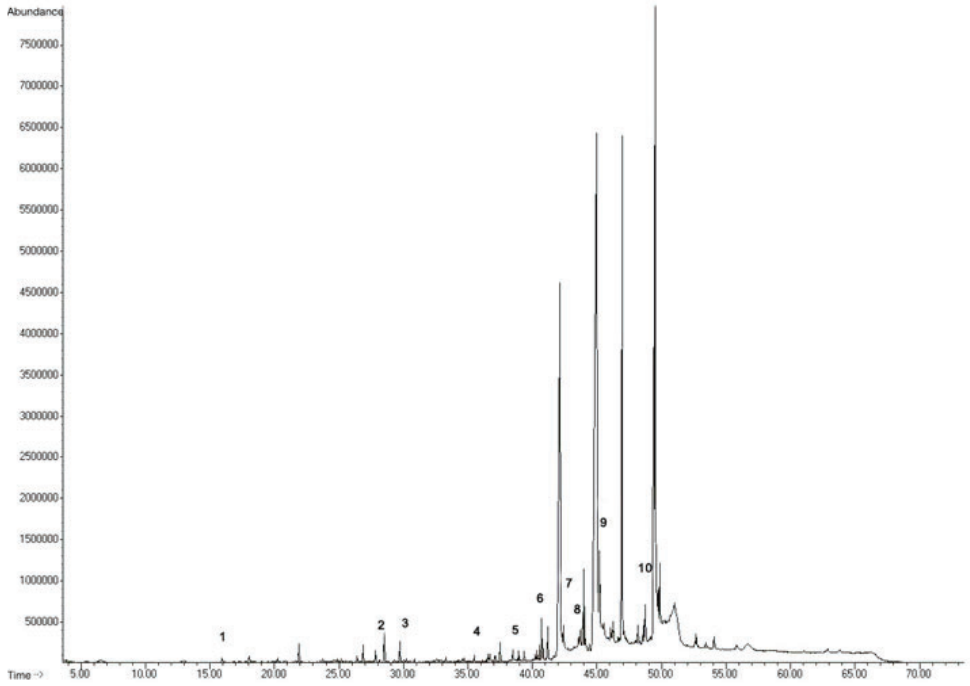

Figure 1 Chromatogram of volatile compounds in the goat milk from farm D: (1) 2-Heptenal, (2) 2,4-Decadienal, (3) 4-Methyloctanoic acid, (4) 4-Ethyloctanoic acid, (5) Hexadecenal, (6) Hecadecanoic acid methyl ester, (7) 13-Octadecenal, (8) 9,12-Octadecadienoic acid methyl ester, (9) Octadecanoic acid, (10) 9,17-Octadecadienal

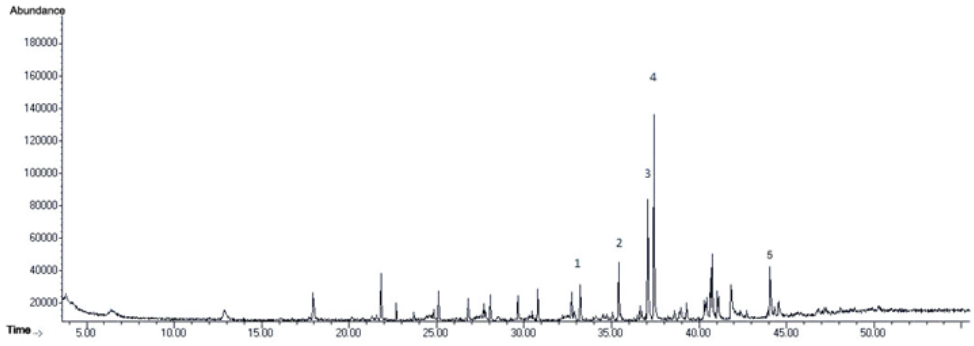

Figure 2 Chromatogram of volatile compounds in the goat milk from farm F: (1) Tridecanal, (2) Tetradecanal, (3) 2-Pentadecanone, (4) Pentadecanal, (5) 9-Octadecenoic acid methyl ester

Conclusion

With reference to our survey, dairy goat farm managements of 6 Muslim farms were considerably different in feeding stuff, rearing, and milking process. However, some information such as goat pedigree and genetics, goat age, and its fertility was not recorded due to the disregarding of this important information by those farms. Compositions of goat milk from the 6 farms remarkably followed the standard values of Thai Agricultural Standard (2008) in some categories of percentage of fat and total

solid, and specific gravity. Regarding other components for instance, percent protein, SNF, and freezing point, the goat milk from all farms was graded as sub-standard. The component of fatty acids in the goat milk from all farms was found to be varied in quantities, which are mainly medium chains of 5 fatty acids, (C10:0, C14:0, C16:0, C18:0, C18:1) accounting for the milk fat quality in goat milk. The goat milk from 3 farms were rejected by tasters due to the off flavor and odor. Our data suggest that the variation in goat milk quality including intensive off-flavor and odor is influenced by insufficient nutrition in diet and poor farm management of some Muslim families. Lack of crucial information such as goat breeding, age, lactation stage and environmental conditions may lead to the imprecise conclusion. Nonetheless, our finding will challenge small Muslim farms to emphasize the improvement of their goat milk nutrition and composition to meet the standard grading as well as focusing on the retention of goat milk flavor and aroma. Establishment of goat breeding improvement programs in the Muslim community together with the improvement of feeding stuff through better nutrition for dairy goats based on the family income and proper farm management will be the key of success of small Muslim farms in Ayuthaya province.

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