The Effect of Storage Condition on the Mineral and Lactose content in Goat's Milk

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Abstract

Milk is a part of essential food as it is considered as a good source of minerals such Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca) and Iron (Fe). There is a little academic attention given in the studies of goat's milk. An initiative was taken to study the effect of storage condition on the mineral and lactose content in goat's milk since such research has a little academic attention. There are several studies dealing with the storage condition, but they are more focus on bacteria content in milk. It is known that changing of the mineral and lactose content has a rather significant effect to the consumer. The goat's milk samples are collected from a goat's milk farm and are then proceed to be store in the freezer and chiller in a plastic container and are tested on three different periods. Mineral contents as Na, K, Mg, Ca and Fe were diluted and tested using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) while the lactose content in the goat's milk samples is tested using the Benedict's method. Although there were few errors with the findings that may due to the way the diluted samples were prepared it is found that mineral contents in goat's milk decrease with time but mineral contents in goat's milk samples stored in freezer did not decrease much from the constant. Whereas for lactose, it increases with time in the chiller. The increase value of lactose is due to the synthesizing of glucose to lactose in the goat's milk samples. The value of lactose in freezer is inconsistent because of the errors during the titration process of the experiment. This error can be easily prevented with ensuring that the each and every change in the titration experiment is observed carefully and precisely.

Keywords: Goat milk; Lactose; Mineral; Storage Condition

1. Introduction

Milk is an essential food product for human and a part of a healthy diet. It can be considered a source of macronutrients and micronutrients, and also contains a number of active compounds that play a significant role in both nutrition and health protection drink (Wafti, Yoo, Lin, Yaw, & Abdullah, 2011). The composition of the milk of various animal species differs, but in every case it has a high priority in human nutrition. It contains a number of essential elements such as Ca, Mg, P, Na and Fe (Arora & Joshi, 2013). These nutrients are needed by the body especially for infants and growing babies because the minerals will help them to build muscles and increase the immune system in the body to prevent sickness and diseases. (Arora & Joshi, 2013) The milk also contains lactose which is a disaccharide sugar derived from galactose and glucose that is found in mammalian milk (Mattar, 2012). It is useful for human because lactose such as carbohydrates, lipids and protein are needed for growth and tissues building (Mattar, 2012). The lactose content was in the range of 4.55% and 4.45% of the total milk for cow and goat's milk respectively (Arora & Joshi, 2013). It shows that goat's milk contain slightly less lactose than cow's milk (Arora & Joshi, 2013).

The various benefits especially for those with lactose intolerance have increased the demand for goat's milk. One of its many benefits is that goat's milk is an alternative for those with cow's milk allergies and other gastro-intestinal ailments because of its unique nutritional and biochemical properties (Lothe et al., 1982 and Host et al., 1988). Based on journal of "Comparative aspect of Goat and Cow milk", fat globules are smaller in goat milk so they are easily digestible (Arora & Joshi, 2013). Commonly, infants, babies and kids have problem in digesting the cow's milk because of the allergic factor that affect them. The cause of this allergenic is the protein allergen known as Alpha S1 Casein found high level in cow's milk. The level of Alpha S1 Casein in goat's milk is 89% less than cow's milk makes it far less allergenic food (Kaylynn Chiarello-Ebner, 2012). Moreover, there are more than 10 of goat's breed for the production of goat's milk all over the world such as Anglo Nubian, Saaneen, British Alpine, and Toggenburg (GICA 2015). The most favored breed of goat for the production of goat's milk is Saaneen. Producing up to 3 gallons per whereas the average amount of milk produce by other goat is 1 1/2 gallons per day. The butterfat of goat's milk produced from Saaneen ranging from 2% to 3% (Menne, 2012).

The current demand for goat's milk has increased the goat population and the production of milk. The worldwide goat population has reached 758 million heads with 55% increase during the last 20 years, and goat milk production has reached 12.2 million tones with 58% increase during the same period (FAO, 2004). Despite its various benefits for human the studies in the field of goat's milk has so far received very little academic attention to aid its current growing demand. Therefore, not many are aware on the proper way to store goat's milk.

The project was designed with the objectives of evaluating the effect of storage condition on the mineral and lactose content in goat's milk. In order to retain the mineral and lactose content in goat's milk, there are specific storage conditions that need to be study to know its effect on the mineral and lactose content in goat's milk. There are two parameters consider for the experiment which are the storage temperature and storage duration. Each parameter is tested for its effect on the goat's milk mineral and lactose content. Based on the studies, the minerals content in the milk can be analyze using inductively coupled plasma optical emission spectrometry (ICP-OES) machine. This method will determine all the desired minerals that are Calcium, Magnesium, Iron, Sodium and Pota sium (Birghila, Dobrinas, Stanciu, & Soceanu, 2008). Different methods for lactose determination were developed in past years, Refractometry method, Polarimetry method (Caprita, Caprita, & Cretescu, 2014) and Benedict's method (Lesniewicz, Wroz, Wojcik, & Zyrnicki, 2010b). The method chose for lactose analysis is the Benedict's method because of its simplicity and this method was suggested as an adequate method for lactose determination in milk and milk product (Lesniewicz et al., 2010b). With these findings, positive impact may be gained in the production and quality of goat's milk in the future.

2. Methodology

2.1 Raw Materials and Apparatus

A goat farm from Pasir Gudang, Johor was selected for the study because of its vicinity. 7 bottles of raw goat's milk samples with volume of 250 ml each were collected from the farm. The milking process was on the morning the day the milk samples were collected. The raw goat's milk from supplier was taken right after the milking and bottling process in order to retain its original mineral and lactose content. The milk samples are kept frozen during collection to prevent milk spoilage. Chemicals used for the experiment are 0.75 N Sulphuric Acid (l), Anhydrous Sodium Carbonate (s), Sodium Tungstate (l), Benedict Reagent (l), QReC 65% Nitric Acid (l) and 6% Hydrogen Peroxide (l). The equipment is for mineral analysis is the Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) that comprised of a Segmented Array Charge-Coupled Device Detector (SCD), Spectrometer, Plasma Torch, Peristaltic Pump, Radio Frequency (RF) Generator, Injectors, Nebulizers and a computer. Pipette, burette, beaker, conical flask, filter funnel, hot plate, retort stand and clamp are used in the lactose analysis process.

2.2 Storage of Milk Samples

The first 250 ml bottle of the milk sample, used as control, was analysed first. The rest of 6 bottles was used as variables for the experiment to check its effect on the storage condition. Firstly, the original volumes of the milk samples in the bottles are measured. The milk samples in the plastic container are then are stored in the freezer with temperature of -14°C and chiller with the temperature of 4°C. The goat's milk samples are store for three different storage periods, which are 1 day, 7 days and 28 days.

2.3 Mineral Content Analysis – Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

Analy is of mineral content in goat's milk samples was done using the Inductively Coupled Plasma-Optical Emis ion Spectrometry (ICP-OES). Atomic Spectroscopy Standard Solution will enable the determination of the minerals Calcium, Iron, Potassium, Magnesium and Sodium. The standard solution is prepared in two concentrations of 5 ppm and 20 ppm. The materials and apparatus for the process of mineral analysis are 0.75 N Sulphuric Acid (l), QReC 65% Nitric acid (l), 6% Hydrogen Peroxide (l), deionised water, conical flask and hot plate. The conical flask is clean from impurities by using the deionised water. Samples for the mineral analyse using

ICP-OES was prepared by diluting the 1g of goat's milk samples in 5ml of 0.75 N Sulphuric Acid and 5ml off QReC 65% Nitric acid Is it then heated for 30 minutes at 60 . Carbohydrates, lipids and proteins in the goat's milk samples are removed through the dilution process of the goat's milk samples. It is important to be remove as it can damage the ICP-OES machine. The dilution is to be determined by using 10 ml of sample. After that, the sample must be added with hydrogen peroxide and nitric acid equally till the total solution is 50 ml. Then the diluted solution is stored in sample bottles. Settling up the pressure of Argon 80 psig, Nitrogen 60 psig, and Air 80 psig runs the ICP-OES. The wavelength of each mineral are determined and was set on the ICP-OES software. After all the necessary steps are taken, the sample can be tested using ICP-OES.

2.4 Lactose Content Analysis – Benedict's Method

Analysis of lactose content in the goat's milk samples was done using the Benedict's Method (Lesniewicz, Wroz, Wojcik, & Zyrnicki, 2010a). Lactose analysis through Benedict's method uses the titration method, where Benedict's reagent (l) will act as the indicator and will change color from Blue to Red. Benedict's method begins by adding 10 ml of goat's milk samples into a 50.0 ml volumetric flask (Lesniewicz, Wroz, Wojcik, & Zyrnicki, 2010a). Then, 5 ml of 10% N-Tungstate solution and 5 ml of 0.75 N Sulfuric Acid solutions is added into the volumetric flask, the solutions are mixed well and are let to settle for 10.0 min. Distilled water are added into the 50.0 ml volumetric flask to reach the mark and are mix well. The solutions are then filter. The clear filtrate is added to burette. 25.0 ml of Benedict's solution is measured using 25.0 ml measuring cylinder and poured into a conical flask. 2 gm of Anhydrous Calcium Carbonate is measured with electronic mass balance and added to the solution in the conical flask. A few pieces of pumice stone are introduced to reduce bumping. The solution is titrate with the milk titrate in the burette while it is boiling. When blue color has completely disappeared and only white precipitation remains signals the end point is reached. The experiment is repeated for the goat's milk samples for the two different parameters that need to be tested.

2.5 Equations

2.5.1 Volume of samples exhausted from titration are measured by using Equation (1):

$$\begin{aligned} &Volume\ of\ sample\ exhausted\ from\ titration,\ R\ (mL) \\ &= Final\ volume\ of\ titrate - Initial\ volume\ of\ titrate \end{aligned} \tag{1}$$

2.5.2 The amount of lactose are measured by using Equation (2):

$$Lactose\ \% = \frac{0.0678}{R} x\ 10\ x\ 100$$

$$Where\ R = Volume\ of\ sample\ exhausted\ from\ titration \tag{2}$$

2.5.3 The volume needed for the dilution process is determined by using Equation (3):

$$M1V1 = M2V2 \tag{3}$$

2.5.3 To calculate the percentage of difference between the mineral and lactose content between the control goat's milk samples and the goat's milk samples from the variables is by using Equation (3) and (4)

$$Percentage\ of\ difference = \frac{Mineral\ Content\ from\ Variables - Control\ Mineral\ Content}{Control\ Mineral\ Content} x\,100\% \quad (3)$$

$$Percentage\ of\ difference = \frac{Lactose\ Content\ from\ Variables - Control\ Lactose\ Content}{Control\ Lactose\ Content} x\,100\% \quad (4)$$

3. Results and discussion

3.1 Lactose Content

Table 1. Comparison of Lactose percentage between Chiller and Freezer

Type of Container	Testing Day	Color Change	Percentage of Control Lactose Content (%)	Percentage of Lactose in Chiller (%)	Percentage of Lactose in Freezer (%)
Plastic		Blue to red		2.6279	2.6279
Plastic	2	Blue to red	3.5497	3.1389	4.2375
Plastic	3	Blue to red		2.1592	4.55

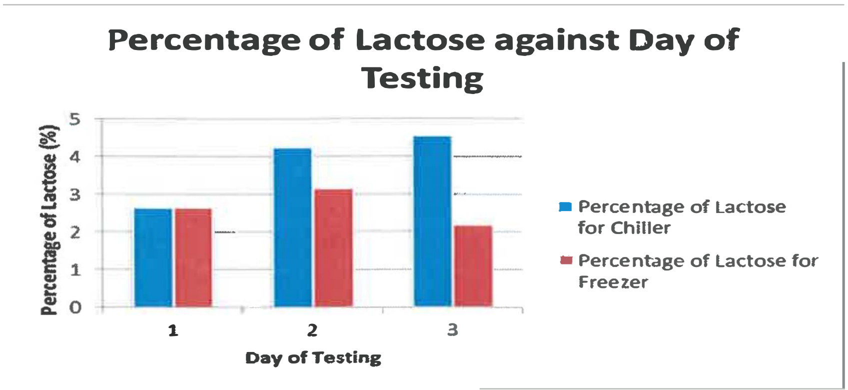

Fig. 1. Bar chart of Lactose percentage comparison between Chiller and Freezer

Lactose is a type of glucose specifically disaccharide glucose. Benedict's experiment was conducted in order to obtain the percentage of Lactose for each of the Goat's Milk sample. The color change of Benedict's reagent from blue to red is because of the presence of glucose in the sample specifically the presence of lactose. Lactose is reducing sugar. When reducing sugars are mixed with Benedict's reagent and heated, a reduction reaction causes the Benedict's reagent to change color from blue to red (UNCFSU).

The goat's milk samples were stored at two different temperatures which was in the freezer and chiller with the temperature of -14°C and 4°C respectively (Progress Energy). On the first day of testing, the percentage of lactose content for goat's milk samples in the chiller and freezer is similar which is 2.628%. The percentage difference of lactose on the first day of testing with the control percentage of lactose is This similarity of lactose percentage due to the of goat's milk samples in the chiller and freezer was tested for lactose the day after the sample was taken for the farm and only minor synthesis occur but did not interfere with the percentage of lactose content in the goat's milk samples. The increase of lactose percentage was observed in the goat's milk sample in the chiller starting from the day two of testing. The percentage of lactose increased by 1.61% in the chiller whilst in the freezer the percentage of lactose increased only by 0.511%. The percentage of lactose content in goat's milk samples continue to increase slightly by 0.312% on the third of testing in chiller. Although the percentage of lactose increase in the chiller, it can be observed that the percentage of lactose decrease on the third of testing by 0.98%. The rather inconsistent of percentage of lactose in the freezer is because of the error during the titration process the lactose titrates. The errors can be easily prevented by ensuring that the each and every change in the titration process is observed carefully.

The increase of lactose percentage is due to synthesis of glucose to lactose during the storage of goat's milk samples (Reiss & Barry, 1953). The synthesis of glucose to lactose is aid by the enzyme Lactase (ANSCI). The average temperature of chiller is 4°C (Progress Energy). The temperature is not low enough to halt the process of synthesizing glucose to lactose, therefore the increasing percentage of lactose in goat's milk for chiller (Reiss & Barry, 1953).

3.2 Mineral Content

Table 2. Concentration of minerals in chiller

Emission line	Container	Standard Solution (mg/L)	Constant Conc. (mg/L)*	Day 1 of testing (mg/L)*	Day 2 of testing (mg/L)*	Day 3 of testing (mg/L)*
Ca 315.880	PLASTIC	5 & 20	14.28	15.27	17.30	14.42
Mg 279.071			1.601	2.095	2.755	1.663
Fe 259.933			-0.168	-0.148	-0.174	-0.069
Na 588.983			7.566	8.345	11.09	6.885
K 766.455			4.654	4.442	7.035	3.994

*The result are calculate by mean data from ICP

Table 3. Concentration of minerals in freezer

Emission line	Container	Standard Solution (mg/L)	Constant Conc. (mg/L)*	Day 1 of testing (mg/L)*	Day 2 of testing (mg/L)*	Day 3 of testing (mg/L)*
Ca 315.880	PLASTIC	5 & 20	14.28	4.686	2.733	15.22
Mg 279.071			1.601	3.184	0.139	1.643
Fe 259.933			-0.168	-0.016	-0.178	-0.069
Na 588.983			7.566	9.822	0.584	4.053
K 766.455			4.654	31.02	8.587	4.352