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Review Article

Factors Affecting Milk Production and Milk Chemical Compositions of dairy cows. Review

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Abstract

This paper has reviewed factors affecting both milk yield and chemical compositions of dairy cow milk. Genetics, stage of lactation, and level of milk production, age of cow, environment, disease (for example, mastitis) and nutrition are some factors which could influence milk chemical compositions. Therefore, this article summarized that season, parity, and stage of lactation significantly influenced milk performance and somatic cell count; it increased with parity and reduced milk yield and lactose but increased fat and protein content in milk. Season, temperature, humidity and environmental stress are also non-genetic and non-nutritional factors that affect both the quality and quantities of milk. Milking frequency and milking intervals are other factors that strongly affect both composition and milk yield.

Keywords: Chemical, Composition, Factor, Milk and Yield

1. Introduction

Milk may be defined as the whole, fresh, clean lacteal secretion obtained by the complete milking of one or more healthy milking animals, excluding that obtained within 15 days before or 5 days after calving (such periods where milk is rendered practically colostrum free, and containing the minimum prescribed percentage of milk fat and milk-solids that are non- fat). Over the last 24 years, total milk production in the world has increased by 32% whereas per capita world milk production has declined by 9%; this indicates that the world milk production has not kept pace with the increase in world population as cited by. Milk yield, Lactation curves, and chemical constituents of milk are primarily affected by many factors including genetics of the cow, lactation stages, milking system and nutrition [1]. The chemical constituent of milk has been of noticeably interest to improve the nutritional values of milk and to increase the processing of dairy products mainly in developed countries [2]. Nowadays, in many parts of the world the human population is skyrocketing as a result of which milk demand is highly increasing. However, the milk production potential as global and Africans and Asians as a particular is below the requirement. The exhibition of the quantity and quality of milk is one of the highly imperative aspects of dairy sector [3]. Fresh milk yield, its physical chemical composition at production site depends on several factors of both external and internal situations. described external factors like heat stress, season, humidity while internal factors include parity, stage of lactation, udder health, metabolic status [4, 5].

Improving milk quality can have a beneficial impact on farm profitability as pricing
arrangements encourage the production of milk with a high compositional quality,
which attracts bonus payments. Dairy products are a rich source of protein and play
an important role in our diet. Milk proteins contribute directly to the nutritional value
and physical characteristics of many dairy products [6]. Summarized that season, parity, and stage of lactation significantly influenced milk performance and somatic cell count; it increased with parity and reduced milk yield and lactose but increased fat and protein content in milk.

2. Factors that affecting milk yield

2.1. Breed: The variation between breeds can leads to difference both in quantities and composition of milk. Breeding can make a significant contribution to increasing milk protein in the medium to long term. Differences in milk protein content occur between breeds; however large variations in milk protein content can exist within breeds also.

2.2. Age of the animals

As referenced in the paper of Age and parity the animal can obviously affect milk yield. Milk yield increases with age because as the age of the animal increases, the hormonal status of the animal body, metabolic activity, secretory cells and nutrient intake which are used in milk synthesis increase too [7-9]. Age within parity affected lactation length and milk

yield [10]. from their finding concluded that first-calving age is affected by several management factors during the rearing period: the amount of milk fed to the calves, waste milk feeding, and the minimum age the farmer used for starting the first insemination [11].

2.3. Nutrition

Cited in his paper that animal diet is one of the main factors that affect milk yield and composition; however, environmental factors such as ambient temperature (T), relative humidity (RH), wind speed (WS), solar radiation (SR), and rainfall (RF) can influence the welfare of animals and, therefore, can influence the production and chemical composition of milk [12, 13]. Described that addition of roasted soybean meal to dairy cattle diet resulted in improved milk production as a result of increased crude protein and rumen undegradable protein intakes and improved energy status [14].

According to there was a consistently higher milk production in cows fed on High undegradable dietary protein and high plane) fed concentrate mixture containing high undegradable dietary protein and at higher plane of feeding [15]. The higher milk yield due to High undegradable dietary protein and high plane diet could be due to higher energy and other nutrients intake through concentrate mixture. Compared farm size in terms of feed quantity they may offered and concluded that Small farms often use public grazing areas or use a cut and carry system where fresh forage is cut, brought back to the farm and fed to animals while larger dairy farms may not have sufficient land to grow their own forages or have the time to cut and carry enough high quality forage from their own or public lands as a result of which small farms produce more milk yield per cows than large farms [16]. Summarized that the supplementation of plant oil increased milk yield, with the highest milk yield in RSO group [17]. Percentages of milk fat, lactose, solids-not-fat and SCC were not affected by treatments except for an increase in milk protein content in oil supplemented groups. The fatty acid (FA) profile of milk was altered by fat supplementation. Feeding plant oils reduced the proportion of both short-chain (C4:0 to C12:0) and medium-chain (C14:0 to C16:1) fatty acids

2.4. Stage of Lactation

The concentration of ketone bodies in milk rise during stage of lactation and because of this it resulted in reduction of milk yield [18]. That early and overall lactation milk losses associated with elevations in serum β-hydroxybutyrate Acid in the first week after calving [19, 20]. Elevated serum β-hydroxybutyrate in the second week after calving was associated with milk losses in early lactation but higher overall milk production. Concluded that Lactation stage and pregnancy significantly affected the milk yield; the highest yield was recorded in mid stage and lowest in late stage of lactation. The yield was higher in non-pregnant than pregnant cows [21].

2.5 Milking Frequency and Interval

Provides evidence for a strong individual variation in milking interval that correlates to individual variation in milk yield and milk composition in terms of fat and protein content [22]. The correlations mean that cows with higher yield achieve their higher yields by combining higher yield per milking with higher milking frequency when allowed almost free access to milking units [23]. Found that comparison between fixed milking frequencies of 2 and 3 times a day showed that milk yield was increased by up to fourteen percent with more frequent milking which agrees with that of finding [24]. Reported that increasing the milking frequency from two to three times per day resulted in a fixed increase of three-point five-liter daily milk yield and ninety-two gram of fat yield per day [25, 22]. Provided that there was an evidence that a strong individual difference in milking interval that correlates to individual variation in milk yield and milk composition in terms of fat and protein content. The correlations mean that cows with higher yield achieve their higher yields by combining higher yield per milking with higher milking frequency when allowed almost free access to milking units.

2.6. Season

Concluded that milk yield and lactation length are affected by year and season of calving [10]. Adjusted milk yield (adjusted for lactation length) and lactation lengths are affected by year into season of calving interaction, but actual milk yield is not affected by year by season of calving interaction. from their experiment confirmed the negative effect of heat stress on dairy cattle performance reported under different studies and demonstrate that the negative effects of high Temperature Humidity Index are more prolonged then the generally reported 2 to 4 d; he extent to which milk production is affected varies among traits and parities; Multiparous cows are more susceptible to heat stress, and the decrease in milk yield can reach as much as 1 kg/d [26].

2.7. Parity

Cows under different parties even those who are the same breed have different milk yield. Reported that milk yield is high in 5th parity of Sahiwal cows; Also reported rising in milk yield towards 3rd parity; Reported increase in milk yield towards 5th parity and decline thereafter to 12th parity [27-29].

2.8. Environment

Generalized that herd milk production capacity is influenced by numerous factors including nutrition, reproduction, genetics, environment, and management and among these factors, the impact of management and environment where cows are housed is the least known. Some of these environmental factors modify herd performance indirectly by causing a reduction on the animal well-being and a subsequent increase in stress.

3. Factors Affecting milk compositions

Factors that affect milk composition include genetics, stage of lactation, and level of milk production, age of cow, environment, disease (for example, mastitis) and nutrition. Fifty five percent of the variation in milk composition is due to heredity while 45 percent is due to environmental factors such as feeding management [30]. The milk composition also varies within the cows from milking to milking. The composition of milk also differs within species. The lactose content

of milk is moderately constant between dairy breeds, protein varies to some degree, but fat varies widely.

The age of the cow closely related to the number of lactations, an increase in number of lactations is associated with decrease in fat and solids not fat (SNF) content of milk. Feed and diet compositions are important factors that can cause changes in milk composition. Protein concentration can be changed to some extent but lactose scarcely. Addition of substances like Vegetable oil, sugarcane or urea to compensate the fat, carbohydrate or protein content of diluted milk can affect composition [31]. These Although other diseases can affect milk components level and distribution, mastitis has been the milk yield increase in dairy cows that results from their genetic improvement requires the use of large amounts of concentrates that are rich in energy and crude protein (CP) to meet their nutrients requirements [32]. The protein level of concentrate is important to ensure an adequate supply of dieter protein in supporting milk production in in the tropics because of low crude protein (Cp %) content in typical tropical roughage [33]. Feeding high levels of concentrate when high quality pasture is readily available increases milk yield, but the response diminishes as additional concentrate fed. The optimum level of concentrate feeding that optimizes income over concentrate cost is a function of milk price and concentrates cost [34]. Generally, if the milk protein-to-milk fat ratio is less than .80 for Holsteins, milk protein depression is a problem. When this ratio is greater than one, the herd suffers from milk fat depression (low milk fat test). The milk protein percentage follows changes in milk fat test, except during milk fat depression and when high levels of fat are fed milk protein [30]. The amount and composition of proteins in milk is largely determined by the genetics of the animal and is difficult to change through nutrition. However, due to the high requirement of protein synthesis for energy, the milk protein yield can be affected by the energy content in the diet [35].

3.1. Nutrition

Dietary feed affects fat concentration and milk protein concentration [23]. Fat concentration is the most sensitive to dietary changes and can vary over a range of nearly three percentage units; dietary management consequences in milk protein concentration changing approximately 0.60 percentage units while concentrations of lactose and minerals, the other solids constituents of milk, do not respond predictably to adjustments in diet. Milk urea nitrogen and lactose concentrations in milk may vary from herd to herd, between cows of the same herd, and along the course of lactation [36]. Concluded that Variations of milk urea nitrogen during lactation are highly influenced by the changes in days in milk, lactose, and fat percentage [37]. Furthermore, lactose levels depend on days in milk and are related to fat, milk urea nitrogen, and somatic cell count. There was an agreement of researches on the fact that milk component yield increased under the condition of evaluating either wet or dry distillers' grains with soluble [38-41]. Concluded that Milk fat, and lactose contents were significantly affected while the remaining milk contents were not significantly different among different feed protein level which agrees with who noted differences in milk composition under different concentrate feeding [42]. Milk fat composition was affected by the amount and composition of dietary component as cited and also higher fat and protein can be recovered in milk by feeding high forage diets or improving the energy [41]. In general, it can be concluded that supplementing cows with peanut meal has no effect on chemical composition of milk except fat content.

According to, energy and protein are the most significant factors affecting milk performance. Proper feeding and good balanced rations remain the cornerstone of a successful dairy operation. Based on milk production responses and the levels of milk production cows achieved, concluded that 17% dietary protein is adequate for maximum milk production during the first seven weeks of lactation [43].

One of the main limiting factors for milk production of the high-yielding dairy cow is the intake of energy. Energy and protein are the most significant factors affecting milk performance. Fat supplements such as oilseeds are commonly added to ruminant diets to increase caloric density and to enhance the proportions of desirable unsaturated fatty acids in edible products [11]. According to there was no differences regarding Dry matter intake, and Fat Corrected Milk, but total milk yield was affected (reduced) by Sesame Waste supplementation for mid lactating Holstein Frisian dairy cows [44].

3.2. Breed

from his experiment founded that breed of cow had significant effect on the water, fat compositions and essential minerals with milk fat varying extensively in contrast to these facts, the ash, protein and lactose contents of the milk did not affect by breed variation [45]. Reported that an inherited character of breed variation in breeds resulted in difference of fat concentration and breeds having higher fat content produce less milk quantity than those with low fat content [46].

3. 3. Factors affecting milk fat

3. 3. 1. Breed: Genetics of different breeds of dairy cattle vary for milk fat. The predominant breeds of dairy cattle in many parts of the worlds are high percentage Holstein cattle (MOAC, 2005). Thus, the genetics of the Holstein breed have a major influence on milk fat. Previous studies in Thailand have shown milk fat percentage levels for Crossbred cattle ≥75% Holstein having milk fat values of 3.77 %, with a protein content of 3.17. Breeds such as Sahiwal and Red Sindhi have milk fat values of between 4.3-5.2 % and 4.5-5.2%, respectively [47, 48]. Dairy cows, Holstein-Friesian breed can have more intensive emotion of feeling hungry, than other breed, as a greater proportion of their energy is expended through milk output the cow milk composition of the herd under traditional management practices shows that breed of cow had significant effect on the fat and water compositions with milk fat varying extensively. The ash, protein, lactose, mineral and amino acid compositions were not affected by breed differences. According to the conclusion from the result, breed has no effect on protein and lactose content of milk. The ash, protein and lactose contents of the milk did

not differ significantly among the three cow breeds (White Fulani, Muturu and Red Bororo). However, breed of cow had significant effect on the water and fat compositions with milk fat varying extensively [45]. Concluded that the variation of fat content of milk may be ascribed to different genetics and physiological status of the cow breeds. According to milk fat can be affected by different herd management by the owners [49]. Variations in fat content among breeds of cow is an inherited character which implies that breeds with higher fat content produce less milk quantity than those with low fat content [46].

3. 3. 2. Nutrition

Appropriate and balanced ration feeding helps the cows to exploit their genetic potential as evidenced in Holstein population. Nutrition has a major effect on milk fat. An increase in concentrate feed, increase in milk protein components up to a point where dry matter in the diet is more than 50% concentrate, the increase in starches shows to decrease milk fat percentage. The two main causes of milk fat depression, one being a high grain low forage diet, and two large amounts of plant and/or marine oils in the diet [50]. When looking at feeding practices, diets and their effect on milk fat and yields, the amount of dietary fiber from forages, in particular green grasses are important for normal rumen function and avoiding milk fat depression. According to, the nutritional factors that are having major influence on milk protein content are forage-to-concentrate ratio, the amount and source of dietary protein, and the amount and source of dietary fat. A grain alone is responsible for milk fat depression, while mixed diets promoted the production of milk and milk protein [2]. Reported that all the factors affecting milk composition, nutrition and feeding management are most likely to cause problems. Milk fat depression can be alleviated within seven to twenty-one days by changing the diet of the cow while milk protein changes may take three to six weeks or longer if the problem has been going on for a long period [51, 52]. Nutrition and feeding management are considered the best solutions to a milk fat or protein problem other than genetics [53].

3. 3. 3. Lactation Stage

The first secretion after parturition namely colostrum is high in globules, chlorides, and low lactose content. The yield increases and attains maximum within 2-4 weeks and then slowly decrease. When the yield is more, Fat and SNF decrease and vice versa. A thorough review on how dairy cow nutrition affects milk composition was done by. He reported that at different stages of lactation affects milk fat, lactose and protein contents differently. Solids-non-fat solid content is frequently at peak during the first 2 to 3 weeks, afterward, which it reduces slightly [54]. In the first stage of lactation, the cows use their body fat to satisfy energy deficit, and the loss of body weight of 1kg gives enough energy for about 6-7 kg of milk, and 3-4 kg of protein.

3. 3. 4. Milking Interval

When milking is done between longer intervals, the yield is more with a corresponding decrease in fat and vice versa but has no more effect on solid-not-fat content. Milk protein, lactose and somatic cell count are not influenced by the milking interval, whereas fat content decreases as well as milk production rate with increasing milking interval [55]. Concluded that milk secretion rates impaired by extended milking intervals of 24 and 40 hrs. However, recovery is relatively rapid with frequent milk removal.

3. 3. 5. Age

Milk fat content remains relatively constant while milk protein content gradually decreases with advancing age. A survey of Holstein Dairy Herd Improvement Association (citation) across lactation records the milk protein content typically decreases 0.10 to 0.15 units over a period of five or more lactations or approximately 0.02 to 0.05 units per lactation. There was no significant difference between the adult and young cows in terms of milk yield. However, SNF and protein contents of milk are lower in young than adult cows while fat, lactose and pH of the milk between age groups were the same. Fat percent increase up to third lactation and after wards decreases. SNF will be high in the first lactation and slightly decreases as lactatrons increased. Cows produce more milk as they attain certain ages after which a progressive reduction in the level of milk production occurs and continues until they die. During first lactation at an average age of 2.5 years cow produces approximately 76% of the milk produced by a mature cow. Average figures for 3-year-old cows indicate that they produce approximately 85% of the milk produced by a mature cow; the figures for 4 and 5-year-old cows are 92% respectively. Cows of most breeds are considered mature between 6 and 7 years old. There is some variation among breeds. When cows are 8 to 9 years of age, a reduction in the level of milk production commences. In addition to the increase of milk production with age, there is a slight decrease in the SNF and fat percent through the fifth lactation, beyond which there is little change. Cows produce more milk as they attain certain ages after which a progressive reduction in the level of milk production occurs and continues until they die [56-58].

4. Conclusion

There are numerous factors that affect milk yield and milk composition of dairy cows. Among these factors diet of the dairy cow influences the production and proportion of milk compositions. Non-nutritional aspects such as inheritance, days in milk, Number of lactations, diseases and number of secretory cells, including environmental conditions like temperature and humidity, often overshadow nutritional effects. Appropriate nutritional administration of the dairy cattle can develop the quality and quantity of milk. In addition to these, feeding to improve the quantity of milk with proper milk fat and crude protein is essential for such achievement.

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