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Effect of non-genetic factors on milk fat composition: A review

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Abstract
Milk fat comprises of mono- and polyunsaturated fatty acids; some of them are recognized to exert a beneficial effect on human health. Short and medium chain saturated fatty acids are synthesized *de novo* in the mammary gland while long chain fatty acid are derived from blood circulation. Milk fat is the main source of energy and natural carriers' of triacylglycerols and bioactive molecules to the intestine of infants. They are also involved in providing the information needed for the growth of intestinal mucosa, the immune and nervous systems along with metabolic activity. They have impact on the technological and nutritional properties of the milk, hence, are important components of milk composition. The composition of milk fatty acid is affected by numerous non genetic factors such as species differences, parity or lactation order, age, size and health status of the cow, dietary composition, feeding, season, pregnancy, sire service period, lameness, heat stress, milking interval *etc*. Changes in milk fatty acid composition could alter nutritional and commercial values of milk as an input for dairy processing. Thus, milk fatty composition is of great importance to the dairy industry as most milk is traded as a processed product.

Keywords: Milk, milk fat, non-genetic factor, PUFA, human health

1. Introduction

Recently, the fatty acid composition in cattle milk has received considerable importance due to its major implications for human health and milk quality characteristics. Milk fat is one of the most complex natural fats that consist of approximately 400-500 fatty acids [1]. Short and medium chain fatty acids are synthesized *de novo* in the mammary gland, whereas, long chain fatty acids are derived from blood lipids, which are originating from the diet and endogenously produced lipids [2, 3]. Milk fat, either obtained from the circulating fat or synthesised in the mammary gland, is secreted as a mixture of milk fat globules (MFG) with different sizes, with a mean diameter between 3.3 and 5.2 µm, but ranging from 0.1 to 20 µm [4, 5]. Milk fatty acid composition traits are the most economically important traits controlled by numerous genes and environmental factors in dairy animals.

2. Fatty acid composition

Milk fat is characterized by high amounts of saturated fatty acids (SFA) and low amounts of polyunsaturated fatty acids (PUFA). A more unsaturated milk fat is preferred from human nutritional and health perspectives. Long chain fatty acid especially conjugated linoleic acid (CLA) have a role in modulation of plasma lipid concentration as well as anti-carcinogenic and anti-inflammatory effects [6]. Triglycerides, the lipidic fraction of milk contain ~70% saturated fatty acids (SFA) and 30% of unsaturated fatty acids (UFA) [7]. Low proportions of UFA and relatively high proportion of SFA have been shown to increase the level of blood LDL-cholesterol [8], especially C14:0 and C16:0, which is associated with both the increase of the blood cholesterol levels and cardiovascular disease in humans [9, 10].

In cattle milk PUFA account for as little as ~3% of all fatty acids [11]. The predominant n-3 FA in milk fat of the majority of mammals is α-linolenic acid. Among the MUFA group, the oleic acid (C18:1) is characterised by the highest content (24%), [12, 13]. O'Donnell *et.al.* [14] and Strzałkowska *et al.* [15] reported that in ruminant's milk, there are also relatively small but significant contributions from other MUFA such as C14:1 (about 1%), C16:1 (about 1.5%), and very desirable vaccenic acid, which is a precursor of CLA in human organism (1.5-5%).

3. Factor affecting the milk composition
Milk fatty acid composition is variable in dairy cows and is influenced by species differences, parity or lactation order, age and size of the cow, dietary composition, feeding, season, pregnancy, sire service period, lameness, heat stress, health status of the cow, milking interval, genetic factors and other day to day variation behaviour or milking temperament, udder health, locality and stage of lactation. The effect of different non genetic factors affecting milk fatty acid composition are:

3.1. Effect of Breed /genetic group
Between and within breeds, fat varies the most and lactose the least [16]. Gaunt [17] reported cattle in the United States tend to have the lowest percentage of milk fat. The lower milk fat% of 4.73±0.39 is seen in Gir cows [18]. The differences in the gene frequencies controlling the quality and quantity of milk components largely account for the average genetic differences among the breed. It has been found that the difference in milk constituents among the individuals within a breed is greater than the average difference among breed. The variation of fat percentage within a breed may be as much as 2%. Some Holstein Friesian (H.F.) produced milk contains 5% fat, whereas, some Jersey produced as low as H.F. breed average [19].

Poulsen *et al*. [20] showed that there was a considerable difference between breeds in the milk fatty acid composition. Some of the FA are more regulated by the environment (long chain FAs), while, the regulation of other FAs (short and medium chain FAs) is more influenced by genetics. The Danish Jersey (DJ) cows were characterized by higher levels of saturated short chain FAs compared to the Danish Holstein (DH), whereas, the DH had higher content of unsaturated C18 FA.

Lowest fat% (3.33±0.03), in milk was reported by the Misra and Joshi [21] from Karan Fries cows during the rainy season in Karnal and highest fat% (5.98±0.11) was reported by Yadav *et al*. [22] from JH cross bred in Hisar. Frequency distributions demonstrated that milk fat content of CLA and CLA-desaturase index varied over three fold among individuals. Holsteins had a higher milk fat content of CLA and CLA-desaturase index, but breed differences were minor [23]. Misra [24] reported that Jersey half breds were superior to the H.F. half breds with respect to fat% and SNF% in milk.

3.2. Effect of Season
The effects of seasonal variation on milk fatty acid composition and the physico-chemical properties vary throughout the year to different extents. Milk composition traits were highest in hot humid season but lowest in milk yield as compared to other seasons according to Sarkar *et al*. [25].

Lowest fat% (3.33±0.03), in milk was reported by the Misra and Joshi [21] from Karan Fries cows during the rainy season in Karnal and highest fat% (5.98±0.11) was reported by Yadav *et al*. [22] from JH cross bred in Hisar. DairyCo [26] reported that in the years 2009–2013, fat levels from the UK national herd gradually decreased from January to July, followed by a sharp increase to more than 4.20% in August and September, and remained constant in October, November and December.

Heck *et al*. [27] reported lower fat and protein contents in summer than in winter milk. This could be attributed to the different temperatures and feed composition, because cows consume more dry feed in winter, whereas, in summer they eat grass and stay outside for longer [28].

Raw milk produced in the autumn period had a significantly higher fat content than in other periods which is broadly in line with the UK national statistics [26]. Yadav *et al.* [29] reported that fat percentage higher in winter calvers during 1st and 10th month of lactation, in the rainy season calver during 3rd and 4th lactation, in summer calvers 6th, 7th, and 8th month of lactation. Wiking *et al*. [30] showed that MFG sizes vary with diurnal fat production. As daily milk fat production increases, so does the milk fat globule size.

3.3. Effect of Parity/ Lactation
The age of the lactating animal is an important physiological factor affecting the composition of milk [31]. Barbary *et al*. [32] observed that milk fat percentage of H.F. cows was significantly affected by parity. There is report that milk fat% (4.9±0.02) and SNF% (9.1±0.01) contents of Sahiwal cows attained a peak value in the 3rd lactations and declined thereafter to the minimum (4.8±0.06% fat and 9.0±0.05%SNF) in the 10th [33]. Misra and Joshi [21], furthermore, reported that the milk constituents had highest value in 1st parity, and whereas, the observation of Yadav *et al*. [22] revealed a gradual increase in the average fat% in milk during the whole lactation, on or up to peak day and on or up to week parity.

Lactation number of the animal has no significant effect on fat and SNF content of Tharparkar, Red Sindhi and Karan Swiss cow [33]. Shavaby [34] also found that the effect of lactation were non-significant for fat percentage in milk.

Schutz *et al.* [35] reported that fat yield was increased with parity of Guernsey, Holstein and Jersey cows. They also reported that sample day milk constituent's yields (including fat yield) were greater for Holsteins than Guernsey or Jerseys. The effect of parity was significant on fat% in Karan Fries cattle [21]. However, perusal of literature revealed both significant [36] and non-significant [37] effect of parity on different milk constituents and yield traits.

3.4. Effect of Stage of lactation
Generally, higher milk yield at early lactation are accompanied by low constituents percentage [38, 39]. Fat percentage was higher in 1st month of lactation. It decreased thereafter until the fifth or sixth month and increased subsequently in H.F. cows [40]. Altenhofer *et al*. [41] found significant difference for milk fat globules from the start, middle and end of lactation in bovine. Similar results have been observed in ewes [42].

Zurkowska [43] reported that milk fat% declined in the 1st month of lactation and in 2nd month it was maintained at a low level. Then at 3rd month it get increased. Intrieri and Minieri [44] revealed that fat% decreased in the first two months and then gradually increased reaching to maximum towards the end of lactation. Sharma *et al.* [45] found that fat percentage declined initially, then increasing after 4 months in H.F. whereas, in Jerseys the rise was from the beginning of lactation.

4. Conclusion
The composition of cows' milk fat is influenced by numerous non genetic factors. Therefore, desirable changes in fat composition can be achieved by adjusting non genetic factors to improve the nutritional value of milk. The utilization of these factors could be possible owing to the genetic variability in fatty acid composition. It is important to understand the

relationship of non-genetic factor effects with milk production, resulting from genetic correlations between milk yield, fat content and proportions of FAs. Selection of cows for low fat content can result in a more desirable milk fat composition for human health, while selection for milk yield can affect the proportion of most individual FAs to a limited extent.

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