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Feeding of High Forage diet to enhance Conjugated Linoliec Acid (CLA) in Cow's Milk interest of Human Health : A Review

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Abstract

Dairy cows diets is usually composed of forages especially pasture, silage, hay. The main fatty acid found in forage are palmitic acid (C16:0), steric acid (C18:0), oleic acid (C18:1 n-9), linoleic acid (C18:2 n-6) and linolenic acid (C18:3 n-3). Milk fatty acid is synthesized in mammary gland from *de novo* and dietary fatty acid source. Consumption of milk contributes mineral, vitamins, energy and essential fatty acids linolic (C18:2n-6) and linolenic (C18:3 n-3) to human, but inclusion of high proportion milk and milk product especially, saturated fat in human diets is becoming questionable because of the health risk like obesity, cancer, diabetics, and cardiovascular disease. This creates negative altitude on consumers towards milk and milk product. The aim if this review was to summarize the concentration and it's health promoting effect of conjugated linoleic acid (CLA) in cow's milk through feeding high forage diets. This review was carried out by using secondary data sources mainly published journals. Studies in rat revealed that CLA (rumenic or vacenic acid) rich butter at 2% of its diet show reduction in mammary tumor and cholestrol induced coronary heart disease in rat. Research findings showed it is possible to enhance the unsaturated fatty acid in the milk by manipulating the cow's diet. Compromising the milk yield inclusion up to 70% of forage enhances n-3 PUFA, CLA. However, the contribution of the unsaturated fatty acid especially CLA from milk to the total human diet seams relatively low. Since for human to be effective it need reasonable to add 20% of its diet.

Keywords: Forage , Milk Fatty Acids, CLA

Introduction

In the past decades, the average milk yield per cow per lactation has highly increased due to major improvement in feeding strategies, health care, selection and breeding. But, the increment in milk yield led to increase in the proportion of concentrates in the diet to satisfy the nutrient requirement of the dairy cows (Patel, 2012). Inclusion of more concentrate increases the total milk production (Intisar et al., 2012). However, the price of concentrates has been increasing and making for indoor feeding is not economical (Patel, 2012). Beside to this, feeding of dairy cows on high level of concentrate has risk of ruminal acidosis and lower milk fat (Boddugari et al., 2001).

It is now fairly common to see rations that contain 55 to 70% forage in the daily ration of lactating cows (Chase & Grant, 2013). Dairy farmers that have adopted higher forage rations report additional benefit such as reduce the amount of purchased concentrates (Patel, 2012), higher milk components, better rumen function, lower veterinary cost and increased production life time of a cow (Chase, & Grant, 2013).

There is also growing interest of consumer need for organically produced milk and public's awareness on functional foods (Milner, 1999, Patel, 2012). Because, majority fat in milk and milk product are in the form of saturated fatty acids which have health risk of obesity and coronary heart disease (Bauman *et al.*, 2006). Beside to this, there is also confirmation that milk from ruminant animals contain omega 3 poly unsaturated fatty acid and conjugated linoleic acid (CLA) which has positive effects on disease prevention like cancer (Elgersma et al., 2006; Arvidsson, 2009). Today, feeding high forage diet to dairy cow is becoming an interesting research area and feeding strategy and many research finding showed that it is possible to enhance health promoting fatty acid in milk through feeding good quality forage (Magowan et al., 2010; Patel, 2012). Hence, the aim of this review was to summarize the effect of feeding high forage diets on saturated fatty acids and unsaturated fatty acids in the milk; particularly in relation to heath promoting fatty acids such as *n*−3 PUFA and CLA.

2. Literature review

2.1 Milk and Human Health

Cow milk contributes proteins, energy, minerals, vitamins, and essential fatty acids (C18:2n-6) and C18:3 n-3) to human (Bauman, 2006; Arvidsson, 2009; Patel, 2012). However, inclusion of high proportion milk and milk product especially, saturated fat in human diets is becoming questionable because of the health risk like cardiovascular disease (Dowhurts et al., 2003b; Arvidsson, 2009). Elgersma et al. (2006) reported that the saturated (SA), mono unsaturated (MFA) and poly unsaturated fatty acid (PUFA) proportion of cow milk is 69, 27 and 4 % respectively but about 40% of saturated fatty acid categorized as less healthy. Among the major saturated fatty acid in the cow; myristic acid (C14:0) and palmitic acid (C16:0) are the main medium chain fatty acids which have potential to increase low density lipoprotein (LDL) cholesterol level (Williams, 2000). The type of cholesterol in the body can be High density lipoprotein (HDP) which is use full or LDP which can lead to cardiovascular disease (Ma, 2004). Accumulation of cholesterol in the wall of arteries lowers the amount of oxygen and blood which will reach to heart. When the wall of arteries is blocked due to high accumulation of cholesterol then the person will face stroke or heart attack.

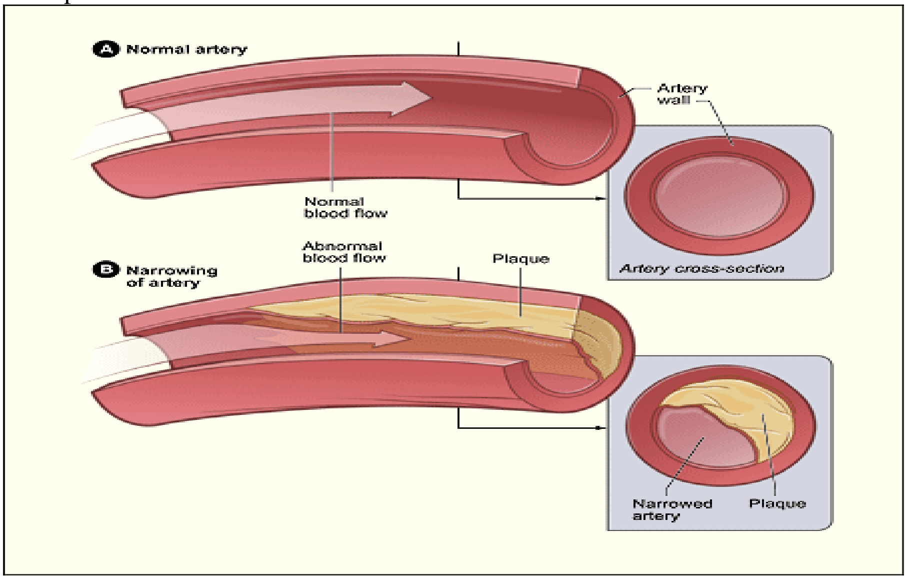

Figure 1; A shows a normal artery with normal blood flow. Figure B shows an artery with plaque buildup (Adapted from U.S national institute of health, http://www.nhlbi.nih.gov/health)

Elgersma et al. (2006) recommend that cardiovascular risk can be reduced by lowering the amount of undesirable SFA intake. Dewhurst et al. (2006) reported that today many countries have implemented, or plan to introduce, legislation to solve these public health concerns. In 2003 the world health organization (WHO) suggested that the total fat, saturated fatty acids, n−6 PUFA, n−3 PUFA and trans fatty acids should share <0.15–0.30, <0.10, <0.05–0.08, <0.01–0.02 and <0.01 of total energy intake in human diet respectively (Elgersma *et al*., 2006).The other alternative could be consumption of ruminant product (meat and milk) rich in CLA (Elgersma et al. 2006). Meat and milk are the main diatry source of CLA and because of the its health promoting effect; improving the concentration of CLA in meat and milk has become an important goal in many animal nutrition research (Grinary and Bauman, 1999).

2.2. Fatty acid profile of Forage

Dairy cow diets are usually composed of forages especially pasture, silage, hay, and concentrate especially oil seed by products and grain (Elgersma et al., 2006). According to Arvidsson (2009), the main fatty acid found in forage are palmitic acid (C16:0), steric acid (C18:0), oleic acid (C18:1 n-9), linoleic acid (C18:2 n-6) and linolenic acid (C18:3 n-3). Another study by Elgersma et al. (2006) point out that fresh grass can contains 50 to 75 % of total FA content as linolenic acid. But, the proportion of this fatty acid depends on light intensity, temperature, leaf to steam ratio, season, day length, stage maturity (Harwood, 1980; Elgersma et al., 2005). Further study by Boufaïed et al. (2003) revealed that a 30% reduction in palmitic, oleic, linoleic and linoleneic fatty acid was found as the maturity of timothy advance. Cutting at an early stage of maturity, nitrogen fertilization of grass may result in a higher total fatty acid content in the forage (Boufaïed et al., 2003; Arvidsson, 2009). In contrast to this, Lee et al. (2006) reported that phosphorus application to grass have less effect on total fatty acid compare to nitrogen.

Arvidsson (2009) and Magoan et al. (2010) reported that oxidation during field wilting and biohydrogenation in the rumen are the major factors that results losses of PUFA from the forage. The loss of PUFA in during wilting and biohydrogenation might be dueto lipolysis, as aresult of either plant or Microbial lipases (Arvidsson, 2009). ‘Stay-green’ grasses have provided one strategy to reduce fatty acid losses during wilting (Magowan et al., 2010). Furthermore, the concentration of fatty acid were found higher in fresh grass than grass silage (French et al., 2000). The effect is much higher when wilting and ensiling in perennial ryegrass (Elgersma et al. (2003a).

2.3. Effect of forage on Milk Fatty acids

Dairy cattle and other ruminants have ability to convert forages feeds into valuable product products such as meat and milk (Patel, 2012). The daily feed intake of dairy cow ranges between 12 – 16 kg DM/day. Kolver et al. (1998) reported that low dry matter intake (DMI) is the major factor limiting milk production kept in pasture. Another study by Beever et al (2000) emphases that total DMI of high producing cows fed pasture diets alone is lower than cows fed pasture diets plus concentrates. In contrast to this, Bargo et al., (2002a) point out the dairy cows can consume large quantities of forage when high quality and digestible forages are offered.

Furthermore, a study done by Bertilsson and Halling (2001) indicated that dairy cows fed on legume-grass silage produce more milk compare to grass silage alone due to its higher protein, rapid digestion which can lead to higher DMI. A study conducted by Patel (2012) also revealed that no significant difference in milk production were observed when dairy cows fed on diet containing 51 and 62 % of silage, but further increase in proportion of silage resulted significant reduction in milk production while increased milk fatty acid were observed (Table 1). The increment in milk fat due to inclusion of more forge will result higher milk fat which is mode of payment in most countries.

The milk fatty acid is synthesized in the mammary gland from *de novo* and dietary fatty acid source (Bauman *et al.*, 2000). The type and amount of fatty acid depends on cow diet. Milk fat depression (MFD) is a typical example of effect of nutrition on milk fat observed when lactating cows fed on high concentrates, oil rich feeds, low fiber and finely grind roughage (Bauman et al., 2006). According to (Bargo et al., 2002), most conventional farms use high level of concentrate than forage to achieve high milk production.

However, feeding high level of concentrate decreases the proportion of acetate which is main precursor of milk fat (Bannink et al., 2006). As a result the fat content in the milk decreased (Bauman et al., 2006). During milk fat depression, the amount of all individual fatty acids is reduced, but the decrease is severe in short chain (acetic, butyric) and medium chain (palmitic and steric) fatty acids (Bauman et al., 2006). On the other hand, a study conducted by Dewhurst et al. (2003) indicated that the concentration of linolenic acid increased much when a cow fed on less amount of concentrate, but high proportion of red clover silage.

Dairy cows feed on fresh grass produce milk rich in Omega 3 poly PUFA and CLA as compared compare to concentrate diets (French et al., 2000; Elgersma et al., 2006). Lock and Gransworthy (2003) seasonal variation in quality of forage have effects the amount of CLA in the milk. Other study done by Reklewska et al. (2003) indicates that the concentration of CLA in the milk at summer and winter were 8.4 and 6.3 g/kg, respectively. Elgersma et al. (2006) reported that cow fed on good quality pasture produce milk with much higher PUFA.

Further study by Nał˛ecz-Tarwacka to compare cows fed fresh grass during summer and silage & brewers' grains during winter. The Author found that the concentration of PUFA during summer and winter was 344 and 308g/kg fat, respectively. Moreover, CLA concentrations difference due to seasonal fluctuation was also studied in The Netherlands (Figure 2).

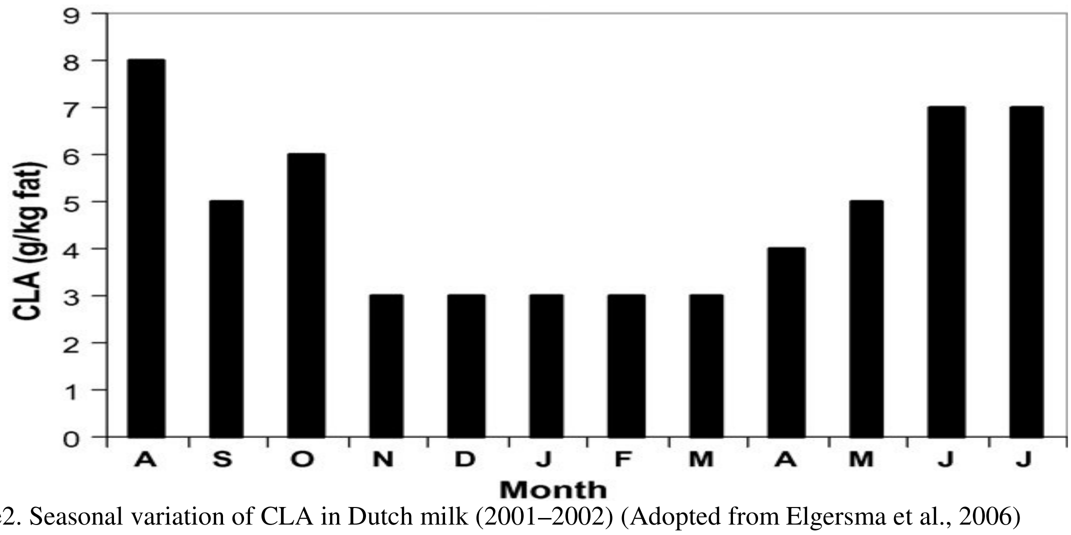

Figure2. Seasonal variation of CLA in Dutch milk (2001–2002) (Adopted from Elgersma et al., 2006)

3. Discussion

Milk contains 14 isomers of CLA but the most aboundants and nutritional important are *cis*-9, *trans*-11 CLA and *trans*-10, *cis*-12 (Lock et al., 2004). *trans*-10, *cis*-12 have risk of increasing very low density cholesterol (Hodgson *et al.*, 1996) and inhibit *de novo* milk fat synthesis through its influence on gene regulation and decreasing main enzyme activity in the mammary gland (Bouman, 2006). *cis*-9, *trans*-11 also called rumenic acid is of interest as a functional food component and contributes about 90 % of total CLA in the milk (Bouman, 2006; Arvidsson, 2009). Vaccenic acid is also another intermediate product of linoleic and linolenic acid in the rumen and its conversion to rumenic acid is catalyzed by Δ^9-desaturase in the mammary gland (Bouman, 2006). Both isomers (rumenic and vacenic acids) are formed due to biohydrogenation in rumen through the help of rumen microbes (Arvidsson, 2009).

According to Aro et al. (2000) and Belury (2002), rumenic acid had shown positive effect on anti cancer. Many studies conducted in animal model showed that supplementation of butter rich in rumenic acid or vacenic acid showed reduction in mammary rommor of breast cancer, antiatherogenic effects and reduce total plasma cholesterol level (Lock et al., 2003; Bouman, 2006). So the health risk due to feeding milk and milk product might be solved through minimizing intake of saturated fatty acids and increasing intake of health promoting fatty acids. Today, many research findings showed that it is possible to increase milk fat production as well as reduce the health risk by manipulating the cow's diet (Arvidsson, 2009; Magowan et al., 2010; Patel, 2012). The milk yield of dairy cow kept indoor feeding with high forage and concentrate yields 9,500 kg per lactation as compare to pasture passed i.e 6,000 kg per lactation (Hofstetter et al., 2011). On the other hand, a study conducted by Auldist et al. (1998) indicates that the amount of milk fat especially concentration of polyunsaturated fatty acid was 3 times higher in pasture than cows fed in door.

Another study done by Bargo et al. (2006) found that the short, medium, and long-chain FA content in the milk increase when cows graze on good quality pasture, while Concentrate supplementation increased saturated fatty acids and reduced unsaturated fatty acid content. Bauman et al. (2000) point out that increasing the proportion of concentrates in the diet reduces rumen pH and inhibits biohydrogenation of dietary unsaturated fatty acids. Similarly, Elgersma et al. (2006) reported that feeding of concentrate results lower CLA (6.1 g/kg) than forage (11.7 g/kg).

It is obvious that, the concentration of PUFA especially, n-3 fatty acid is higher in organic farms compare to conventional farms (Ellis et al., 2006), because organic dairy farms use more than 60 % of forage to feed their cows. The increase in level of milk fat when cows feed on high forage is due to production of more VFA (more Acetate and butyrate, less propionate) which is precursor for milk fat in the mammary gland through *de novo* synthesis (Patel, 2012). But, the disadvantages of increasing the proportion of unsaturated fatty acid is it decrease shelf life of butter as the result of oxidative deterioration (Murphy, 2000). On the other hand, Lourenco et al (2007) conducted a study using 70 % well managed rye grass silage and botanically diversified silage from unfertilized pasture. The Author concluded that lambs feed well managed rye grass deposit high proportion of omega–3 fatty acids and PUFA in their muscle. The reason why botanically diversified pasture plants show less unsaturated fatty acid might be due to the presence of secondary metabolites like tannins which can interfere with fat digestibility through inhibiting the lipase activity. Generally, increasing the proportion of high quality forage in the diet of lactating cow can enhance the amount of beneficiary fatty acids in the milk to some extent.

4. Conclusion

The presence of beneficial bioactive component in the milk (rumenic and vacenic acid) is very impressive to solve the public perception regarding the health risk associated with saturated fatty acid in the milk and to produce healthy food from milk and milk product to consumers. Studies showed that CLA (rumenic or vacenic acid) rich butter at 2 % of rate diet show reduction in mamary tumor in rat and reduce cholestrol indiuced coronary heart disease in rat. Research findings showed that it is possible to reduce the cardiovascular health risk by manipulating the cow's diet. Cows feed on fresh grass produce milk rich in Omega 3 poly PUFA and CLA as compared compare to concentrate diets. Compromising the milk yield inclusion up to 70% of forage enhance n-3 PUFA, CLA (rumenic and vacinic acid). However, the contribution of these unsaturated fatty acid from milk to the total human diet is relatively low. This is due to the fact that, for human to be effecteive, it is reasonable to add 20% of its diet. Beside to this, the findings are still under animal model so further study is still needed to test its real effect on human health.

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