International Journal of
Dairy Science

ISSN 1811-9743

Academic
Journals Inc.

www.academicjournals.com

International Journal of Dairy Science 6 (3): 165-171, 2011
ISSN 1811-9743 / DOI: 10.3923/ijds.2011.165.171

Conjugated Lenoleic Acid: A Good Fat for Human Health-A Review

[1]V.P. Singh and [2]N. Sachan
[1]Department of Livestock Products, Technology, [2]Department of Veterinary Public Health, College of Veterinary Science and Animal Husbandry, Pt. Deen Dayal Upadhyay Pashu Chikitsa Vigyan Vishwavidyala Evam Go Anusandhan Sansthan, Mathura-281001 (UP), India

Corresponding Author: V.P. Sing, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry Pt. Deen Dayal Upadhyay Pashu Chikitsa Vigyan Vishwavidyala Evam Go Anusandhan Sansthan, Mathura-281001 (UP), India Tel: +91-9412190865

ABSTRACT

Conjugated linoleic acid is a good fat which is naturally found in many foods like milk and meat of the ruminants particularly cows, sheep and goats. It is a potent cancer fighter along with several other positive health benefits. It can be transformed from lenoleic acid by the rumen bacteria. It is simply an excretory metabolites or metabolic intermediates of rumen bacteria and normally produced in ruminants as for symbiotic purposes thus it promotes health and longevity of the animals. CLA is also capable to prevent obesity, atherosclerosis and diabetes mellitus etc. The only need is to exploit the possibilities for its beneficial effects and exploration of its natural sources as a food. Among all organic milk is a richest food sources and may be the good alternative in this concerned. However, its detection, monitoring and quality control are the prime considerations.

Key words: Conjugated lenoleic acid, milk, health benefits, lenoleic acid, fats

INTRODUCTION

Conjugated Linoleic Acid (CLA) is also known as bovinic acid or rumenic acid. It is a mixture of positional and geometric isomers of linoleic acid which transforms from linoleic acid by the rumen bacteria. It is the only naturally occurring substance that has been shown to unequivocally prevent cancer. It is a good fat which is naturally occurs in many foods especially in milk and meat from ruminants such as cows, sheep and goats. The presence of fatty acids with conjugated double bonds was first demonstrated in food products derived from ruminants by Booth *et al.* (1935) working with milk fat from cows turned out to spring pasture. Subsequently, Parodi (1977) demonstrated primarily represented conjugated cis-9, trans-11 octadecadienoic acid. Milk and dairy products have been associated with health benefits for many years containing bioactive peptides, probiotic bacteria, antioxidants, vitamins, specific proteins, oligosaccharides, organic acids, highly absorbable calcium, conjugated linoleic acid and other biologically active components (Bhat and Bhat, 2011).

CLA is a potent cancer fighter and produced by bacteria in rumen. It can block all three stages of cancer i.e., initiation, promotion and metastasis while anti-cancer agents block only one of these stages. It also has the ability to slow down the growth of an unusually wide variety of tumors including cancers of the skin, breast, prostate and colon. A recent survey of Aro *et al.* (2000) determined that women with the CLA in their diets had a 60% reduction in the risk of breast cancer. Other than the cancer fighting ability it also helps to prevent obesity, atherosclerosis and diabetes mellitus. Watkins and Seifert (2000) suggest that CLA enhances bone formation thus it is responsible for stronger bones by blocking of excess production of an inflammatory substance called PGE2. CLA is also known for its body weight management properties like reducing body fat and increasing lean muscle mass. CLAs are the only natural fatty acids accepted by the National Academy of Sciences of USA as exhibiting consistent antitumor properties at levels as low as 0.25-1.0% of total fats.

Structure of CLA: The molecular formula of CLA is $C_{18}H_{32}O_2$ and molar mass is 280.44548. Conjugated linoleic acids are a family of at least 28 isomer of linoleic acid found especially in the meat and dairy products derived from ruminants. As the name implies the double bonds of CLAs are conjugated. Soft fats found in milk and meat has 18 carbon atoms (C18) and two double bonds. They get twisted into different shapes and the bonds go in different places and give them unique chemical properties. Milk's CLA content varies and can range from 2.5 up to 18 milligrams per gram of fat. The usual range is 4.5 to 5.5 mg (0.45 to 0.55%). So, if milk is 3.5% fat then its CLA content is between 0.01 and 0.025%. The contents of CLA present in different foods are shown in Table 1.

On the molecular level CLA resembles with Linoleic Acid (LA) and both CLA and LA have 18 carbon atoms and two double bonds holding the chain together as shown in Fig. 1. The main difference is in the placement of those bonds. There are 28 possible isomers of CLA each one with a slightly different arrangement of chemical bonds. The type most commonly found in meat and dairy products has double bonds between the 9th and 11th carbon atoms and is referred to as cis 9, trans-11 CLA or rumenic acid. It comprises of 80-90% of total CLA of ruminant fat and considered as intermediate product in the biohydrogenation of linoleic acid in the rumen. However, CLA and LA appear to have opposite effects on the human body such as LA promotes tumor growth while CLA blocks it.

Table 1: Content of CLA in different foods

Food items	Contribution in CLA (in %)
Milk	0.55
Ground beef	0.43
Vegetable oils (canola, corn, olive oil)	0.02

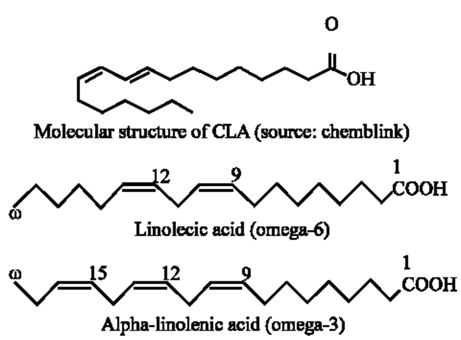

Fig. 1: Molecular structure of CLA and other related fatty acids

Sources of conjugated linoleic acid: Many of the functional ingredients of milk and milk products are good for heart and posses good qualities of human health as a whole (Midau *et al.*, 2010). The meat and milk of grass-fed ruminants offers the richest source of natural CLA (Singh *et al.*, 2009; Foda *et al.*, 2009). Whole milk, cream, butter, cheese and whole milk yogurt from grass-fed animals are excellent sources of CLA (Mirhosaini *et al.*, 2010). Moreover, CLA can also be found in the milk and meat of grass-finished cows, sheep, bison, goats, elk and other ruminant animals. Fermented dairy products may represent particularly good sources of CLA as fermentation by lactic acid bacteria actually increases the CLA content of cheese. Moreover, the beneficial bacteria naturally present in the digestive tract can produce CLA for the maintenance of healthy gut flora. Milk fermented with strains of beneficial bacteria naturally found in the human digestive tract increased the amount of CLA present in yogurt.

Food products from ruminants especially milk is a richest source of CLA and contributes 70% of total CLA while meat contributes 25% to total CLA (McGuire *et al.*, 1996). The CLA content in milk varies greatly from 0.2% or less to a high 2% or more of the milk or tissue fat. Among them milk fat is considered as the richest natural source of CLA. Kay *et al.* (2004) concluded that CLA content in milk from ruminants grazing on pasture is higher (3-5 times more). Table 2 is showing different fatty acids including their sources and structural basis.

Than animals fattened on grain in a feedlot. Another method of higher CLA content in milk is supplementing of total mixed ration with plant oils or oil seeds (Lock and Garnsworthy, 2002).

Table 2: Chemical names and descriptions of some common fatty acids

Common name	Carbon atoms	Double bonds	Scientific name	Sources
Butyric acid	4	0	Butanoic acid	Butterfat
Caproic acid	6	0	Hexanoic acid	Butterfat
Caprylic acid	8	0	Octanoic acid	Coconut oil
Capric acid	10	0	Decanoic acid	Coconut oil
Lauric acid	12	0	Dodecanoic acid	Coconut oil
Myristic acid	14	0	Tetradecanoic acid	Palm kernel oil
Palmitic acid	16	0	Hexadecanoic acid	Palm oil
Palmitoleic acid	16	1	9-hexadecenoic acid	Animal fats
Stearic acid	18	0	Octadecanoic acid	Animal fats
Oleic acid	18	1	9-octadecenoic acid	Olive oil
Ricinoleic acid	18	1	12-hydroxy-9-octadecenoic acid	Castor oil
Vaccenic acid	18	1	11-octadecenoic acid	Butterfat
Linoleic acid	18	2	9,12-octadecadienoic acid	Grape seed oil
Alpha-Linolenic acid (ALA)	18	3	9,12,15-octadecatrienoic acid	Flaxseed (linseed) oil
Gamma-Linolenic acid (GLA)	18	3	6,9,12-octadecatrienoic acid	Borage oil
Arachidic acid	20	0	Eicosanoic acid	Peanut oil, fish oil
Gadoleic acid	20	1	9-eicosenoic acid	Fish oil
Arachidonic acid (AA)	20	4	5,8,11,14-eicosatetraenoic acid	Liver fats
EPA	20	5	5,8,11,14,17-eicosapentaenoic acid	Fish oil
Behenic acid	22	0	Docosanoic acid	Rapeseed oil
Erucic acid	22	1	13-docosenoic acid	Rapeseed oil
DHA	22	6	4,7,10,13,16,19-docosahexaenoic acid	Fish oil
Lignoceric acid	24	0	Tetracosanoic acid	Small amounts in most fats
Conjugated linoleic acid	18	2	C18:2, cis-9, cis-12 Conjugated linoleic acid	Ruminants milk and meat

Vaccenic acid is the precursor to CLA that is available through ruminant products in diet (Singh and Sachan, 2010a). It can be transformed into CLA by ruminants and human beings. CLA is also available in the form of synthetic pills but it has some side effects.

Process of CLA synthesis: CLA is produced in ruminants by some specific bacteria via modification of linoleic acid in animals feed and fodder. After that it is then absorbed by the ruminants and enters its tissues including mammary tissues and skeletal muscles. Previously it was supposed that the CLA produced in the rumen was the most important source of CLA in milk and meat but recent results suggest that endogenous synthesis of cis 9 trans11 $C_{18:2}$ in the mammary gland or in the subcutaneous or intramuscular fat is the predominant production pathway. Endogenous synthesis of cis 9, trans11 $C_{18:2}$ involves action of the delta-9-desaturase on trans11 $C_{18:1}$ (TVA) which is produced in the rumen (Raes *et al*., 2004). There are mainly three ways to increase the concentration of desired FA in ruminant food products i.e., by increasing amount or concentration of their precursors in the diet, by reducing the extent of biohydrogenation in the rumen and/or by enhancing activity of the Δ^9-desaturase enzyme that converts vaccenic acid into CLA in the mammary gland.

What actually the CLA is: It is simply an excretory metabolites or metabolic intermediates of rumen bacteria (Singh and Sachan, 2010b). It is normally produced in ruminants as for symbiotic purposes thus it promotes health and longevity of the animals. It is also considered that CLA is produced by rumen bacteria as a factor specific for promotion and preservation of bacterial species in rumen.

Important considerable points for CLA concentration in foods

Grazing of animals: Grazing of animals is an important point in CLA rich milk or meat production. And it is considered that grass fed animals has more CLA in their milk and meat than the animal's rear on a feedlot (concentrates rich) diet (Sachan and Singh, 2010). The butter is made from cows that are raised on pasture gives five times higher CLA, higher Vitamin E and beta carotene than commercial butter, whether organic or non-organic (Singh *et al*., 2011). Milk products from 100 percent grass-fed cows are as much as seven times higher in cancer-fighting CLA than ordinary milk and far lower in cancer-promoting linoleic acid.

Altitude effect: Animals grazed at relatively high altitudes may produce the healthiest foods as compared with lowland grazers. Milk from high altitude grazers (3700-6200 ft) has even more omega3s and CLA and significantly less saturated fat. This is because plants growing in higher altitudes have more omega-3 fatty acids which solidify at lower temperatures than other fats and therefore act as a form of anti-freeze.

Mode of CLA production: Natural CLA from grazing animals is superior to synthetically available CLA in the form of pills. It has been found that CLA in the form of synthetic pills (CLA (t10, c12) may cause serious health complications like enlarged liver, lower levels of HDL (good cholesterol) and insulin resistance.

Genetic factors: The amount and quality of CLA is greatly influenced by the genetic configurations, individuality and breed characteristics of animals. Murray (2001) has concluded the differences among and within dairy breeds indicates genetic selection may be a valid way to alter levels of CLA produced in milk. It is believed that CLA is produced in the mammary gland from some of the breakdown products from the action of rumen bacteria. One enzyme seems to play key role in this process. The research is going on to identify the genes that control this enzyme. If scientists get success then it will be the revolution in the field of CIA.

Environmental factors: Season and prevailing temperature also affects CLA concentration in the ruminant foods. Cows raised in colder climates have comparatively more omega-3 and CLA.

Nutritional factors: Nutrition is the main factor that affects milk fat composition (Singh and Sachan, 2009). It is a logical place to alter fatty acid composition and CLA levels. A large number of feeding trials have been carried out. Pasture feeding has been shown to increase CLA concentration over TMRs containing stored forage and concentrate. Sunflower oil, linseed oil and soybean oil have all been used to increase CLA levels of up to five times the base line levels. Calcium salts of oils from canola, soybean and linseed for rumen can be used to give a five to seven-fold increase in CLA. Supplementation with fish oil can also increase CLA content of milk.

Commercially prepared synthetic CLA tends to have a wider range of CLA and have a greater effect on fat metabolism. Feeding calcium salts of this CLA to cows in most cases has caused milk fat depression, lowered milk fat percentage, lower fat yield and in some cases lower milk yield. The concentration of CLA in this milk may increase but overall the quantity has not gone up due to the lowered overall milk fat. This form of synthetic CLA, due to its inhibitory effect on fat synthesis, may be useful in altering fat-protein ratio in milk.

Possible adverse effects of CLA in humans: The use of CLA supplements by overweight people may tend to cause or to aggravate insulin resistance which may increase their risk of developing diabetes (Riserus *et al*., 2002). Most supplements contains mixtures of two CLA isomers i.e cis-9, trans-11 isomer as well as the trans-10, cis-12 (t10, c12) isomer. It is the trans-10, cis-12 isomer that is linked to many adverse side effects. Research indicates that supplementation with t10 c12 CLA dramatically increases rates of oxidative stress to levels considerably higher than that observed in heavy smokers (Riserus *et al*., 2002). However, the evidence is controversial and some studies using a mixture of c9t11 and t10c12 CLA showed no changes in insulin sensitivity (Dajanta *et al*., 2008). Although researchers are still not sure of the long term health effects of consuming CLA from supplements. Foods naturally enriched in CLA such as beef and dairy are safe alternatives. In the another report published in International Journal of Obesity in 2008 suggest that t10c12 CLA produced a 32% increase in biliary cholesterol concentration which increases the chance of gallstone formation. In 2006, a study of US Department of Agriculture suggested that CLA can induce essential fatty acid redistribution in mice. Changes in Docosahexaenoic Acid (DHA) and Arachidonic Acid (AA) levels were observed in some organs. For instance, the t10, c12 CLA reduced the DHA content of heart tissue by 25% while in the spleen, DHA content rose and AA fell. DHA is an omega-3 fatty acid important to cardiovascular health and the dramatic reduction of DHA in heart tissue can have serious health consequences. In contrast, c9, t11 CLA did not alter DHA content in the heart but did reduce spleen. These studies raise the question of whether CLA may increase the risk of cardiovascular and inflammatory diseases but it has yet to be established whether such changes occur in humans and whether they are clinically relevant.

CONCLUSION

An increasing interest in enhancing the CLA content in food products is attributed to its potential anti- carcinogenic, anti- diabetic, anti-atherogenic and immunomodulatory functions in animal and human beings. It is obvious that possible health benefits offer niche market potential for high-CLA milk and products made from it. The high-CLA milk looks much like regular milk. The challenges in CLA rich food production and marketing are its lack of economical testing and monitoring methods to identify high-CLA milks and herds. By management of some factors CLAs could be a wonderful success story for dairy products.

REFERENCES

Aro, A., S. Mannisto, I. Salminen, M.L. Ovaskainen, V. Kataja and M. Uusitupa, 2000. Inverse association between dietary and serum conjugated linoleic acid and risk of breast cancer in postmenopausal women. Indian Dairy J., 38: 151-157.

Bhat, Z.F. and H. Bhat, 2011. Milk and dairy products as functional foods: A review. Int. J. Dairy Sci., 6: 1-12.

Booth, R.G., S.K. Kon, W.J. Dann and T. Moore, 1935. A study of seasonal variation in butter fat. Biochem. J., 29: 133-137.

Dajanta, K., E. Chukeatirote and A. Apichartsrangkoon, 2008. Effect of lactoperoxidase system on keeping quality of raw cow's milk in Thailand. Int. J. Dairy Sci., 3: 112-126.

Foda, M.I., S.M. Kholif and A.M. Kholif, 2009. Evaluation of goat milk containing galactooligosaccharides after supplementing the ration with amino acids. Int. J. Dairy Sci., 4: 27-33.

Kay, J.K., T.R. Mackle, M.J. Auldist, N.A. Thomson and D.E. Bauman, 2004. Endogenous synthesis of cis-9, trans-11 conjugated linoleic acid in dairy cows fed fresh pasture. J. Dairy Sci., 87: 369-378.

Lock, A.L. and P.C. Garnsworthy, 2002. Independent effect of dietary linoleic and linolenic fatty acids on the conjugated linoleic acid content in cow's milk. Anim. Sci., 74: 163-176.

McGuire, M.A., M.K. McGuire, M.A. Guy, W.K. Sanchez and T.D. Shultz *et al*., 1996. Short-term effect of dietary lipid concentration on content of Conjugated Linoleic Acid (CLA) in milk from dairy cattle. J. Anim. Sci., 74: 266-266.

Midau, A., A. Kibon, S.M. Moruppa and C. Augustine, 2010. Influence of season on milk yield and milk composition of red sokoto goats in mubi area of Adamawa State, Nigeria. Int. J. Dairy Sci., 5: 135-141.

Mirhosaini, M., I. Nahvi, R.K. Karmanshahi and M. Tavassoli, 2010. Isolation of bacteriocin producing *Lactococcus lactis* strain from dairy products. Int. J. Dairy Sci., 5: 192-197.

Murray, B., 2001. Ruminations column of the Ontario. Milk Producer Magazine, pp: 27-39.

Parodi, P.W., 1977. Conjugated octadecadienoic acids of milk fat. J. Dairy Sci., 60: 1550-1553.

Raes, K., S. De Smet and D. Demeyer, 2004. Effect of dietary fatty acids on incorporation of long chain polyunsaturated fatty acids and conjugated linoleic acid in lamb, beef and pork meat: A review. Anim. Feed Sci. Technol., 113: 199-221.

Riserus, U., S. Basu, S. Jovinge, G.N. Fredrikson, J. Arnlov and B. Vessby, 2002. Supplementation with conjugated linoleic acid causes isomer-dependent oxidative stress and elevated c-reactive protein. Am. Heart Associat. J., 106: 1925-1929.

Sachan, N. and V.P. Singh, 2010. Standards and quality control aspects of Indian Dairy industry-a review. Livest. Int., 14: 18-20.

Singh, V.P. and N. Sachan, 2009. Role of milk ingredients in bakery industry. Processed Food Ind., 13: 43-45.

Singh, V.P., N. Sachan and G.R. Bansal, 2009. Organic food: The key of human health. Proceedings of the Workshop on Organic Farming, Dec. 23-24, RVSKVV, Gwalior, M.P. pp: 33-39.

Singh, V.P. and N. Sachan, 2010a. Organic milk: The new era with old concept. Processed Food Ind., 13: 29-34.

Singh, V.P. and N. Sachan, 2010b. Quality assurance of milk and milk products. Agrovet Buzz, 2: 32-36.

Singh, V.P., V. Pathak and N. Sachan, 2011. Synthetic doodh-khatra evam bachav. Brij Me Krishi Evam Pashupalan, 5: 37-39.

Watkins, B.A. and M.F. Seifert, 2000. Conjugated linoleic acid and bone biology. J. Am. Coll. Nutr., 19: 478-486.