www.ioirp.com

International Journal of Innovative Research in Technology, Science & Engineering (IJIRTSE)
ISSN: 2395-5619, Volume – 1, Issue – 5. July 2015

Conjugated Linoleic Acid (CLA) as a Functional ingredient in Dairy foods

Dr.N.Karthikeyan
Assistant Professor, Department of Livestock Products, Technology (Dairy Science),
Veterinary College and Research Institute, Namakkal. India
karthitamil_2007@rediffmail.com.

***Abstract*— Conjugated linoleic acids (CLA) represent a heterogeneous group of positional and geometric isomers of linoleic acid, which are predominantly found in milk, milk products, meat and meat products of ruminants. CLA is a collective term used to describe positional and geometric isomers of linoleic acid (c9,c12 C18:2) with two double bonds in conjugation. Numerous animal studies associating CLA with beneficial health properties such as reducing the risk for cancer, atherosclerosis, and diabetes have been conducted.CLA has also been shown to have positive effects on immune function, bone formation and body composition.**

Biological synthesis of CLA occurs through the microbial isomerization of dietary linoleic acid in the digestive tracts of ruminant animals Therefore, ruminant species and their products are rich dietary sources of CLA. The major dietary sources of CLA for humans are dairy and meat products. Because of these biological properties and health benefits of CLA, recently there has been a lot of interest in enriching egg, meat and dairy products for human consumption.Despite the numerous health benefits seen in CLA-fed animals, the health effects of CLA in human beings remain controversial. The aim of this topic is to summarize whole merits, demerits and benefits of CLA for further improvement.

I. INTRODUCTION

A. History of CLA

[1] The first time established the presence of conjugated FA in milk fat. later concluded that CLA was bonded with two conjugated double bonds. In 1979, CLA was first identified from fried beef by Micheal Pariza, from the University of Wisconsin. In July 2008, CLA received a no objection certificate from the FDA on it GRAS (Generally Regarded as Safe) status for certain food categories including fluid milk, yogurt, meal replacement shakes, nutritional bars, fruit juices , soy milk and meat products.

B. Bio structure and synthesis of CLA in Rumen

CLA is a true isomer of LA, in that it does not possess an additional oxygen.

- Positional and Geometric isomers of LA
- $C_{18:2-}$ Linoleic acid-Omega-6 fatty acid
- $C_{18:3-}$ Linolenic acid-Omega-3 fatty acid

Conjugated linoleic acid is having both a "trans" fatty acid and a "cis" fatty acid.
The "cis" bond causes a lower melting point and also the observed beneficial health effects. Unlike other "trans" fatty acids, it is not harmful, but beneficial. The conjugated double bonds occur at carbon atoms 10 and 12 or 9 and 11, with all possible cis and trans combinations

CH_3-$(CH_2)_4$-C=C-CH_2-C=C-$(CH_2)_7$-COOH

↓

Normal structure of Linoleic acid

CH_3-$(CH_2)_6$-**C=C=C**-$(CH_2)_7$-COOH

↓

Normal structure of Conjucated Linoleic acid

C=C=C

↓

Beneficial to Humans[1]

C. Bio synthesis

CLA synthesis occurred in the rumen only. It was regarded as the only source of CLA in the milk and meat of ruminants. In rumen linoleic acid is biohydrogenated by the bacteria *Butyrivibrio fibrisolvens* [2]. CLA is now accepted to have two different origins as 1.Rumen 2.Endogenously in the tissues

1.Most Common Pathway - Rumen (High Roughage)

A. Linoleic Acid(LA)- Pathway

Linoleic acid *(cis*-9, *cis*-12-18:2)

↓

Conjugated linoleic acid (CLA, *cis*-9, *trans*-11-18:2) → Blood circulat., → M.gland→Milk

↓

Vaccenic acid (*Trans*-11-18:1)

Stearic acid (18:0)

B.Linolenic Acid(LNA)- Pathway

Linolenic acid (cis-9, cis-12, cis-15-18:3) →(Cis-9, trans-11, cis-15-18:3)

↓

(Trans-11, cis-15-18:2) → Trans-(11-18:1)Vaccenic Acid (TVA) Stearoyl CoA Desaturase

↓

M.gland →Epithelial cells → CLA → Milk

↓

Stearic acid (18:0)

This reaction probably major source of CLA in milk and tissues from ruminants.The enzyme responsible for the conjugation of *cis*-9, *cis*-12 double bonds -linoleic acid isomerase (EC 5.3.1.5)-particulate enzyme bound to the bacterial cell membrane Another rumen bacteria *Megasphaeraelsdenii* YJ-4 have also been shown to produce *t*-10, *c*-12 isomer of CLA. Rumen pH has an important role in maintaining a viable rumen environment suitable for *B. fibrisolvens* involved in the bio hydrogenation of LA and LNA. It has been shown that ruminal pH at 6.0 or above has a positive effect on TVA and CLA contents in rumen cultures.

D. Formation of CLA by Lactic acid bacteria (LAB)

Dairy starter culture, *Propinibacterium freudenreichii*, had the ability to produce CLA using free linoleic acid as a substrate

The metabolic pathway of lactic acid bacteria

LAB

↓ microaerobic conditions

LA

↓ linoleate isomerase

Hydroxy fatty acids

↓

precursors of the CLA isomers c9-t11

Same way *Lactobacillus reuteri* and *Lactobacillus acidophilus* also had the ability to produce CLA using free linoleic acid as a substrate in MRS broth.The presence of various medium components such as albumin, starch, cholesterol and lecithin help protect bacteria from free fatty acids during their growth. However, the complete mechanisms of CLA production by lactic acid bacteria remain unclear.

E. CLA Concentrations of various food products

CLA concentrations in dairy products typically range from 2.9 to 8.92 mg/g fat of which the 9-*cis*, 11-*trans* isomer makes up to 73% to 93% of the total CLA.

Meat products contains CLA in a similar range with the 9-cis, 11-trans isomer contributing 57% to 85% of total CLA.

CLA concentrations in fats from non ruminants and vegetable oils typically range from 0.6 to 0.9 mg/g fat.CLA content of various foods are as follows

Products	Mg/ g of fat
Dairy foods	
Homogenized milk	5.5
2% milk	4.1
Butter fat	6.1
Condensed milk	7.0
Cultured buttermilk	5.4
Butter	4.7
Sour cream	4.6
Ice cream	3.6
Low-fat yogurt	4.4
Custard style yogurt	4.8
Plain yogurt	4.8
Frozen yogurt	2.8
Medium cheddar	4.1
American processed	5.0
Other foods	
Fresh ground beef	4.3
Veal	2.7
Lamb	5.8
Pork	0.6
Chicken	0.9
Fresh ground turkey	2.6
Salmon	0.3
Egg yolk	0.6
Sunflower Oil	0.4

F. Factors influences CLA content

Several factors influence the CLA content of food products, such as:

- Temperature
- Protein quality
- Choice of starter cultures
- Period of aging

Variations of CLA content in foods are also affected by the animal's:

- Diet (type of feed, feeding regimen, grass quality, dietary restriction)
- Age or breed
- Seasonal factors
- Other processing factors that can influence the CLA content in dairy and meat products include cooking methods (grilling), the addition of hydrogen donors, and the addition of whey protein
- The seasonal variation of CLA is significant, with highest levels in cow's milk reported when the cows are allowed to graze in pastures

G. CLA in Humans

In humans, CLA has been detected mainly in blood, bile, adipose tissue and milk .CLA has also been found in human cervix because of bacterial colonization and activity is more in cervix

CLA in humans can result from two possible sources

1. Dietary sources such as ruminant meat and dairy fats contribute to CLA levels in human tissues, human serum and milk
2. Endogenous synthesis of CLA in humans may be formed by synthesis from linoleic acid in the human organism through anaerobic microbial activity in the large bowel [3].

H. Health implications of CLA

- Anti-cancer
- Anti-diabetes
- Anti-atherosclerosis
- Lipid metabolism
- Immune system
- Anti-oxidation
- Human skeletal health-Bone metabolism-Increased bone mass-Increased calcium absorption-Reduction in bone resorption
- Improved reproduction
- Studies have shown that CLA can delay or reduce the onset of chemically induced tumors in various sites of rats and mice, including skin, mammary glands, and fore stomach
- Proposed mechanisms of CLA and its anti carcinogenic activities include a reduction in cell proliferation, vitamin A metabolism, and prostaglandin metabolism
- CLA decreased mammary tumor incidence by 50% and tumor number by 45% in rats fed CLA at 0.8% of the diet.[4]
- Similarly, when human breast cancer cells were cultured with CLA enriched milk, cell number decreased to 61% of the original level [5].

I. Anti-diabetic

In humans, supplementation with mixed isomers of CLA was associated with improved fasting blood glucose. CLA was as equally effective as thiazolidinediones, a class of oral insulin sensitizing agents that improve glucose utilization without stimulating insulin release, in reducing fasting glucose.

Anti-oxidant

CLA isomers of *t*-10, *c*-12 and *c*-9, *t*- 11 are having effective antioxidant properties [6] both *c*-9, *t*-11 and *t*-10, *c*-12 isomers of CLA quench free radicals.

J. Lipid metabolism

A major effect of CLA in this respect is the reduction of lipid uptake by adipocytes which leads to the reduction in body fat gain

K. Improved Immune system

The implications of immunomodulatory effects of CLA on livestock production would probably be in enhancing the response of animals to vaccination and conferring disease resistance. [3] suggested that CLA influences the immune system by altering the effects of cytokine, interleukin, leukotriene and many immunoglobulins

Potential anti obesity mechanisms of CLA are:

- Decreased pre adipocyte proliferation and differentiation into mature adipocytes,
- Blocking of cell cycle during mitotic division and apoptosis of the adipocyte cells,
- Decreased fatty acid and triglyceride synthesis,
- Down regulation of key lipogenic enzymes, and increased energy expenditure,
- Lipolysis, and fatty acid oxidation.

Influence on Bone-metabolism

CLA has shown the innate ability to increase bone mass in a variety of animal models. This increase of bone mass, in general, can be explained by an increase in osteoblastic activity or a decrease in osteoclastic activity. [8] A higher rate of bone formation in chicks fed butterfat, which was suggested to be due probably to increased CLA intake. Increased ash content in CLA fed animals is due to protection of bone loss from cytokines [7]. Higher levels of bone ash in the tibia of CLA-fed chicks compared to control [3].

L. Reproductive performance

- Increased pregnancy rates
- Decreased number of days open
- Suppression of PGF2α and thereby decreasing the risk of early embryo losses
- Possible effect on the size of pre-ovulatory follicles

M. Steps to Increasing the Concentration of CLA in Milk

- Two possible ways to increasing CLA in bovine milk.
  1. Dietary modification in an attempt to increase cow's natural production of CLA
  2. Feeding mixtures of CLA isomers protected from the microbial biohydrogenation in the rumen.
- Steps
  1. Allowing cows to graze pasture
  2. Supplemental dietary oil to the rumen microbes
  3. CLA can be synthesized in laboratory
  4. CLA isomers are protected from the rumen environment
  5. Encapsulation of the fat in casein or feeding the fat as a calcium salt

II. CONCLUSIONS

Conjugated linoleic acids are predominantly present in products from ruminants because of the action of rumen micro-organisms in fatty acid biohydrogenation. The diet has a strong influence on CLA content. As has been shown in many studies, there are several ways to increase CLA levels in meat and milk from ruminants. In monogastric animals only the supplementation of CLA itself or its precursor trans-vaccenic acid are effective in elevating CLA contents.

CLA research has drawn much attention in the last two decades, in areas ranging from anticancer activities to obesity. With so many research papers published nowadays with regard to CLA's additional biological functions, mechanisms, and toxicity, it is clear that we do not know how these relatively simple structured fatty acids can have such a variety of functions in particular the isomer specificicity. Safety concerns regarding the use of CLA in humans persist and need further investigation, not only for CLA as a mixture but also as individual isomers, with better experimental designs that will clarify the mechanisms of CLA's activities.

References

[1] R.G.Booth, S.K. Kon, W.J. Dann and T. Moore, A study of seasonal variation in butter fat. II. A seasonal spectroscopic variation in the fatty acid fraction. *Biochem. J.,* 1935.pp 29: 133-137.

[2] A. C. Fogerty, G. L. Ford, and D. Svoronos. Octadeca-9,11-dienoic acid in foodstuffs and in the lipids of human blood and breast milk. *Nutr. Rep. Int.* 1988. pp.38:937.

[3] M. E. Cook, D. DeVoney, B. Drake, M. W. Pariza, L. Whigham and M. Yang. Dietary control of immune induced cachexia: conjugated linoleic acid and immunity. In: (Ed. M. P. Yurawecz, M. M. Mossoba, J. K. G. Kramer, M. W. Pariza and G. J. Nelson). Advances in Conjugated Linoleic Acid Research. Vol. I. AOCS Press, Champaign, IL, 1999. pp. 226-237.

[4] H. B. McDonald. Conjugated linoleic acid and disease prevention: a review of current knowledge. *J. Am. College Nutr.* 2000. pp.19:111S-118S.

[5] A. Miller, C. Stanton, J. Murphy and R. Devery. Conjugated linoleic acid (CLA)-enriched milk fat inhibits growth and modulates CLA-responsive biomarkers in MCF-7 and SW480 human cancer cell lines. *Br. J. Nutr.* 2003.pp. 90:877-885.

[6] L. Yu, D. Adams and M. Gabel. Conjugated linoleic acid isomers differ in their free radical scavenging properties. *J. Agric. Food Chem.* 2002. pp.50:4135-4140.

[7] Y. Park, M. K. McGuire, R. Behr, M. A. McGuire, M. A. Evans and T. D. Shultz. High-fat dairy product consumption increases Δ9 c,11 t18:2 (Rumenic acid) and total lipid concentrations of human milk. *Lipids.* 1999. pp.34:543-549.

[8] B. A. Watkins, C. L. Shen, K. G. Allen and M. F. Seifert. Dietary (n-3) and (n-6) polyunsaturates and acetylsalicylic acid alter *ex vivo* PGE2 biosynthesis, tissue IGF-I levels, and bone morphometry in chicks. *J. Bone Miner. Res.* 1996.pp. 11:1321-1332.