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Influences of Conjugated Linoleic Acid on Poultry Products

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ABSTRACT

Conjugated linoleic acid (CLA) has a potential role in the prevention of cancer tumors of the skin, breast, stomach and intestine. CLA also has the ability to prevent cardiovascular disease, atherosclerotic disease, diabetes, regulation of immune responses and change in body composition by reducing body fat. Fats that originated from the ruminants are the main sources of CLA. But poultry products are contain traces of these fatty acids. Fatty acids content in monogastric diets did not change after digestion and absorption, compared with ruminants. So use of synthetic CLA or its precursors, can increase the synthesis and save of this fatty acid in poultry products. After absorption, the CLA or its resources, are stored in phospholipids of call membrane, fatty tissue and eggs. Therefore attempts to enrich poultry production via CLA as an appropriate method for improving human nutrition by organic sources, will cause the useful results.

Key words: Conjugated linoleic acid; Poultry products

INTRODUCTION

In the early 1980s, some researchers have found that; the beef containing active substances that are attributed to genetic mutations. These researchers subsequently stated that these molecules also prevent the development of skin tumors in mice (Schmidt et al, 2005).

The active molecules, which are isomers of linoleic acid, were named as conjugated linoleic acid (CLA) (Aydin, 2005).

Many studies have been done on CLA, because this fatty acid has a potential role in the prevention of cancer tumors in the skin, breast, colon and stomach of the laboratory animals.

In addition, it was found that CLA is effective in the prevention of cardiovascular disease, atherosclerotic and regulation of immune responses. CLA has ability to change body composition by reducing body fat (MacDonald, 2000; Belury, 2002).

Foods that contain ruminant fats are important source of CLA. Milk and dairy products contain the highest amount of CLA, but poultry products are contain low amount of this fatty acid. The poultry meat and egg are containing 0.6 and 0.9mg of CLA per gram of body fat, respectively (Kelly, 2001).

Dietary CLA isomers, stored in membrane phospholipids and adipose tissue after absorption, therefore if birds fed diets supplemented with CLA or its precursors, leading to increase this fatty acid in their meat or eggs. These products can be considered as beneficial food source for human’s (Aydin, 2005).

STRUCTURE OF THE CLA

Fatty acids are known as the most important energy sources for animals. The energy content of fatty acids is 3-2 times more than carbohydrates and protein. Omega-3 and omega-6 are most important of fatty acids, which are derived from linolenic and linoleic acid respectively. Linoleic and linolenic acids must be present in the diet, because poultry are not able to synthesize them. These essential fatty acids are precursors of 20 and 22-carbon unsaturated fatty acids which play important role in the formation of the structure and function of the cell.
membrane and moreover are precursors of eicosanoids (group of hormone-like substances such as prosta-
glandins, leukotrienes, thromboxane’s, prostacyclin and
Lipoxin). Double bonds are separated by a single
methylene group in the carbon chain of linolenic and
linoleic acid but there is no methylene group between the
double bonds of conjugated fatty acids isomers, this
means that single and double bands located alternately in
conjugated fatty acids. (Kelly, 2001; Khanal and Dhiman,
2004).

Linoleic acid is an 18-carbon unsaturated fatty acid with
two double bond at positions C9, C12. In structure of this
fatty acid the double bonds are arranged in a Cis form. But
double bonds of CLA located at C9, C11 or C10, C12
positions and the double bonds are arranged in both Cis
(c) and trans (t) forms. So it could be at least 24 isomer of
CLA. However the Isomers which containing at least one
trans double band have biological activity and a few of
these isomers are found in natural foods. The identified
isomers of conjugated linoleic acid include the; CLA: c9-
t11, CLA: t10-c12, CLA: c10-t12, CLA: c8-t10 and CAL: t7-
c9. CLA: c9-t11 is the most abundant isomer in natural
foods. Since the value of this isomer is higher in ruminant
milk than other foods known as Rumenic Acid (RA). It is
believed that this isomer has the highest biological
activity compared to other isomers of CLA, because this
isomer can be deposited in the phospholipids of animal
tissues (Khanal and Dhiman, 2004). In recent years it has
also been observed biological activity of other isomers, in
particular CLA: t10-c12.

SYNTHESIS OF CLA

CLA is naturally synthesized through bacterial isomeri-
ization, ruminal hydrogenation of polyunsaturated fatty
acids and unsaturation of trans fatty acids in adipose
tissue and mammary gland (Khanal and Dhiman, 2004;
Schmidt et al, 2005).

Several studies have shown that in vivo synthesis of CLA
in human and poultry is carried out through unsaturation
of vaccenic acid by Delta- (9), desaturase. Fatty acids
content in monogastric diets did not change after
digestion and absorption, compared with ruminants. So
use of synthetic CLA or its precursors, can increase the
synthesis of this fatty acid in poultry. Also, the CLA
isomers are produced artificially by alkaline
isomerization of linoleic acid. There is no difference
between synthetic and natural isomers of CLA. However
relative amounts of each of the isomers in these two
sources are differ (Pariza et al, 2006).

Both CLA: c9-t11 and CLA: t10-c12 are active Isomers
which there are in both natural and synthetic sources. It
seems that these two isomers rapidly absorbed and
stored in body. The ratio of CLA: c9-t11 and CLA: t10-c12
in synthetic sources is 1:1. While 80% of CLA is as the
CLA: c9-t11 form in natural resources (Khanal and
Dhiman, 2004).

PHYSIOLOGICAL
CHARACTERISTICS OF CLA

CLA is an anti-cancer agent, Strong antioxidant,
strengthen the immune system and reduce "fat obesity".

The anti-cancer properties of this fatty acid due to an
inhibitory effect on the proliferation of cancer cells and
prevent the deformation of cells. These properties reduce
the risk of cancer of the breast, prostate, colon, lung, skin,
and stomach (Belury, 2002).

In addition, it has been suggested that the part of anti-
cancer effect of CLA may be is related to its antioxidant
properties (Ann, 1999).

The CLA prevents atherosclerosis and it is effective on
reducing food allergy reactions. All cell membranes are
made of fat and fatty acids. These agents act as a signal in
the cells. According to some researchers CLA act by signal
of immune system and regulate the body’s metabolism
and inhibits cellular enzymes that are getting fats. CLA
increases the enzymes that are responsible for
transporting lipids and fatty acid oxidation. In fact, will be
transfer and burning the fats from resources in body. CLA
reduces the necessary enzymes for the absorption of fat
and triglycerides in fat cells. Also reduced lipoprotein
lipase activity by CLA, so reduced ability of fat cells to take
of blood fats and increase the capacity of fatty acids
oxidation in adipose tissue and skeletal muscle (Muller
and Delahoy, 2005).

CLA increases the sensitivity of muscle tissue to insulin,
so increase and maintain muscle mass and fat oxidation.
Ultimately increase basal metabolism and reduce body
fat stores. It is believed that the CLA reduces body fat and
increase muscle tissue, also increases bone density and
strength. Formation and increase bone strength is due to
inhibitory effect of CLA on the production of anti-
inflammatory prostaglandins (Du and Ann, 2002; Jason,
2012).

While CLA is beneficial to human health, but
unfortunately there are not enough in the daily diet of
people. In a study that conducted in the United States,
proposed that the daily consumption of CLA must be 300
to 600 mg; it was later announced that, this value should
be about 3 g or more to achieve positive results.

This is a challenging question that; to supply the needs of
CLA, whether must be consume more dairy and poultry
products or increase the CLA level in dairy and poultry
products through enrichment of animal diets?
EFFECTS OF CLA ON EGG QUALITY

In recent years, focused by many researchers on the enrichment of eggs by fatty acids to enhance human health. For example, due to the role of cholesterol in cardiovascular disease, much effort have been done to reduce the cholesterol content of egg yolk. In this field through the addition of long-chain polyunsaturated fatty acids in the diet of laying hens, some success has been achieved. Also, due to the beneficial effects of CLA on human health many study have been done to increase the CLA content of egg by supplementation of laying diets. Yolk can be suitable source for these fatty acid because the yolks contain 35-30 % fat. Attempt to enrich poultry production by the CLA as a suitable method to improve human health, have been achieved both positive and negative results. So that supplementation of the diet of laying hens on the one hand, increase the CLA content of the yolk but on the other hand, decrease egg quality such as increase hardness of yolk during storage, color of albumen and yolk, disturbing of pH gradient between the albumen and the yolk (Ann, 2007).

In addition, CLA has led to increase saturated fatty acids and reduced hatchability of fertilized eggs. A study showed that dietary supplementation by CLA, changed pH of yolk and albumen when egg storage at 4˚C. So that after 10 weeks the pH of yolk and albumen were changed from 6.12 and 9.06 to 7.89 and 8.23, respectively (Ann, 2007). Also, after 10 weeks, increased Mg and Na concentrations of yolk containing CLA, while decreased the percentage of iron in the yolk. In addition Mg and Na concentrations in albumen was reduced compared to the control group. The hypothesis that; alkaline ions such as Mg, K and Na are replaced between the yolk and albumen during storage of eggs. So increase the pH of yolk and changes in permeability of vitelline membrane. Degrade the proteins of yolk when change pH and hardness of it. This yolk will be elastic and rubbery. Studies have shown that yolk of CLA eggs contains more water. It can be the reason of negative influence of CLA on egg quality (reduction of albumen and yolk color) (Khanal and Olson, 2004).

Most of fatty acids concentration of egg yolk changed after dietary supplementation with CLA. So that the concentration of myristic, palmitic and stearic acids are increased as quadratic equation by increasing dietary CLA and simultaneously reduced the concentration of oleic, linoleic, linolenic and arachidonic acids of egg yolk lipids.

Since this enzyme catalyzes the formation of a double bond between carbons 9 and 10 in the hydrocarbon chain. So this inhibition that induced by CLA decrease concentration of fatty acids with a double bond and increase saturated fatty acids in yolk. It seems that the most of these changes are due to inhibition of the enzymatic Δ-9, desaturase system by CLA: t10-c12 (Du and Ann, 2002). Changes in fatty acid levels may be due to changes in the enzymatic Δ-9, desaturase system in the liver of hens that affected by CLA. It has been found that dietary supplementation with CLA resulted in decreased mRNA transcription followed by reduced activity of Δ-9, desaturase in the liver of egg-laying chickens.

| Table 1: Effect of different levels of dietary CLA on fatty acid composition of egg yolk (% of total fatty acids) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | 0 % CLA         | 2.5 % CLA       | 5 % CLA         |
| Saturated Fatty Acids | 31.81d          | 40.30d          | 43.66d          | 44.84d          | 45.68d          |
| Mono Unsaturated Fatty Acids | 36.10e          | 29.07e          | 26.46c          | 26.49c          | 25.81c          |
| Poly Unsaturated Fatty Acids | 31.82e          | 30.40b          | 29.63c          | 28.86d          | 27.34c          |
| Total CLA        | 0.01e           | 2.08d           | 5.95c           | 10.05b          | 14.15a          |
| CLA: c9-11       | 0e              | 1.67d           | 4.33c           | 6.98b           | 9.63a           |
| CLA: t10-c12     | 0e              | 0.40d           | 1.50c           | 2.73b           | 4.02a           |
| CLA: c9-c11      | 0e              | 0e              | 0e              | 0.14b           | 0.22a           |
| CLA: c9-11       | 0.01d           | 0.02d           | 0.15c           | 0.21b           | 0.28a           |

Means within each row with different superscripts are significantly different (p<0.05)
Received from: Ann (2007)

| Table 2: Effect of different levels of dietary CLA on fatty acid composition of egg yolk (% of total fatty acids) |
|-----------------|-----------------|-----------------|-----------------|
|                 | 0 % CLA         | 2.5 % CLA       | 5 % CLA         |
| Saturated Fatty Acids | 34.96           | 43.90           | 44.66           |
| Mono Unsaturated Fatty Acids | 33.92           | 22.76           | 25.10           |
| Linoleic Acid     | 23.43           | 22.37           | 14.72           |
| Linolenic Acids   | 1.37            | 1.07            | 0.32            |
| Total CLA         | -               | 6.82            | 14.89           |
| Arachidonic Acid  | 3.74            | 2.72            | 2.47            |
| Decosahexaenoic Acid | 2.06           | 0.82            | 0.34            |

Statistical analysis has not been done
Received from: Ann (2007)
EFFECTS OF CLA ON GROWTH AND QUALITY OF POULTRY MEAT

In recent years, one of the main topics of poultry industry is weight gain and reduced feed conversion ratio. However, other parameters such as loss of stored body fat in poultry must be considered. One of the most important effects of CLA on animal performance is reduced fat accumulation and muscle growth (development). Some researchers have suggested that CLA can reduce body fat content in adult and young animals by increasing low fat muscles. Because CLA reduces lipoprotein lipase activity and increases lipolysis in fat cells (Ann, 2007).

CLA through inhibition of lipoprotein lipase activity can reduce the triglycerides and glycerol in fat cells and thus leads to fat reduction and body composition changes. The effects of CLA on body composition is due to reducing fat storage, increase lipolysis in adipocytes and increases fatty acid oxidation in fat and muscle cells. It has been reported that diets containing 0.5% CLA decrease significantly fat, protein, water and ash in the body of rat. So that body fat was decreased about 60% and body protein was increased more than 10% (Corino et al, 2002).

The chicken that have consumed a diet containing 1% CLA, do not accrued changes in the hardness, pH and sensory characteristics (including texture, flavor, aroma, texture and color) of their meat. But if the CLA level increased to 2-3 %, affects the quality of breast meat, so that the stiffness and strength of breast is increased and amount of its water is slightly reduced.

These changes are due to changes in fatty acid composition of muscles. Melting of fat is increased by increase the amount of body saturated fatty acids, which may explain the increased hardness of poultry meat and reduce of its succulent. Furthermore, increasing the protein content of meat could be another reason for the increased stiffness of breast meat. Due to the antioxidant activity of CLA, it seems that dietary supplementation with this fatty acid lead to improved oxidative stability of meat during storage and storing (Schmidt et al, 2005).

Since the CLA in poultry diets decreased the content of polyunsaturated fatty acids and increased levels of unsaturated fatty acids of meat, so that the meat has a low sensitivity to oxidative corruption and so low volatile compounds will be created.

Researchers found that feeding of moderate levels of CLA resulted in a linear increase of the concentration of CLA isomers in muscles fat. CLA isomers stored in fat contents of various organs, although the accession of CLA isomers are different.

As storage of CLA: c9-t11 and CLA: c11-t13 in poultry meat is more than CAL: c10-t12 and the other isomers (Schmidt et al, 2005; Javadi et al, 2007).

<table>
<thead>
<tr>
<th>Table 3: Effect of different levels of dietary CLA on fatty acid composition of egg yolk (% of total fatty acids)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Palmitic+ stearic acid</td>
</tr>
<tr>
<td>Palmitoleic+oleic acid</td>
</tr>
<tr>
<td>Linoleic acid</td>
</tr>
<tr>
<td>Linolenic acids</td>
</tr>
<tr>
<td>Total CLA</td>
</tr>
<tr>
<td>Arachidonic acid</td>
</tr>
<tr>
<td>Eicosapentaenoic acid</td>
</tr>
<tr>
<td>Docosahexaenoic acid</td>
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</table>

Means within each row with different superscripts are significantly different (p<0.05)
Received from: Ann (2007)

<table>
<thead>
<tr>
<th>Table 4: Effect of different levels of dietary CLA on fatty acid composition of poultry carcasses (% of total fatty acids)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Saturated Fatty Acids</td>
</tr>
<tr>
<td>Mono Unsaturated Fatty Acids</td>
</tr>
<tr>
<td>Linoleic acid</td>
</tr>
<tr>
<td>Linolenic acids</td>
</tr>
<tr>
<td>Total CLA</td>
</tr>
<tr>
<td>Arachidonic acid</td>
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<tr>
<td>Eicosapentaenoic acid</td>
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<tr>
<td>Docosahexaenoic acid</td>
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</tbody>
</table>

Means within each row with different superscripts are significantly different (p<0.05)
Received from: Ann (2007)
CONCLUSION

Given the expectation of the poultry products, we can increase the amount of CLA in poultry products through supplementation of their diets with synthetic CLA or natural resource of it. It should be noted that the effects of CLA isomers are different. The Lipolysis inhibition and decreased activity of Δ-9, desaturase is mainly related to CLA: t10-c12, this isomer changes body composition and reduces body fat. While anti-cancer and antiatherosclerotic characteristic is related to CLA: t10-c12 and CLA: C9-t11.

REFERENCES


Table 5: Effect of different levels of dietary CLA on fatty acid composition of broiler breast tissue (% of total fatty acids)

<table>
<thead>
<tr>
<th>CLA levels (% diet)</th>
<th>Poly Unsaturated Fatty Acids</th>
<th>Saturated Fatty Acids</th>
<th>Mono Unsaturated Fatty Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 % CLA</td>
<td>2.93</td>
<td>29.97b</td>
<td>32.62b</td>
</tr>
<tr>
<td>2 % CLA</td>
<td>2.67</td>
<td>38.65a</td>
<td>23.32b</td>
</tr>
<tr>
<td>3 % CLA</td>
<td>2.11</td>
<td>37.07*</td>
<td>23.44b</td>
</tr>
</tbody>
</table>

Table 6: Effect of different levels of dietary CLA on CAL amount of broiler breast tissue (% of total fatty acids)

<table>
<thead>
<tr>
<th>Total CLA (% diet)</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 % CLA</td>
<td>5.37a</td>
<td>7.11a</td>
<td>2.23a</td>
<td>3.28a</td>
</tr>
</tbody>
</table>

Means within each row with different superscripts are significantly different (p<0.05) Received from: Du and Ann (2002)

Muller, L.D and J. Delahoy (2005) Conjugated Linoleic Acid (CLA) Implications for Animal Production and Human Health. DIR & ANIM SCI.

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