Effect of dry carboxylate salt mixture of fish oil supplementation on fatty acids compositions of cow milk fat

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Abstract. A study was conducted to determine the effect of feeding dry carboxylate salt mixture of fish oil (DCM-FO) on fatty acids composition of cow milk fat. Eight lactating Friesian Holstein crossbred cows with an average weight of 275 to 300 kg produced 3 to 3.5 liters milk per day, were randomly allocated to two treatment groups. All cows were fed approximately 4 kg of concentrate and maize husk, each weight 2 kg. Two treatment groups were given no supplement and 90 g of DCM-FO as a supplement, respectively. Result of the study showed that supplementing DCM-FO in lactating cows feed significantly increased milk fat, caprylic acid (C8:0), capric acid (C10:0), myristic acid (C14:0), EPA (C20:5n-3), and DHA (C22:6n-3). Inversely, 90 g DCM-FO supplementation in dietary can significantly decrease oleic acid (C18:1). Supplementing 90 g DCM-FO in dietary had no significant effect on lauric acid (C12:0), palmitic acid (C16:0), stearic acid (C18:0), linoleic acid (C18:2), and linolenic acid (C18:3). The study indicated that supplementing 90 g of DCM-FO in lactating cows feed did not enhance long-chain fatty acids except for EPA and DHA in cow milk. However, it increased milk fat and short-chain fatty acids in cow milk fat.

1. Introduction
During mid to late lactation, it tends to be difficult for dairy cows to maintain body fat storage. This condition can lead to low production of milk in the next lactation. High energy feed can be given to help restoring body fat for the next lactation. One of the approaches to increase energy in the feed intake is by feeding fat-supplement feed in mid to late lactation period in cows\textsuperscript{[1]}. Several technologies are currently used to provide rumen-protection fat for dietary supplements with calcium salt of fatty acids.

Dry carboxylate salt mixture of fish oil (DCM-FO) is fish oil processing product. It is rumen-by pass fat source of essential fatty acid as EPA (eicosapentaenoic acid; C20:5n3) and DHA (docosahexaenoic acid; C22:6n-3) for lactating dairy cows\textsuperscript{[2]}. Responses to supplementation of dairy cows dietary with carboxylate salt varied between treatments. Feeding rumen bypass fat to dairy cows has been reported to increase milk fat without affecting the digestibility of other dietary nutrients. The objective of this study is to determine the effects of supplementing DCM-FO on fatty acids composition of cow milk fat.

2. Material and Methods
Eight lactating Friesian Holstein crossbreed (FHC) cows in mid-lactation, producing 3 to 3.5-liter milk per day with an average weight of 275 to 300 kg were used in this study. The cows were randomly allocated to two treatment groups with 4 cows in each group. All cows were fed 2 kg of
concentrate (70% TDN and 16% crude protein) and 2 kg of maize husk mix (2 kg each). The first group was given no supplementation while the second group was given 90 g of DCM-FO. The treatment was given for eight weeks with 2 weeks prior for feed adjustment and 2 weeks for measurement.

Each cow was housed individually in 2x3 m² pen and milked twice a day at 5 AM and 3 PM. Milk yields were recorded daily for each cow. Milk samples from individual cows were collected for two consecutive days on the fourth week then subjected to laboratory analysis. Fat milk was analyzed using the Gerber method. Fatty acids composition analysis was done by gas chromatography method in Kliem et al[3]. The data collected then analyzed using t-test student [4 SAS 1996].

3. Discussion
The present study showed that supplementation of 90 gram DCM-FO significantly increased milk fat, short-chain fatty acids, polyunsaturated fatty acid n-3 (PUFA n-3). Inversely, supplementation of 90-gram DCM-FO significantly decreased mono-unsaturated fatty acid (MUFA, C18:1). The supplementation had no significant effect on lauric acid (C12:0), palmitic acid (C16:0), stearic acid (C18:0), linoleic acid (C18:2), and linolenic acid (C18:3). Milk fat and fatty acids composition in cows milk fat are given in table 1.

| Variable          | Concentrate + Maize husk 0 g DCM-FO | Concentrate + Maize husk 90 g DCM-FO |
|-------------------|-------------------------------------|--------------------------------------|
| Milk fat (%)      | 3.45 ± 0.31 a                       | 6.60 ± 0.49 b                        |
| Caprilic acid (C8:0) | 0.96 ± 0.08 a                       | 1.30 ± 0.14 b                        |
| Capric acid (C10:0) | 1.87 ± 0.21 a                       | 2.52 ± 0.26 b                        |
| Lauric acid (C12:0) | 2.27 ± 0.26 a                       | 2.37 ± 0.38                          |
| Miristic acid (C14:0) | 1.29 ± 0.64 a                       | 8.73 ± 0.10 b                        |
| Palmitic acid (C16:0) | 19.67 ± 0.77 a                      | 22.95 ± 2.86                         |
| Stearic acid (C18:0) | 6.92 ± 0.39 a                       | 9.09 ± 1.72                          |
| Oleic acid (C18:1) | 18.02 ± 1.51 b                      | 12.46 ± 1.37 a                       |
| Linoleic acid (C18:2) | 3.02 ± 0.12 a                       | 2.78 ± 0.85                          |
| Linolenic acid (C18:3) | 0.36 ± 0.27 a                       | 0.35 ± 0.18                          |
| EPA (C20:5n-3)    | 0.0 ± 0.0 a                          | 0.06 ± 0.03 b                        |
| DHA (C22:6n-3)    | 0.0 ± 0.0 a                          | 0.02 ± 0.01 b                        |

a,b Different superscripts in the same line represent significant difference between treatments (p<0.05)

Increasing short-chain fatty acids (SCFA) in milk suggested that supplementation with DCM-FO did not affect longer chain fatty acids (C18:0), except for Oleic acid (C18:1). A more likely explanation is that this was caused by inhibition of mammary gland de novo synthesis by long-chain unsaturated fatty acids which have either escaped rumen biohydrogenation or are intermediates of this process. Several studies showed that increasing amount of long-chain (≥ 18 carbon) of unsaturated fatty acid (USFA) in dietary has been found to inhibit de novo synthesis [5]. Calcium salts of unsaturated fatty acids reduce milk fat concentration of saturated fatty acids (SFA) synthesis de novo [6].

Table 1 showed that DCM-FO provided almost twice the amount of total fat than the other treatment. This result differs from Lounglawan et al [1] which suggested that feeding rumen-protected fat in form of Ca-salt fatty acids did not significantly affect total milk fat. Inversely, this study results are in accordance with Kliem et al [3] which stated that supplementation of Ca-MUFA also resulted in linear increases of milk fat (p<0.05).

Castaneda-Gutierrez et al [7] reported that Ca salts of fish oil provide rumen inertness about adverse effects on milk fat but provide no protection against bio-hydrogenation of EPA and DHA in rumen. Post ruminal supply of EPA and DHA from Ca-salts of fish oil is a function of the limited proportion of these fatty acids that escape rumen bio-hydrogenation. Concentration of PUFA (n-3), for example, EPA (C20:5n-3) and DHA (C22:6n-3) was very low in milk fat because DCM-FO feed consists of unsaturated fatty acids that prevent drastic modifications of the rumen environment and
release of unsaturated fatty acids will occur slowly. During the baseline period, EPA and DHA average in milk fat was only 0.06% and 0.02%, respectively. Changes in the milk fatty acids profile were observed for other fatty acids especially with DCM-FO treatment where alterations include marked reduction of oleic acid.

Decreasing oleic acid concentration in milk fat with dietary DCM-FO was not reported by Kliem et al [3] which suggested that increasing the inclusion level of Ca-MUFA in diet linearly increased oleic acid in milk fat. DCM-FO supplementation in lactating cows resulted in increasing all short-chain fatty acids (p<0.05) except for lauric acid (C12:0) and palmitic acid (C16:0) which not significantly increased. This indicates that DCM-FO supplement did not prevent drastic modifications of rumen environment because the release of unsaturated fatty acids (USFA) occurs slowly. No clear conclusion can be drawn as to which of these individual fatty acids changed in concentration when their respective sums were increased by DCM-FO supplementation.

It was proposed that by feeding Ca-salts, unsaturated fatty acids are removed from free fatty acids pool by bio-hydrogenation. Ca-salts of PUFA will further dissociate to maintain balance between dissociated and undissociated unsaturated fatty acids, thereby conferring rumen inability to affect fiber digestion by this more gradual shift.

4. Conclusion
Supplementation with 90 g of dry carboxylate salt mixture of fish oil mix (DCM-FO) in dietary of lactating cows enhanced milk fat, short-chain fatty acids except lauric acid (C12:0) and palmitic acid (C14:0), EPA (C20:5n-3) and DHA (C22:6n-3), decreased oleic acid (C18:1) but did not increase long-chain fatty acids, stearic acid (C18:0), linoleic acid (C18:2), and linolenic acid (C18:3).

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6. References
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