Review: The Effect of Protected Lemuru Fish Oil in Total Mixed Ration of Thin-Tailed Sheep

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Abstract. Sheep is one of the small ruminant producing red meat in Indonesia. Sheep meat contains higher saturated fatty acid compared to non-ruminant meat products. Meat consumption with high saturated fatty acid should be limited due to a higher risk of atherosclerosis (blood vein constriction) causing coronary heart disease. Strategy to reduce saturated fatty acid in the sheep meat should be conducted by increasing unsaturated fatty acid content in sheep meat. Accelerating unsaturated fatty acids can be done by feed supplementation containing unsaturated fatty acid. It can be done by protecting unsaturated fatty acids to avoid bio-hydrogenation process in the rumen. Lemuru fish oil can be utilized as an unsaturated fatty acid source. Supplementation of protected lemuru fish oil in total mixed ration (TMR) is considered to improve treatment effectivity, due to sheep is unable to choose certain feedstuffs and instead of ingesting the whole diets so that the consumed diet had balance nutrient. Supplementation of protected fat is suggested to not modify rumen fermentation, improving sheep performance, and increasing unsaturated fatty acid content of sheep meat. This review provides previous research studies with protected fat supplementation in sheep diet.

1. Introduction

Thin-tailed sheep is one of the local sheep from Indonesia or most known as Javanes Thin-Tailed Sheep. The sheep is categorized as meat producing sheep. In the beginning, the thin-tailed sheep was only located in Central Java and West Java, however, in the present, the sheep have been grown in all Indonesia island, especially Java island. The sheep excels in the category because of prolific characters (able to conceive 2-5 twin in every birth), easy to breed, unaffected by seasonal mating season, ability to adapt to tropic climate, and bad feeds [1].

The threats in developing sheep as meat producing livestock are the high level of cholesterol content and saturated fatty acid. This increases the risk of blood vein constriction (atherosclerosis) and causing coronary heart disease. This condition causes community to restrict to consume sheep meat and enabling reduction in sheep meat consumption. Therefore, a strategy to reduce saturated fatty acid level in sheep meat and enhance unsaturated fatty acid to ensure the health safety issues should be justified.

One of strategy to address by feed supplementation with unsaturated fatty acid source. However, feed supplementation with high fat content have high potentiality inhibiting rumen microbial activity, in addition fat in the rumen can undergo bio-hydrogenation process. Bio-hydrogenation process in the rumen alter unsaturated fatty acid into saturated fatty acid. Therefore, it is essential to develop feedstuffs protection to protect unsaturated fatty acid from being involved in the rumen bio-hydrogenation process and not affect rumen ecology. Source of unsaturated fatty acid can come from either plant-based oil or animal-based oil. Animal-based oil such as lemuru fish oil, meanwhile as plant-based oil such as soya oil, crude palm oil, and sunflower oil.
Total Mixed Ration (TMR) is feeding provision in complete feed presentation in which the diet will be full mixture of crude feed, concentrate, protein source, mineral, vitamin, and feed supplement. TMR presentation is mixed into single complete feed to avoid the livestock to select specific feedstuffs, so that the feed consumed is balance ration with balance nutrient content [2]. Supplementation of protected fatty acid in the feedstuffs in the form of TMR is suggested to reduce cholesterol level, increase unsaturated fatty acid in sheep meat, and improve sheep performance.

2. Fat Metabolism in Rumen
Fat is one of the energy sources with calories value equivalent 2.25 times carbohydrate. In ruminant, fat content in the diet should not above 5% because high fat content affect rumen microbial activity by reducing fiber degrading microbe population [3]. Fat (triglyceride, glycolipid, phospholipid) if being consumed by ruminants and enter rumen site, undergoes two processes, hydrolysis process of ester chain of fat from feed and bio-hydrogenation process of unsaturated fatty acid after fat is being hydrolyzed into free fatty acid [4]. Hydrolysis of dietary lipids is predominantly due to rumen bacteria with little evidence for a significant role by rumen protozoa and fungi, or salivary and plant lipases. Although the extent of hydrolysis is generally high (>85%), a number of factors that affect the rate and extent of hydrolysis have been identified [4].

3. Lemuru Fish Oil as Unsaturated Fatty Acid Source to Protect Fat Content of Feed
Source of unsaturated fatty acid for feed supplementation in ruminant can be from animal-based oil. Lemuru fish oil is one of animal-based oil from the waste of fish processing and have high potentiality to be used as energy source due to high energy content as much as 8400 kcal/kg [5]. Lemuru fish oil contain high unsaturated fatty acid (80.12%), meanwhile, crude palm oil contained 56.24% monounsaturated fatty acid and 43.48% saturated fatty acid [5]. Based on [6] study, lemuru fish oil contains Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA), whereas sunflower oil and corn oil have no EPA and DHA content.

High quality fish oil is fish oil with high level of fatty acid that is beneficial for health. Omega-3 is one of unsaturated fatty acid which is essential for body and required especially for people with high cholesterol level. EPA and DHA are omega-3 forms mostly found in fish oil. EPA and DHA are not produced by fish, otherwise by see plants such as algae. EPA and DHA content in fish is a result from consuming algae that contain both fatty acids [7].

4. Fat Feed Protection Methods
The utilization of oil supplementation constrained due to hydrolysis and hydrogenation process. Feed supplementation with high oil content have high risk of inhibiting rumen microbial activity. Therefore, feed protection is suggested to protect the fat from being hydrolyzed and hydrogenated in the rumen but is able to be digested in intestinal site. In addition, fat protection can avoid the negative effect of fat in ruminant diet, such as reduction in fiber digestibility [8].

Several technologies to protect fat in accordance to [9], have been conducted physically or chemically by mean to reduce the negative effect of fat towards carbohydrate digestibility and rumen bacterial population as well as suppress hydrogenation process of fat in the rumen. The saponification technology process is one of the most recent technology compared to formaldehyde technologies which have been applied commercially.

Protection method to shield fat from being degraded in the rumen can be conducted by binding carboxyl group with minerals, such as Ca and Mg. This method is known as formation of calcium soap or magnesium soap. Polyunsaturated fatty acids such as linoleate or linoleic can be protected using this method so that can be directly utilized by animals without prior degradation process [3]. Calcium soap is one of protected fat form and one of effective fat source in ruminant feeds, ensuring rumen fermentation remains normal, have high fatty acid digestibility, and the soap can be easily mixed with feeds [9,10]. The soap formation of calcium (Ca-Soap) is done through chemical process involving
fatty stuffs with NaOH aliquot through the saponification process. It then followed with mixture of CaCl solution to obtain calcium soap which unable to dissolve in water [11].

5. Total Mixed Ration
Total Mixed Ration (TMR) is feeding provision in complete feed presentation in which the diet will be full mixture of crude feed, concentrate, protein source, mineral, vitamin and feed supplement [2]. TMR contains balance nutrient to meet nutrient requirement of animals [2,12]. Animals being provided with TMR were classified based on nutrient requirement [12,13]. The advantage of TMR presentation is the opportunity of feed consumed in each bite have complete and balance nutrient. Issues arise from unhomogenized mixing process, feed selection by animals, milk fat depression, and other digestion issues are relatively low with TMR feeding [14]. TMR presentation is mixed into single complete feed to avoid the livestock to select specific feedstuffs, so that the feed consumed is balance ration with balance nutrient content [2].

Crude feed with low quality or low palatability feedstuffs are going to be consumed by animals if presented through TMR [2]. This is due to mixing process overpowers the palatability of single feed [12]. Therefore, farmers can utilize waste feed to reduce operational cost [12]. Other advantages by implementing TMR is feed consumption can be adjusted to its feed requirement, reducing feed refusal and suppressing feed cost [2]. Furthermore, feed efficiency can be enhanced 4% compared to separately feeding the course and concentrate feeds, twice a day [12]. Feed with low palatability can be mixed in the TMR to increase the intake [13].

Meat conversion ratio was lower with Kacang goat diet in TMR form with formaldehyde protected 50% soybean meal (SBM) compared to control group with only TMR [14]. This indicates TMR is efficiently improving carcass production [15].

6. Effect of Protected Fat Supplementation
6.1. Productivity traits.
Supplementation of soap lemuru fish oil did not affect sheep performance [6]. Meanwhile, study showed that inclusion of 10% crude palm oil in concentrate feeding did not reduce feed consumption but resulted in lower average daily gain (ADG) compared to control group (87.68 vs 100.18 g/day). On the other hand, if the crude palm oil is protected, then the ADG would be greater (112.86 g/day) [9]. When the protected fatty acid content is increased in the diet, sheep performance will not be getting better, supplementation of protected fatty acid should not be excessively more than 10% in concentrate feeding [16]. Reduction in ADG was shown with fish oil supplementation at level 2 and 4.5% as much as 62 and 66 g/day, however, such reduction was not found with 1.5% supplementation 85 g/day [17]. Saponification technique with calcium in fish oil enhances sheep performance. Supplementation of Ca-soap in fish oil improve ADG up to 99 g/day. However, calcium soap fish oil supplementation resulted in lower consumption compared to calcium corn oil. This is possible due to fishy smells from the fish oils [18]. Supplementation of 3% protected fish oil (PTO = protected tuna oil) and unprotected fish oil (UTO = unprotected tuna oil) affect dry matter consumption (847 g/day vs 736 g/day) but did not affect fat consumption (59.3 g/day vs 52.3 g/day) [19].

6.2. Meat Fatty Acid Profile.
Calcium soap supplementation in sheep reduce total fat content, high density lipoprotein (HDL), and low density lipoprotein (LDL). Optimum supplementation of calcium soap to reduce HDL and LDL level in sheep meat was at 3% calcium soap in the diet [17]. Optimization of NaOH 20% content in the saponification process towards lemuru fish oil can reduce saturated fatty acid in meat and increase unsaturated fatty acid especially omega 3, 6, 9, EPA dan DHA [6]. Linoleic acid, arachidonate acid, and linoleic acid in the site of M. longissimus dorsi of sheep supplemented with PTO were higher compared to UTO diet [20]. Feeding fish oil/fish meal markedly increased the total n-3 content, especially by an increase in EPA and DHA concentration in the intramuscular fat due to a higher
dietary n-3 supply. This requires that considerable amounts of these fatty acids reach the small intestine. In monogastrics, this is obvious. In ruminants, biohydrogenation of EPA and DHA appears to be limited, even when the fish oil was not protected by technological interventions.

Table 1. Effect of feeding fish oil or fish meal to Lamb on the long chain PUFA of the longissimus (g/100 g of total fatty acids) and its effect on the P/S and n-6/n-3 ratio

|                     | LA  | ARA | LNA | EPA | DPA | DHA | P/S | n-6/n-3 | Reference |
|---------------------|-----|-----|-----|-----|-----|-----|-----|---------|-----------|
| Control diet        | 4.58| 1.39| 0.79| 0.61| NA  | 0.44| 0.13| NA      | [21]      |
| Protected tuna oil  | 8.27| 1.64| 1.06| 1.81| NA  | 1.01| 0.23| NA      | [21]      |
| Basal diet          | 2.23| 0.70| 0.67| 0.27| 0.34| 0.10| 0.17| 1.80    | [22]      |
| 1.5% Fish oil       | 2.55| 0.77| 0.68| 0.90| 0.56| 0.47| 0.16| 1.40    | [22]      |
| 1,5% fish oil + 9% sunflower meal | 2.44| 0.77| 0.57| 0.77| 0.51| 0.44| 0.19| 1.30    | [22]      |

NA: data not available
ARA: arachidonic acid (C20:4n-6)
DHA: docosahexaenonic acid (C22:6n-3)
DPA: docosapentaenoic acid (C22:5n-3)
EPA: eicosapentaenoic acid (C20:5n-3)
LA: linoleic acid (C18:2n-6)
LNA: linolenic acid (C18:3n-3).

a The control diet was tallow based.
b The basal diet contained mainly alfalfa and oat and served also as the control diet.

7. Summary
Efforts to improve animal products such as meat with rich unsaturated fatty acid is growing along with increasing awareness of community to maintain health. Several studies about fat protection in ruminant fed from animal-based oil showed prominent and significant results in improving unsaturated fatty acid profile in sheep meat. However, increasing unsaturated fatty acid profile in sheep meat with protected fat needs further comprehensive studies to justify the effect towards rumen fermentation, diet acceptability, production performance, and meat quality.

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