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Performance and Meat Quality of Thin Tailed Sheep in Supplementary Feeding Lemuru Fish Oil Protected By Saponification with Different NaOH Concentration

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Abstract. This study was aimed to obtain oil and the exact saponification with different NaOH concentration to protect unsaturated fats, which can result in good production performance and lamb meat quality with low saturated fatty acid. Stage one studied the performance of sheep production on supplementing lemuru fish oil (LFO) protected with different saponification optimization. Twenty lambs aged 5-6 months early weighing 8-14 kg were alloted to 4 treatments, namely P0 basal feed (50% elephant grass + 50% concentrate), P1 (basal feed + soap LFO NaOH 10%), P2 (basal feed + soap 20% LFO NaOH) and P3 (basal feed + soap 30% LFO NaOH) in completely randomized design and 5 replication for performance and 3 replication for meat quality. The results showed that the treatment effect was not significant (P>0.05) on the consumption of dry matter (DM), crude protein (CP), ether extract (EE), total digestible nutrient (TDN), daily gain and blood cholesterol. P2 yield the highest daily gain namely 130.95±19.29 g/head/day and the lowest cholesterol 58.67 mg/dl. Stage two evaluated the criteria of lamb carcass and meat quality in supplementary feeding LFO protected with different saponification optimization. Twelve sheeps were slaughtered for P0, P1, P2 and P3. The results showed that the treatment effect was not significant (P> 0.05) to slaughter weight, carcass weight and carcass percentage, the physical quality of meat (pH, water holding capacity, cooking losses and tenderness), and chemical quality of the meat (DM levels, CP, EE, saturated fatty acids and unsaturated fatty acids) except in EPA and DHA increased very significantly (P<0.01). Conclusively, giving soap LFO with different optimization did not significantly affect the appearance and quality of sheep meat production, except in EPA and DHA which were significantly increased.

Key words: protected fat, lemuru fish oil, production performance, meat quality

Abstrak. Penelitian ini bertujuan mengevaluasi penampilan produksi dan kualitas daging pada pemberian pakan tambahan lemak tak jenuh terproteksi dengan konsentrasi NaOH yang berbeda dalam penyabunan. Dua puluh ekor domba jantan umur 5–6 bulan dengan bobot awal 8–14 kg dibagi 4 perlakuan yaitu P0 ransum basal (50% rumput gajah + 50% konsentrat), P1 (ransum basal +sabun minyak ikan lemuru NaOH 10%), P2 (ransum basal + sabun minyak ikan lemuru NaOH 20%) dan P3 (ransum basal + sabun minyak ikan lemuru NaOH 30%) dengan rancangan acak lengkap. Ulangan masing-masing 5 kali untuk penampilan produksi dan ulangan 3 kali untuk parameter kualitas daging. Hasil penelitian menunjukkan bahwa perlakuan berpengaruh tidak nyata (P>0,05) terhadap konsumsi BK, protein kasar (PK), lemak kasar (LK), TDN, pertambahan bobot badan harian (PBBH) dan kolesterol darah. P2 memberikan hasil PBBH tertinggi yaitu 130,95±19,29 g/ekor/hari sekaligus kadar kolesterol terendah yaitu 58,67 mg/dl. Duabelas ekor domba dipotong untuk P0, P1, P2 dan P3. Hasil penelitian menunjukkan bahwa perlakuan berpengaruh tidak nyata (P>0,05) terhadap bobot potong, bobot karkas dan persentase karkas, kualitas fisik daging (pH, daya ikat air, susut masak dan keempukan), dan kualitas kimia daging (kadar BK, PK, LK, asam lemak jenuh dan asam lemak tak jenuh) kecuali pada EPA dan DHA meningkat sangat nyata (P<0,01). Kesimpulan pemberian sabun MIL dengan optimasi yang berbeda tidak berpengaruh nyata terhadap penampilan produksi dan kualitas daging domba, kecuali pada EPA dan DHA yang secara nyata meningkat.

Kata kunci : lemak terproteksi, penampilan produksi, kualitas daging

Introduction

Lamb meat has a complete nutritional content of human needs despite the high saturated fatty acids compared to other livestock. Efforts to increase mutton production and to decrease levels of saturated fatty acids and cholesterol by increasing the unsaturated fatty acids have become challenge and demand. The main factors to consider in order to increase the levels of unsaturated fatty acids in

sheep meat is the biohydrogenation process from unsaturated into saturated fatty acids in the rumen which causes fat entering the small intestine mostly in the form of saturated fatty acids. Other property of unsaturated fatty acids is antimicrobial cellulolytic. Supplementation in ruminant diets will coat the fibers then inhibit the action of cellulase enzymes, and inhibits the activity of cellulolytic microbes to degrade the fiber. Efforts to prevent biohydrogenation of unsaturated fatty acids in the rumen consisted of saponification and capsulation to protect the fatty acids.

Unsaturated fatty acids are double-bond fatty acids (Murray et al., 2009), considered to have better nutritional value, and essential because they are more reactive. Examples of unsaturated fatty acids are C18: 1 (oleic acid), C18: 2 (linoleic acid), C18: 3 (linolenic acid) and C20: 4 (arachidonic acid) (Nelson and Cox, 2008). Fatty acids, together with glycerol are the main constituent of vegetable oils or fats, and are the raw material for all lipids in living organisms. Lemuru oil is particularly produced in abundance for fish cannery industry, and is therefore a potential animal feed due to the cheap price and is noncompetitive with food demand.

Different NaOH concentration in saponification possibly affects the protection intensity than fatty acid soap; accordingly, when given to sheep, it can affect lamb production and quality performance. This research was therefore performed to administer protected unsaturated fat for lamb ration without disrupting physiological state of ruminal fluid and eventually produce low saturated fatty acid meat.

Problems expected to solve in this research was to what extent the protected unsaturated fat affect of unsaturated fatty acids to the affect the performance and quality of sheep meat production. The purpose of this study was to determine the protective effect of fish oil fatty lemuru, on identified sheep production after feeding with protected unsaturated fatty acids with different NaOH concentration in saponification. Lastly, observing lamb meat quality after supplemented with protected unsaturated fat through different NaOH concentration in saponification.

Noci et al. (2005) reported the effectiveness of PUFA enriched feed for heifers may affect the fatty acid profile in meat. It was stated that the replacement of lard with sunflower seed oil with higher PUFA can linearly increase content of CLA cis-9, trans-11 in meat. Provision of sunflower seed oil in feed heifers significantly decreases C16: 0, and linearly increases C18: 2, CLA cis-9 trans11 and PUFA in Longissimus dorsi musculus.

Protection of essential fatty acids is potential to improve the performance and quality of meat production for livestock because linoleic acid is a precursor to the cell membranes formation. Sinclair et al. (2005) reported that the administration of marine algae and fish oil protection resulted in biohydrogenation decrease from C20: 5 (n-3) and C22: 6 (n-3), increase in the rate of fatty acids in the intestine, increase in plasma fatty acid concentrations, and potential to manipulate the composition of n-3 fatty acids from lamb.

Research results by Ponnampalam et al. (2001) showed that oleic acid in the loin muscle was higher than stearic acid after sheep was fed fatty acids were protected from unsaturated fatty acids sources: fish meal, sunflower seed meal, fish oil and sunflower seed oil. According to Marinova et al. (2001) sunflower seed oil supplementation in animal feed goats that without protection does not significantly affect the growth rate, daily body weight gain, carcass composition and quality (physical and chemical) meat. This suggests that the fatty acid protection engineering in ruminant feed is a necessity.

Reported by Raes et al. (2004), the content of linoleic acid, arachidonic acid and linolenic

acid in M. Longissimus dorsi sheep fed with protected tuna fish oil is higher than that given alone without the protection of fish oil, fish oil and flour and sunflower seeds. According to Van Soest (1994), linoleic acid content in intramuscular meat fed with sunflower seeds without protection is significantly lower at 1%, and given protected sunflower seeds contain 20% linoleic acid.

Materials and Method

Production performance

This study material administered 20 male thin-tailed sheep aged 5-6 months with early weight 8 to 14 kg. Sheep reared in platform individual cages equipped with feed and drink, and separator unit for urine and feces. Sheep were randomly rationed into 4 groups and each treatment consisted of 5 heads.

The basal diet consisted of 50:50 elephant grass and concentrate consisting of 37% milled yellow corn, 34% bran, pollard 24%, coconut meal 4.5% and 0.5% mix minerals. Rations were arranged according to the sheep need (NRC, 1984) and drinking water was provided ad libitum.

Fatty acid soap material in this study was lemuru fish oil and the capsulation was starch, caustic soda (technical NaOH) for optimizing saponification, technical $CaCl_2$, and chemicals for proximate analysis, blood cholesterol, fatty acid profile and cholesterol meat. The tools optimizing saponification were bucket, scales, digital scales, sieves, knives, basking tools, and proximate analysis tools. Feedlot equipment included 20 blocks of cage equipped with the feed and drinking container and a separator unit for faeces and urine in each block.

Optimization of saponification.

Lemuru oil was saponified with NaOH (caustic soda) and 10% starch solution, with 1:2:1 ratio. The concentration of NaOH different into 10%, 20% and 30%.

Experimental animals and experimental design

A total of 20 thin tail male lambs were placed in individual 20 unit cages. sheep were randomly alloted into 4 groups, each had 5 head. Treatment at this stage was the supplementation of fatty acid soaps in the feed, of different NaOH concentrations, i.e. P0: basal diet without lemuru oil soap (as a control), P1, P2 and P3: basal diet and lemuru oil soap with 10%, 20% and 30% NaOH concentration, respectively, given as much as 6% of body weight. Each treatment was repeated 5 times, within 10 weeks. Ration calculated was based on the dry ingredients and the administration was converted into fresh diet. Feeding was 2 times a day in the morning and afternoon at 08:00 am and 03:00 pm. Drinking water was provided ad libitum. Provision of fatty acid soap was 10% of the concentrate. Before morning feeding and drinking, the remaining food was weighed to calculate the daily feed intake of each animal.

The parameters measured in this second stage were feed intake, dry matter consumption, crude protein and crude fat consumption (g/head/day), feed consumption in % body weight (% BW). The next parameter was blood cholesterol (mg/dl) and daily gain (g/head/day). Sheep were weighed once a week to figure daily gain and to adjust the amount of feed given.

Blood cholesterol levels were measured, preceded by 5 cc blood sampling from jugular vein using a disposable sterile needle. The blood was centrifuged 3000 rpm for 10 min to obtain blood plasma for blood cholesterol level analysis. Blood sampling was performed at week 8 of feedlot period.

The data obtained were subject to statistical analysis of variance with SPSS version 17 with one way Completely Randomized Design. Daily body weight gain variable was measured using the GLM analysis of variance covariant with SPSS version 17 with initial weight as covariant. Differences between treatments were tested further by Duncan (Steel and Torrie, 1991).

Table 1. Nutrient composition of experimental diet (%)

Ingredients	Water	DM	% DM				
	%	%	CP	EE	CF	Ash	NFE
Elephant grass	78.75	21.25	8.81	2.25	22.60	16.28	40.33
Pollard	13.16	86.84	9.13	4.95	10.73	1.78	67.41
Yellow corn milled	12.02	87.98	7.55	5.33	3.18	0.56	83.38
Coconut meal	11.89	88.11	16.93	12.80	21.32	4.65	44.29
Rice bran	11.80	88.20	10.02	10.79	11.71	9.22	58.25

DM : Dry Matter CP : Crude Protein
EE : Extract Ether CF : Crude Fiber
NFE : Ntrogen Free Extract

Carcass and Meat Quality

The materials for stage 3 were 12 sheeps randomly taken from feedlot stage 2 to slaughter, divided into 4 groups according to diet, each consisted of three heads. The tools used were slaughtering kit and scale for and carcass weight and carcass components. Equipment for fatty acids analysis was Shimadzu® gas chromatograph GC series 9 AM for long-chain fatty acids meat test. Meat physical quality were measured using pH meter, timer, filter paper, 35 kg weight, plate glass, paper millimeters block and penetrometer.

Fasted for 12 hours, the cattle were weighed before slaughtering to obtain carcass weight data. Fasting was to minimize slaughter weight variance due to digestive tract content and to soothe the cattle for easier slaughtering conduct. Slaughtering started from slitting the throat to cut jugular vein, esophagus, and trachea for perfect bleeding. Esophagus end was fastened to block ruminal liquid when the carcass was hung. Head was removed from the body at occipito-atlantal joint. The front legs and hind legs were removed at carpo-metacarpal joint and Achilles tendon on both hind legs, then the skin was removed. Paring was carried out in upside down hanging position with the rear legs above and head below.

Fresh carcass was obtained after removing the viscera namely the reproductive organs, liver, spleen, heart, lungs, trachea, gastrointestinal tract, gall bladder and pancreas, except kidney. Carcass percentage (%) was obtained by distributing the carcass weight (kg/head) with slaughter weight (kg/head) multiplied by 100. The weight of carcass components was measured by cutting the tail of fresh carcass, then cut symmetrically along the spine of the neck (Ossa cervical vertebrae) to the sacral (Ossa vertebrae sacralis) in order to obtain fresh carcass left and right. Samples of carcass component weight were taken from the left, separated from the components of meat, bone and fat. Carcass component weight included the weight of each component, namely meat, bones and fat.

Meat quality measurements included chemical and physical quality. Chemical quality measurements, samples of meat for proximate analysis and analysis of fatty acids were taken from the carcass right hand on the shoulder. Fatty acid analysis performed was particularly lauric acid (C12: 0), myristic acid (C14: 0), palmitic acid (C16: 0), stearic acid (C18: 0), oleic acid (C18: 1), linoleic acid (C18: 2) and linolenic acid (C18: 3), meat cholesterol levels, as well as EPA and DHA. Determination of fatty acids of meat, water content, protein content, fat and ash was analyzed by the method of AOAC (2005).

Determination of the physical quality of the meat included the degree of acidity (pH) with Hanna® pH meter, water holding capacity (WHC) by the method of Hamm, cooking loss (Soeparno, 2005) and the tenderness of meat with a penetrometer.

The data obtained were statistically tested using analysis of variance with SPSS version 17 one way Completely Randomized Design. Variable criteria covering slaughter weight carcass, carcass weight and carcass percentage using covariant GLM analysis of variance with SPSS version 17. The difference between treatments was tested further by Duncan (Steel and Torrie, 1991).

Results and Discussion

Production performance

Production performance is measured through dry matter intake, consumption of crude protein, crude fat intake, daily weight gain and blood cholesterol. The results showed that the addition of fatty acid soap made of lemuru oil was not significant (P> 0.05) on DM intake, CP and EE, but significant (P <0.05) on lower blood cholesterol in P1 and P2 but not significant on P3. Supplementary feeding fatty acid soap did not significantly affect daily gain despite daily gain value given fatty acid soaps tended to increase compared to that daily gain in sheep given only the basal diet. Wina and Susana (2013) reported that Ca-Fatty acid of palm oil decrease feed consumption in dairy lactation, while hidrogenated fatty acid did not infuence feed consumption. Lock et al. (2006) informed that hidrogenated unsturatted fatty acid decrease effect of satturated fatty acid that impression rumen bacterial growth, Hess et al. (2008) also reported that increasing unsatturated fat is increasing negatif effect on population fiber degradation bacteria.

Carcass and meat quality

Carcass criteria including carcass slaughter weight, carcass weight and carcass percentage in this study was not significantly (P> 0.05) affected by additional feed lemuru oil protected as fatty acid soaps. The average slaughter weight ranged between 17.50 kg to 18.83 kg, 7.67 kg Mean carcass weight up to 8.50 kg and the average percentage of carcass between 38.97% and 44.04%. There was a tendency of daily body weight gain high followed by high slaughter weight and carcass weight, as indicated in the treatment of P2.

Supplementation of oil fatty acid soaps lemuru did not decrease meat fat (P>0.05) compared to sheep given solely basal diet, except in the provision of soap with 30% optimization (P3), significantly increasing the fat content (P<0.05). Stearic acid is saturated fatty acids in meat showed significant decrease in the provision of soap than basal ration. Increasing concentration of NaOH in the optimization of saponification cause decreased levels of stearic acid. Cattle were fed with the basal ration containing stearic acid in the meat of 347.02 mg/100 g of meat. Stearic acid content decreased with increasing NaOH concentration in saponification 10%, 20% and 30% stearic acid in meat produced 243.45 mg/100g, 227.44 mg/100g and 213.52 mg /100 g meat, respectively. The content of unsaturated fatty acids oleic, linoleic and linolenic tended to increase with the increasing optimization, except in P3 (NaOH 30%). The results of this study indicated that different optimization performed different protection intensity. The higher NaOH concentration, the better is the protection on fatty acids. The highest content of omega 3, 6 and 9 in treatment P2 were 5.44 mg/100g, 85.03 mg/100g and 290.64 mg/100g of meat, respectively. Docosahexanoic acid (DHA) was the highest (P<0.01) in P2 treatment. These results were consistent with studies of Sun et al. (2015) that significantly increased the content of unsaturated fatty acids on mutton, rumen fluid and duodenal content with Suaeda glauca seed supplementation on feed sheep. Decrease saturated fatty acids are consistent with the results of research Sudarman et al. (2008) which supplemented fatty acid soaps with different levels of sheep resulted in highly significant (P <0.01) decrease in fat content, low density lipoprotein (LDL), but stated that the

high-density lipoprotein was also declining, which was in contrast with this research that unsaturated fatty acids increased.

Statistical test results showed no differences (P>0.05) for pH, cooking loss, water holding capacity and tenderness. pH value of research results for P0, P1, P2 and P3 was 5.54±0.07; 5.58±0.12; 5.51±0.14 and 5.44±0.05, respectively. pH mutton these results included in the normal pH range of 5.4 to 5.8 flesh (Soeparno, 2005). It was also explained that the ultimate pH is reached depends on the amount of muscle glycogen stores during cutting. Decrease in pH to about 5.4 to 5.5 or lower means electrically myosin point has been reached.

According to Lawrie (2003) meat pH decreased rapidly to 5.4 - 5.5 a few hours after slaughtering. Standard pH of healthy and relaxed slaughter meat was from 7 to 7.2 and continued to decline within 24 hours. The pH

Table 2. Performance of thin tailed sheep

Parameter	P0	P1	P2	P3
DM intake (g/head/day)^{ns}	592.12±51.18	604.05 ± 33.29	601.78±36.34	565.80±19.81
DM intake (%Body weight)^{ns}	4.49	5.03	4.30	4.49
DM intake (g/kgBW/day)	40.92	45.59	38.95	40.94
CP intake (g/head/day)^{ns}	71.59±6.17	73.03±4.03	72.76±4.39	68.41±2.39
EE intake (g/head/day)^{ns}	28.6±2.47	29.18±1.61	29.07±1.76	27.33±0.96
TDN intake (g/head/day)	351.18	341.05	347.62	324.55
AVG^{ns} (g/head/day)	93.86±42.84	105.48±35.81	130.95±19.29	125.00±25.94
Blood colesterol (mg/dl)	70	59	58.67	73.33

Keterangan :
ns : non signifikan
P0 : basal diet
P1 : basal diet and lemuru oil soap with 10% NaOH concentration
P2 : basal diet and lemuru oil soap with 20% NaOH concentration
P3 : basal diet and lemuru oil soap with 30% NaOH concentration

Table 3. Criteria of carcass

Variabel	P0	P1	P2	P3
Slaughter weight (kg)	17.50	18.33	19.17	18.83
Carcass weight (kg)	7.67	7.78	8.50	7.33
Carcass percentage (%)	43.76	42.54	44.04	38.97

Table 4. The average of the results of the proximate analysis lamb fed supplemental fatty acid soaps with different NaOH concentration

Nutrient (%)	P0	P1	P2	P3
Water	72.55	73.97	72.99	69.70
Dry matter	27.45	26.03	27.01	30.30
Ash	1.44	1.06	0.87	1.02
Ether Extract	5.21	5.62	5.22	9.14
Crude Protein	14.92	14.94	15.01	14.94

Table 5. Mean fatty acid profile (mg/100g of meat) lamb fed supplemental fatty acid soaps with different NaOH concentration

Fatty acids	P0	P1	P2	P3
Capric acid (C10:0)	41,037	23.844	11.323	12.050
Lauric acid (C12:0)	12.708	6.853	13.778	3.482
Myristic acid (C14:0)	70.425	69.461	79.489	70.321
Palmitic acid (C16:0)^{ns}	344.028	318.788	386.736	332.477
Palmitoleic acid (C16:1)	46.961	43.970	55.021	42.079
Stearic acid (C18:0)^{ns}	347.022	243.454	227.441	213.523
Oleic acid (C18:1)^{ns}	290.618	243.366	290.640	269.632
Linoleic acid (C18:2)^{ns}	62.826	63.811	85.032	50.659
Linolenic acid (C18:3)^{ns}	3.594	3.306	5.439	2.140
Eikosapentaenoic acid EPA (C20:5n3)^{ns}	19.697	27.177	34.096	18.312
Dokosa heksaenoic acid DHA (C22:6n3)	5.039^{a}	5.824^{a}	9.563^{b}	2.564^{a}

ns : non sinificant
ab : different superscript on the same row differ significantly (P<0.05)

Table 6. Physical quality lamb fed supplemental fatty acid soaps with different NaOH concentration

Parameters	P0	P1	P2	P3
pH	5.54±0.07	5.58±0.12	5.51±0.14	5.44±0.05
Cooking loss (%)	38.05±0.62	36.04±1.26	37.77±2.89	34.18±3.86
Water holding capacity (%)	25.19±8.45	39.30±6.14	33.52±5.58	31.97±5.01
Tenderness (mm/g/secon)	6.53±0.56	5.94±0.57	6.39±0.58	6.32±0.99

value was determined by the amount of lactic acid produced from glycogen during an aerobic glycolysis. Purnomo and Adiono (1985) reported that lactic acid formation decreased meat pH and caused structural damage in muscle protein depending on temperature and low pH. Post-slaughter cattle experienced cessation of muscular oxygen supply, and therefore metabolism remains was irremovable from the muscle, leading to pH decrease from initial slaughtering.

The pH value in this study was relatively similar to that of Sudarman et al. (2008) within within normal meat pH range of 5.74 to 5.78. The results showed that the sheep when the slaughtered did not experience significant stress because post slaughter meat pH was not highly varied.

Lamb cooking loss in this research was 34.18±3.86 to 38.05±0.62%. The best cooking loss was the least fluid loss during cooking. The lowest cooking loss was observed in P0 treatment with basal ration without fatty acid soaps, although not statistically significant. According to Soeparno (2005), in general loss varies cook 15-54.5% with a range of 15-40%. Meat with lower cooking loss had better quality than the meat with higher cooking loss, because of less nutrient loss during cooking. Cooking loss in this study was lower than that of Tiven (2011) namely 37.07±1.35 to 45.05±1.30% in sheep fed with protected supplemental crude palm oil (CPO). While Sudarman (2008) reported 31.54% cooking loss on the administration of calcium soaps with different levels. Soeparno (2005) stated that the meat with lower pH would produce higher cooking loss value, because the lower the pH, the lower the water holding capacity, causing more water removed. Low cooking loss meat had a relatively good quality than the high one, because of less nutrient loss. High cooking loss demonstrated low water holding capacity by

meat protein, therefore more weight loss during cooking caused less tenderness.

The average water holding capacity (WHC) of lamb was 32.48%, or higher than 31.68% by Purbowati (2007) in complete feed lamb, and 25.47% by Tiven (2011) in protected CPO. According to Soeparno (2005), WHC was influenced by meat pH, and according to Rachmadi (2003) ration treatments with insignificant effect on pH would induce insignificant effect on WHC as well. A statistical test result in this study showed that the addition of fatty acid soaps in sheep feed was not significant to the pH and WHC.

The value of lamb meat tenderness in this study was 5.94±0.57 to 6.53±0.56 mm/g/sec. Soeparno (2005) stated that the tenderness and texture of meat were likely the most important determinant of meat quality. Factors affecting tenderness of meat were classified into ante-mortem factors such as genetics, including the nation, and the physiology of the species, age, management, gender and stress, and postmortem factors. Overall impression of tenderness included texture and three aspects; first, easier initial penetration of teeth into the meat; second, easier chewing flesh into fragments/smaller pieces; and third, amount of residue after mastication.

Conclusions

Supplementing lemuru oil fatty acid soaps as additional feed on the lamb did not give significant effect on the performance of lamb production.

Provision of lemuru oil fatty acid soaps as additional feed on sheep showed no significant effect on the quality of the meat, but performed a tendency to lower saturated fatty acids and increase the unsaturated fatty acids in meat. Optimization was the most effective saponification with 20% NaOH which could reduce the content of saturated fatty acids of meat and increase the highest unsaturated fatty acids in omega 3, 6, 9, EPA and DHA.

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