Summary and Conclusions
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Oil Palm (*Elaeis guineensis* Jacq.) is now grown in about 1,00,000 ha distributed in 13 states of India and 20 palm oil factories cater to the processing needs. The by-products of palm oil industry are Empty Fruit Bunches (EFB), Palm Oil Sludge (POS) or Palm Oil Mill Effluent (POME) and Palm Press Fibre (PPF). Among them POS/POME, PKC and PPF are potentially valuable for feeding of livestock. Waste and/or by-product utilization will not only cut down the cultivation cost but also will take care of the environmental issues. One such waste available from palm oil mills is Palm Oil Mill Effluent (POME). For every tonne of Fresh Fruit Bunch processed, 0.67 tonnes of POME is generated. Although POME is non-toxic and totally biodegradable (Ma et al., 1988), it is characterized by high chemical oxygen demand (COD), Biological oxygen demand (BOD), large amounts of total suspended solids and various other organic constituents. Effluent also contains 800 ppm of N and 1600 ppm of K and the protein content is of about 8.2 % with low levels of methionine and lysine.

POME discharged out of the Palm oil extraction mill as a waste material contains various liquids, dirt, residual oil and suspended solids. Palm oil sludge is the material that remains after decanting the palm oil mill effluent. This suspended solid material recovered through decanter process which is available in huge quantities at the mills forms a potential source for feeding of live stock viz., buffaloes, sheep, goats and pigs. The decanter sludge contained 17.9, 0.70, 13.30, 33.60 and 34.50 percent CP, EE, Total ash, CF and NFE on dry matter basis, respectively. The mineral content of the sludge was 0.701, 0.336 and 0.646 per cent Ca, P and Mg, respectively and 14.31, 18.35 and 2361.28 ppm of Cu, Zn, and Fe, respectively. NDF, ADF, Cellulose, Hemicellulose and lignin contents
of dehydrated sludge were 57, 43, 23, 14 and 16.0 % respectively. Similarly NDF, ADF, Cellulose, Hemicellulose and lignin contents of palm kernel cake were 72, 56, 26.0, 16 and 34 % respectively.

Based on the crude protein content available in decanter sludge and PKC, various feeds were formulated and fed to the animals. Body weights were recorded at fortnightly intervals up to twelve fortinights to observe the pattern of growth in various species of animals.

Proximate and mineral composition of Palm oil mill effluent (POME) and Palm kernel cake was analyzed in order to formulate the rations of concentrate mixture for feeding to various species of animals. Physical, chemical and biological characterization of Palm Oil Mill Effluent was carried out to include the organic solids content in concentrate mixtures with a view to clear the pollution, assess the shelf life of stored feeds etc. The fatty acid composition of the various lipids i.e. oil droplets extracted from dried sludge were used to separate the chloroform fraction and was determined by gas chromatography. The fatty acid composition of the individual phospholipids may vary from different parts of the plants and also on the type of organelles from which they are extracted but generally C\textsubscript{16:0}, C\textsubscript{18:2} and C\textsubscript{18:3} are the main fatty acids. The main fatty acids of the phospholipids associated with the oil droplets of palm oil sludge were C\textsubscript{18:0} and C\textsubscript{18:1}. The amino acid composition of palm oil sludge and POME revealed that Aspartic acid and Glutamic acid were present in higher levels. But the lysine was present in very low proportion when compared to the level of other amino acids.

The feed industry also uses peroxide value to assess the stability or rancidity of fats that are used as feed ingredients, by measuring lipid peroxides and hydro
peroxides formed during the initial stages of oxidation. Values are reported as meq of peroxide per kg of fat. Studies conducted to assess the shelf life of various feeds at different intervals revealed that they can be stored for 7 - 8 months; after that rancidity develops in the feed which leads to the change in color, taste, palatability etc. Peroxide levels of 100 meq/kg of fat can be fed to poultry without affecting performance, while young pigs can tolerate levels up to 40 meq/kg of fat. It is necessary to establish a tolerance level for peroxides in animal feeds, a maximum of 80 meq O₂/kg of fat is recommended. Nutritionists and buyers have arbitrarily established maximum initial PV levels of between 5 and 20 meq O₂/kg of fat as acceptable. The results of the present study suggested that the concentrate mixture can be safely stored for 250 days under ideal conditions of storage without any depression in palatability.

Sun dried Palm Oil Mill Effluent (POME) was incorporated at 30, 40 and 50 % level in iso-nitrogenous concentrate mixtures and fed to four Murrah buffalo bull calves of group I, II and III and compared against control concentrate mixture in guinea grass and paddy straw based feeding system. Although, the DM intake and digestibilities of DM, EE, CP, CF and NFE did not differ among the calves fed various diets indicated that inclusion of POME in the diets did not show any adverse affect on the digestibility of feed in calves in comparison to that of calves in control group. However, OM, EE, CP, CF and NFE digestibilities were higher in treatment groups when compared to control although non-significant. In a growth trial of 180 days, it was found that the calves fed with concentrate mixture containing POME at 40 % level grew at the rate of 430 g per day against 410 g in calves of control group. The feed cost per kg gain was significantly (P<0.01) lower in calves fed with concentrate mixture containing 40 % POME (Rs. 48.90) than that in calves fed with control concentrate mixture (Rs. 66.22) with a net saving of Rs. 17.32 per kg gain.
Significantly (P<0.01) higher protein (3.77 %) and SNF (9.86 %) contents were recorded in the milk produced by graded Murrah buffaloes fed with concentrate mixture containing 40 % POME against that (3.46; 9.48 %) in buffaloes fed with control concentrate mixture. It was found that the dehydrated POME could be incorporated in the diets of buffalo calves and buffaloes up to 40 % level without any depression in growth rate and milk production with marked economic advantage in guinea grass and paddy straw based feeding system. Lipid profile of lactating buffaloes indicated that all the serum lipid fractions except TG showed non-significant (P > 0.01) change at the end of 75 days. Serum cholesterol content was higher (119.25 ± 17.71 mg/dl) in the treatment group, as a result of POME feeding when compared to the control group (80.0 ± 8.669 mg/dl). HDL-c was also higher (15.575 ± 2.104 mg/dl) in treatment group, at 75 days of experimental period when compared to control group (11.300 ± 1.546 mg/dl). LDL-c was improved (98.250 ± 15.902 mg/dl) in the treatment group when compared to control group (62.750 ± 6.101 mg/dl). However, VLDL-c was lowered (5.350 ± 0.434 mg/dl) in treatment group when compared to control group (7.150 ± 1.260 mg/dl). Cholesterol/HDL was also lowered in treatment group (7.625 ± 0.235 mg/dl) when compared to control group (8.550 ± 0.607 mg/dl). However, a significant (P < 0.05) reduction in TG was observed in treatment group (26.750 ± 2.174 mg/dl) when compared to control group (38.000 ± 4.358 mg/dl). Lipase activity in serum was determined at the end of experimental period i. e. at 75 days. Increased lipase activity (IU/L) was noticed in the treatment group (52.000 ± 1.080 IU/L) when compared to control group (42.750 ± 7.888 IU/L) although statistically non-significant.

It was found that the dehydrated POME could be incorporated in the diets of lambs up to 60 % level with out any depression on growth rate besides reduction in cost of feeding of lambs for fattening. Dehydrated POME was incorporated at 40, 50
and 60 % in iso-nitrogenous concentrate mixtures and fed to five ram lambs of group I, II and III and compared against control concentrate mixture in guinea grass based feeding system. On-farm trials on lambs indicated that lambs fed with concentrate mixture containing PCME at 60 % level grew at the rate of 80, 49 g per day of CM-I (POME) and CM-II (Conventional concentrate) against 27 g in lambs of control group (Fed exclusively on grass). Feeding POME at 60 % level had significant (P< 0.01) reduction in cholesterol content of subcutaneous adipose tissue; however, a significant (P < 0.01) rise in total lipid content was observed. Feeding POME based diet elevated three fatty acids namely Palmitic, Stearic and oleic fatty acids of subcutaneous adipose tissue fat. On the contrary, the same diet lowered myristic, pentadecylic, margaric, linoleic, linolenic fatty acids. Lipid profile of lambs indicated that all the serum lipid fractions showed non-significant (P > 0.01) change at the end of 75 days. Total cholesterol (TC) content was lowered (81.6 ± 10.04 to 53.4 ± 6.56 mg/ dl) to a greater extent when compared to control group (75.2 ± 12.54 to 60.0 ± 10.64 mg/dl). HDL-c (11.6 ± 2.88 to 13.2 ± 2.30 mg/dl) was elevated at 75 days of experimental period in the treatment group while decreased in the control group (14.8 ± 1.35 to 12.8 ± 2.72 mg/dl) at 75 days. LDL-c was lowered (53.4 ± 4.94 to 34.2 ± 3.54 mg/ dl) to a greater extent than compared to control group (46.2 ± 10.62 to 28.4 ± 7.36 mg/dl). TG was lower (72.0 ± 7.8 to 63.0 ± 8.24 mg/dl) in the treatment group while it was higher in the control group (51.4 ± 9.0 to 64.6 ± 6.86 mg/dl). Lipase activity in serum was determined at the end of experimental period i. e. at 75 days. Higher lipase activity (IU/L) was noticed in the treatment group (32.8 ± 16.02 IU/L) when compared to control group (16.4 ± 7.40 IU/L) although statistically non-significant.
Research work has been carried out on different aspects of POME, which include the basic constituents of it; different treatment methods for making it usable and its use as feed have been presented in this work. The effective use of palm oil sludge as animal feed will be of economic significance, especially in view of the rising cost of feed ingredients while reducing pollution problem.

CONCLUSION

Various experiments carried out in the present study explored the possibility of effective level of incorporation of dehydrated POME in the rations of buffaloes and sheep in order to achieve economic livestock productivity in oil palm farming system.

The following were the specific conclusions drawn from the present study.

 ✓ The dehydrated POME could be incorporated in the diets of buffalo calves and buffaloes up to 40 % level without any depression in growth rate (430 g of ADG) and milk production with marked economic advantage in guinea grass and paddy straw based feeding system. Lipid profile of lactating buffaloes indicated that HDL-c was higher (15.575 ± 2.104 mg/dl) in treatment group, at 75 days of experimental period when compared to control group (11.300 ± 1.546 mg/dl) as a result of feeding concentrate mixtures containing POME. POME feeding resulted in increased serum lipase activity which in turn caused increased break down of TG releasing free fatty acids.
In an on-farm study of 120 d with lambs it was found that, POME could be included at 60 % level in the concentrate mixture for feeding of growing lambs which substantially reduced the cost of feeding for fattening. Lipid profile indicated that Total cholesterol (TC) content was lower (81.6 ± 10.04 to 53.4 ± 6.56 mg/ dl) to a greater extent when compared to control group (75.2 ± 12.54 to 60.0 ± 10.64 mg/dl). HDL-c (11.6 ± 2.88 to 13.2 ± 2.30 mg/dl) was elevated at 75 days of experimental period in the treatment group while lowered in the control group (14.8 ± 1.35 to 12.8 ± 2.72 mg/dl) at 75 days. LDL-c was lowered (53.4 ± 4.94 to 34.2 ± 3.54 mg/dl) to a great extent when compared to control group.

It was found out that the feed cost per kg gain was significantly (P < 0.01) lower in buffalo calves fed with concentrate mixture containing 40 % POME (Rs. 48.90) than that in calves fed with control concentrate mixture (Rs. 66.22) with a net saving of Rs. 17.32 per kg gain. Similarly, the feed and green fodder cost per kg gain was significantly (P < 0.01) lower in lambs fed with concentrate mixture containing 60 % POME (Rs. 94.5) to that lambs exclusively on grazing (Rs. 169.3) with a net saving of Rs. 74.8 per kg gain.