Effect of Dietary Supplementation of Palm Stearin on Growth Performance, Rib Eye Area and Back Fat Thickness in Murrah Buffalo Calves

Thesis

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Dr. Ganvir Shruti Diwakar
Roll No. M-6367

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Veterinary Science
(Livestock Production and Management)

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Dedicated to…

My Beloved Family

and

Guide

भा.कृ.अनु.प.–भारतीय पशु चिकित्सा अनुसंधान संस्थान
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इज्जतनगर –243122, (उ.प्र.), भारत

LIVESTOCK PRODUCTION AND MANAGEMENT SECTION
ICAR-INDIAN VETERINARY RESEARCH INSTITUTE
(Deemed University)
IZATNAGAR - 243 122, U.P., INDIA

Dr. A.K.S. Tomar
M.V.Sc., Ph.D.
Principal Scientist

Dated: 06/12/**2023**

Certificate

This is to be certified that the research work embodied in this thesis entitled "Effect of dietary supplementation of palm stearin on growth performance, rib eye area and back fat thickness in Murrah buffalo calves" *submitted by* **Dr. Ganvir Shruti Diwakar, Roll No. M-6367,** *for the award of* **Master of Veterinary Science** *Degree in* **Livestock Production and Management** *at ICAR-Indian Veterinary Research Institute, Izatnagar, is the original work carried out by the candidate herself under my supervision and guidance.*

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We the undersigned members of Advisory Committee of **Dr. Ganvir Shruti Diwakar, Roll No. M-6367,** *a candidate for the degree of* **Master of Veterinary Science** *with the major discipline* **Livestock Production and Management,** *agree that the thesis entitled* **"Effect of dietary supplementation of palm stearin on growth performance, rib eye area and back fat thickness in Murrah buffalo calves"** *may be submitted in partial fulfillment of the requirement for the degree.*

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Signature
Name Dr. S. K. Singh
External Examiner

Date : 22/01/24

(A.K.S. Tomar)
Chairman
Advisory Committee

Date : 06/12/2023

MEMBERS OF STUDENT'S ADVISORY COMMITTEE

Dr. Hari Om Pandey, Senior Scientist
Livestock Production and Management, ICAR-IVRI, Izatnagar

Dr. V.B. Chaturvedi, Principal Scientist
Division of Animal Nutrition, ICAR-IVRI, Izatnagar

Dr. Avisheck Biswas, Principal Scientist & Head
Division of Poultry Science, ICAR-CARI, Izatnagar

Dr. Abhishek Saxena, Scientist (SS)
Division of Surgery, ICAR-IVRI, Izatnagar

Dr. M.R. Verma, Principal Scientist
Division of LES & IT, ICAR-IVRI, Izatnagar

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ABBREVIATIONS

°C	:	Degree centigrade
%	:	Per Cent
@	:	At the rate o
°C	:	Degree Celsius
ADG	:	Average daily weight gain
BF	:	Back fat
BL	:	Body length
BW	:	Body Weight
CF	:	Crude Fibre
cm	:	Centimeter
cm^2	:	Centimetre square
CP	:	Crude Protein
DM	:	Dry Matter
DMI	:	Dry matter intake
EE	:	Ether Extract
FCR	:	Feed conversion ratio
Fig.	:	Figure
g/d	:	Gram Per Day
g	:	Gram
HB	:	Hip Bone
HDL	:	High-density lipoprotein
HG	:	Heart girth
HW	:	Height at Withers
Kg	:	Kilo gram
LDL	:	Low-density lipoprotein
m	:	Month
mg/dl	:	Milligram Per Decilitre
mg	:	Milligram
min	:	Minutes
NFE	:	Nitrogen-free extract
NS	:	Non-significant
OM	:	Organic Matter
P	:	Phosphorus

PG	:	Pauch girth
PS	:	Palm stearin
REA	:	Rib eye area
rpm	:	Revolution Per Minute
TA	:	Total Ash

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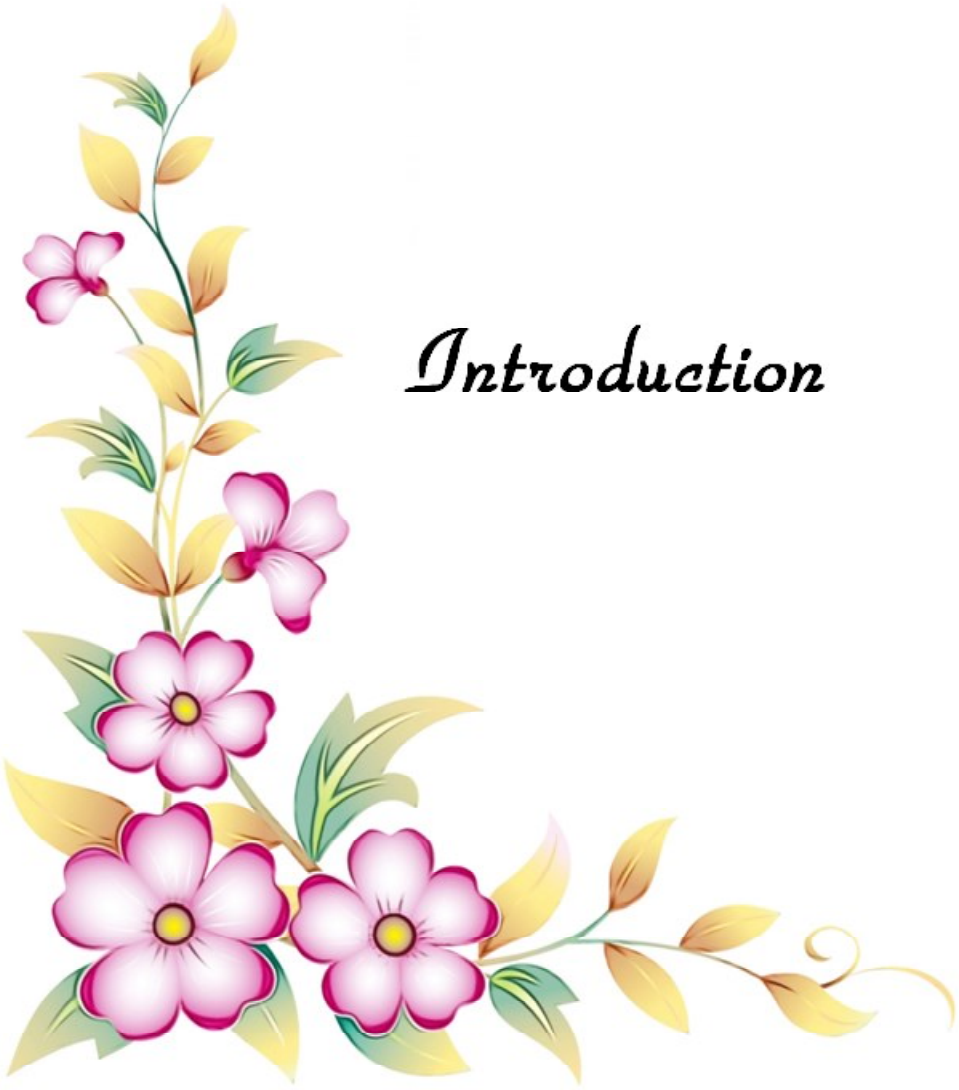


Introduction

1 INTRODUCTION

Livestock plays an important role in the Indian economy. The livestock sector is recording an annual growth rate of more than 13.96%. Its contribution to Indian agriculture and the Indian economy is progressive, with 30.13% of agriculture and allied sector GVA (Gross Value Added) and 6.13% of total GVA (BAHS, 2022). The world's largest cattle and buffalo population is found in India, there are 206.60-208.1 million buffaloes in the globe at the moment, with Asia home to 97.4% of them. India has the highest livestock with a population of 535.78 million. the total buffalo population in the country is 109.85 million i.e., about 20.5% of the total livestock population (20th Livestock Census, 2019). The buffalo population has increased by 1.1% over the previous livestock census. The female buffalo population increased by 8.61% whereas male buffalo declined by 42.35% over the previous census (20th Livestock Census, 2019). India holds the top spot among all countries in the world with 20 recognized breeds of buffalo (NBAGR, 2023).

The buffalo evolved from Asian wild buffalo (*Bubalus arnee*). River buffaloes are raised largely for milk production, while swamp buffaloes are employed mostly for draught power in agricultural tasks (Borghese *et al*. 2005). The domestic or water buffalo belongs to the phylum Chordata, class Mammals, family Bovidae, order Artiodactyl and kingdom Animalia. The Indo-Pak region was the first to domesticate the buffalo, over 5000 years ago. Buffaloes (*Bubalus bubalis*) are important to the lives of millions of people because they provide milk, meat, draught power, transportation, and on-farm waste in several developing countries in Asia, particularly India. Additionally, buffaloes have been noted for their adaptability to various housing, feeding, and management settings, excellent disease resistance, and flexible diets

(Wanapat *et al*., 2013). Buffaloes are better at producing milk and meat from low-quality fibrous diets. According to Terramoccia *et al*. (2000), buffaloes degrade both crude protein (CP) and protein-free dry matter (DM) more effectively than cattle. They are better adapted to a variety of conditions, especially hot and humid ones. Buffalo may be the most underappreciated animal in the world, yet it has amazing potential, making it the animal of the future (Khan *et al*. 2009). Indian buffalo is a key supplier of milk for the organized dairy industry because of their contribution to global milk production, high-fat content, and overall solid content, with a contribution of 49% to total milk production.

Buffaloes also contribute significantly to the production of meat, mostly taken from old animals towards the end of their productive or working life and only to a lesser extent from young animals. In 2021-2022, India produced 9.29 million tons (MT) of meat, ranked 8th in the world there was a 5.62% growth from the previous year (BAHS, 2022). India ranks 1st in buffalo meat production at 1.62(MT) which accounts for17.97% of meat production of India (BAHS, 2022) and 43% of the world's meat production with Uttar Pradesh having the highest production rate (APEDA, 2021). The country has exported 1.24 MT of buffalo meat products to the world for the worth of USD 3.3 billion (DAHD, 2022). Worldwide 27,692,388 buffaloes were butchered in 2021. More than 90% of this production may be attributed to Asia (FAOSTAT, 2021). Since eating buffalo meat is not forbidden by any religion, it has significantly increased in supply relative to other red meats. The demand for carabeef or buffalo meat has increased in both local and foreign markets due to the prohibition on the slaughter of cattle in most Indian states. Furthermore, due to the beneficial properties highlighted by some studies, buffalo meat has gained increasing popularity in recent years, so much so that it has been designated as "the healthiest meat among red meats for human consumption," owing primarily to its lower fat and cholesterol content (Kandeepan *et al*., 2013). Given the similarity of buffalo meat to cattle meat (beef) in several quality attributes and the increasing acceptability of buffalo meat, there are enormous opportunities for buffalo development. Buffalo meat has excellent processing characteristics and is well-suited for the development of value-added meat products. Buffalo meat's low-fat content is responsible for poor marbling. Buffalo meat is lower in fat and saturated fat than beef. The most abundant fatty acids in buffalo meat

phospholipids were discovered to be palmitic, stearic, oleic, and linoleic acids (Kesava *et al.,* 1991). Higher contents of free fatty acids were found in buffalo meat fats (BMF) and the fat was comparable with vegetable fats.

The shortage and fluctuating quantity and quality of feed supply around the year is a major constraint to livestock production in developing countries. Better management and balanced nutrition can boost buffalo productivity. In the last few decades, numerous efforts have been made to improve nutrient supply and utilization in buffaloes. Recent studies on locally available feed resources such as crop residues and industrial bi-products, dietary addition of micronutrients, use of performance modifiers, and use of ruminal-protected fat and protein sources have revealed the significant potential to improve buffalo growth, milk yield, and reproductive performance. The optimal balance of all nutrients, including energy and protein, is important as a macronutrient to improve the performance of Asian water buffalo. Dietary supplementation is one option for increasing the essential nutrient content of the buffalo diet and improving the animal's rumen metabolism. Researchers discovered that supplementing concentrate and rumen-protected fat could alter growth performance and carcass traits without negatively impacting buffalo growth. A sufficient fat supplementation was capable of increasing the concentration of energy in the animals, which could also improve the percentage of fat in the milk as well as the meat quality. The benefits of high energy and protein in dietary supplements may explain the ruminant growth and fattening improvements. The addition of a fat supplement to the diet boosts the growth potential of buffalo calves. The inclusion of protein and fat supplements was significantly associated with improvements in average daily weight gain, body length (BL), height, and heart girth (HG) in buffaloes fed a basal diet (Vahora *et al*., 2013). By adding beneficial fatty acids, buffalo meat can be improved in taste. It has been demonstrated that the fatty acid compositions of buffalo fat influence the nutritional value and a number of characteristics of buffalo meat quality, such as taste and shelf-life (Lambertz *et al*., 2013), as well as the compositions of meat fatty acids (Ekiz *et al*., 2017).

Supplementation of commodity fats, such as whole oilseeds, free oils, and animal fats, is limited by the potentially negative effects of unsaturated long-chain fatty acids on ruminal fermentation. To prevent these current recommendations, limit these fats to 3 to 5% of dietary

dry matter, Palmquist *et al*. (1980), Calcium salts of palm oil long-chain fatty acids (Ca-LCFA), prilled long-chain free fatty acids, and partially hydrogenated animal fats are relatively inert within the rumen. Rumen inert fat is a vegetable oil that contains 85% palmitic acid and has a higher melting point, it bypasses rumen degradation and does not melt in the rumen. This undegraded bypass fat is degraded by lipase enzymes in the small intestine (Singh *et al*., 2014). Ruminants digest saturated fatty acids more efficiently than non-ruminants (Andrews *et al*., 1970a).

Over the last 40 years, the global production of palm oil has increased dramatically. Palm oil is extracted from the mesocarp of palm fruits and contains roughly 50% saturated fatty acids, 40% monounsaturated fatty acids, and 10% polyunsaturated fatty acids. Palm oil has several properties that influence its inclusion in food products. It has a high solid-glyceride content, which gives it the required consistency without requiring hydrogenation. It is highly oxidation resistant and thus has a long shelf life. Its high melting point triglyceride content, combined with its low solid content, aids in the formulation of products with a wide plastic range that is appropriate for hot climates and some industrial applications. Its cost is usually competitive. Because of its high polyunsaturated fatty acid (PUFA) content, it can only be used in small amounts in margarine. Because of its slow crystallization properties, it can cause structural hardness and recrystallization in the finished product (Cottrell, 1991). In ruminant diets, palm oils reduce methane production by inhibiting methanogens and protozoa, increasing propionic acid production, and biohydrogenation of unsaturated fatty acids (Mao *et al*., 2010). Palm oil has two major fractions: olein and stearin. Palm stearin (PS), a by-product, is solid at room temperature.PS, a high-quality and low-cost fat source, has the potential to be used in broiler feed (Arima *et al*., 2007). Mairo *et al*. (2011), PS contains relatively little antinutritional material, making it safer and better for usage in animal feed. When fat supplements like palm, coconut, and corn oils are combined with pasture-raised meat, the percentage of carcass fat, the thickness of flesh-covering fat, and meat marbling have all been observed to increase (Peixoto *et al*., 2014). The availability of fodder, particularly during the dry season, as well as farmer's ignorance of the advantages of palm oil by-products are obstacles to the development of the buffalo.

Meat quality improvement can improve economic development for livestock producers. Ultrasound technology is used to evaluate body composition traits. Real-time ultrasound is the term used to describe the ultrasound technology used to measure carcass traits. Real-time imaging ultrasonography produces cross-sectional images at multiple carcass locations, making it possible to estimate the depth of the muscle, the depth of the fat, or the area of the muscle without having to dissect the carcass. It projects images of the muscle and fat beneath the skin of a living animal using high-frequency sound waves (often between 2 and 10 MHz). A sound-emitting probe, or transducer, is used in this technology and is attached to the animal's back. The sound waves travel through the tissues and bounce off the lines separating the layers of muscle, fat, and hide. On the ultrasound machine monitor, a cross-sectional image is produced as the sound waves are reflected back toward the probe, allowing evaluation of the various carcass (Traitshlawat, 2010). Estimation of carcass characteristics in live animals potentially allows for sorting and selecting livestock for carcass merit. Collectively, current and future applications of ultrasound hold tremendous potential to enhance management for improved carcass production efficiency in livestock. As ultrasound equipment becomes increasingly portable and less costly, it is only a matter of time before the widespread implementation of this technology occurs in the beef industry (William, 2002). Understanding carcass merit can help breeders find superior animals and hasten genetic advancement (Wilson, 1992).

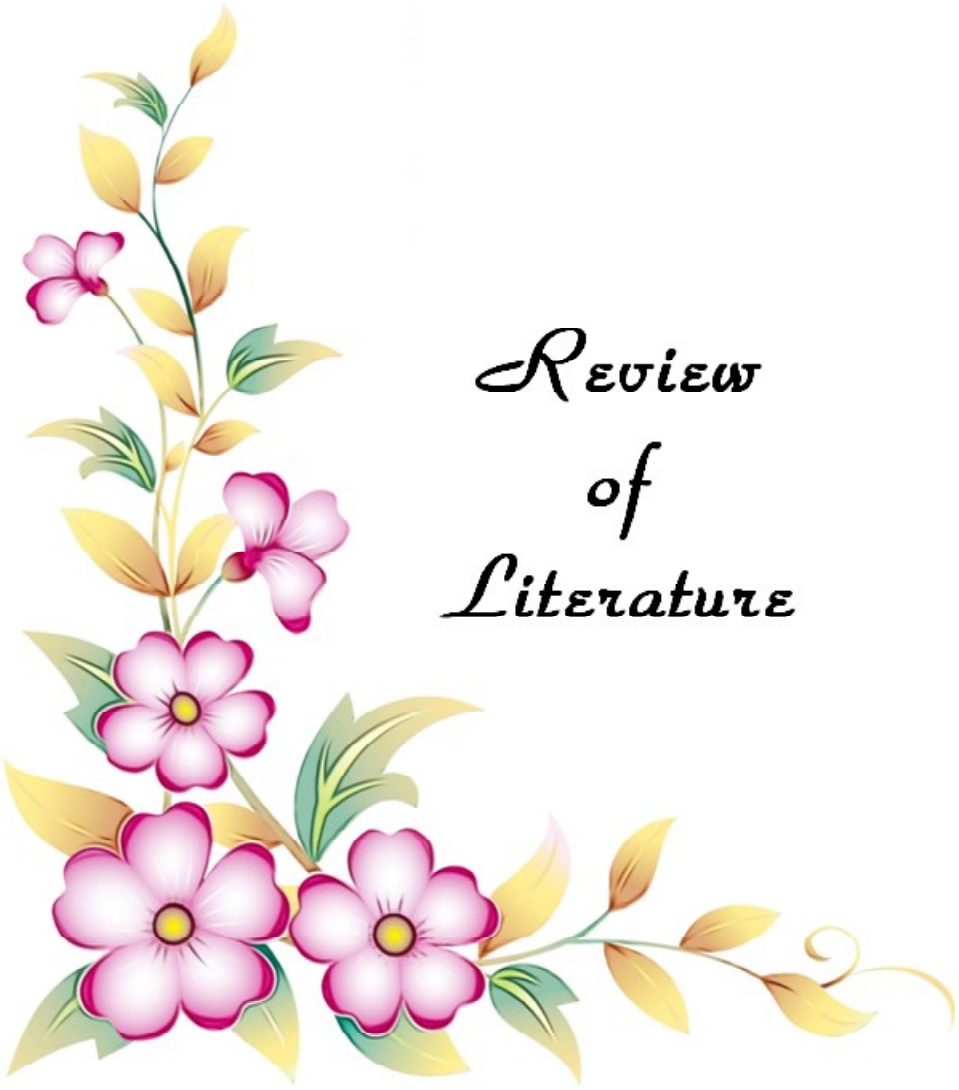
Even though, much of the work has been done on buffalo growth performance and carcass evaluation parameters, the effect of dietary palm stearin supplementation remains unexplored in the case of Murrah buffalo calves. The proposed study may provide a superior dietary regimen for improving growth performance, rib eye area, and back fat thickness, thus, raising the farmer's income in the concerned area. Taking into account the aforementioned facts and figures, the present study has been planned with the following hypothesis and objectives:

HYPOTHESIS: Supplementation of dietary palm stearin to the basal diet may improve the growth performance, rib eye area, and back fat thickness, of Murrah buffalo calves.

OBJECTIVES

- **To study the effect of palm stearin (PS) on the growth performance in Murrah buffalo calves, and**
- **To assess the effect of palm stearin (PS) on the rib eye area and back fat thickness of Murrah buffalo calves, using ultrasonography.**

✍✍✍



Review of Literature

2 REVIEW OF LITERATURE

2.1 Palm stearin properties

South Africa is where the oil palm, *Elaeis guineensis Jacquin*, originated. At the Bogor Botanical Garden in Java, Indonesia, it was first brought to East Asia as an ornamental plant in 1848. In terms of all oils, palm oil is reportedly the second most widely produced vegetable oil in the world today, after soybean oil. It serves the feed industry as a crucial all-purpose raw material (Imoisi *et al.,* 2015). In comparison to all other vegetable-sourced oils, this oil is remarkable. It has a greater level of saturated fatty acids. In addition, palm oil contains five to eight percent diglycerides and free fatty acids, which have a significant impact on physical characteristics (Mohammadreza *et al*., 2015). Additionally, it has been said that palm oil is polymorphism and that combining it with other types of fat when making food enhances its nutritional value. Commercially, two types of vegetable oil are derived from palm oil: crude palm oil (CPO) and palm kernel oil (PKO). CPO is separated into two fractions during processing: PS (30-35%) and palm olein (65-70%). Because it contains a high concentration of saturated fatty acids, PS is solid at room temperature (Choudhary *et al*., 2019). The slip melting point (SMP) of PS is approximately 44-56 ^{0}C. During the fractionation process, a portion of the glycerides crystallizes and solidifies at the normal operating temperature. However, after the solids are separated from the liquid portion, stearin is identified as having a higher melting portion (Nusantoro, 2009). It contains approximately 47-74% palmitic acid, 16-37% oleic acid, 4-6% stearic acid, 3-10% linoleic acid, and 1-2% myristic acid (Rohmah *et al*., 2019)**.** Carbon numbers like C48, C50, and C52 can be used to categorize stearin factions

(Undurraga *et al*., 2001). PS and palm mid-fraction (PMF) are the high melting fractions obtained from dry fractionation. However, since both oils are considered by-products and possess cheaper prices, PS and PMF have a striking potency to be used as a fat stock (Undurraga *et al*., 2001). As PS was more saturated than palm mid fraction, PS contained more high-melting glycerides.

Table 2.1 Distribution of triacylglycerols content in PMF and PS

Triacylglycerolsspecies	Triacylglycerols Distribution (%)	
	Palm mid fraction (PMF)Tm- 38.5 °C	Palm Stearine (PS) Tm- 46.7 °C
POP	61.05	31.06
PPP	2.85	20.61
POO	5.63	15.81
PLP	6.18	8.74
PPSt	3.13	5.65
POSt	11.76	5.6
POL	4.51	5.53
OOO	0.83	1.92
StOO	1.02	1.62
PLL	0.88	0.89
OOL	0.92	0.84
StOSt	1.24	0.79
PStSt	Trace	0.68
LLO	Trace	0.26

Where L (Linoleic), O (Oleic), P (Palmitic), and St (Stearic)

2.2 Dietary palm stearin

Numerous studies (Duckett, Wagner, Yates, Dolezal, & May 1993; Gullet, Buchanan-Smith, & Campbell, 1997; Elmore, Mottram, Enser, & Wood, 1999; Mandell,) have shown that the ratio of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and acids PUFA influences beef flavors. Well-known commercial vegetable fats like palm oil stearin (POS) and palm kernel oil stearin (PKOS) are utilized for specific purposes or combined with other oils to meet the needs of particular food products (Gunstone, 2002). PS, a superior and

more affordable fat source, may be employed in broiler feeding (Arima *et al*., 2007). The more saturated portion of palm oil, called PS, has a more viable composition and thus better physical properties. The wide range in iodine value for this fraction is consistent with the vast variability in solid fat content (Gunstone, 2011). The stearin's palmitic acid content ranges from 47% to 74%, while its oleic acid concentration is between 15% and 37%. Because of their homogeneous triglyceride (TAG) compositions and high melting point, they can be used as low-cost additives. The performance of finished products is improved when cocoa butter is combined with a small amount (5 wt %) of hard fats, such as PS, to encourage desired changes in the crystallization form and physical qualities (Ribeiro *et al*., 2013). In comparison to soybean oil, feeding 3% palm oil to cattle increased subcutaneous (s.c.) adipocyte size and nicotinamide adenine dinucleotide phosphate (NADP) activity. glucose-6-phosphate dehydrogenase and -malate dehydrogenase according to (Choi *et al*., 2013). However, palm stearin has low plasticity, which limits its direct application in fat products (Jahurul *et al*., 2014).

2.3 Other alternatives (lipids)

According to a study by Jabbar *et al*. (2006) Sunflower meal is more cost-effective than Cotton seed cake, a traditional protein source for livestock, and may be added to the fattening rations of crossbred calves without harming production indices. Wanapat *et al.* (2011) fifteen one-year-old swamp buffaloes with an average live weight of 200.5±9.5 kg was randomly assigned to one of three dietary treatments of supplemental vegetable oils in concentrate. Found that supplemental unsaturated fatty acid oil reduced swamp buffalo performance by decreasing average daily gain (ADG), final body weight, and carcass characteristics.

Vegetable and oilseed oils are high in medium-chain fatty acids (FA) and contain very little to no n-3 LC-PUFA (Dubois *et al*., 2007; Jaturasitha *et al*., 2016). Several vegetable oils, such as those made from soybean, sunflower, safflower, and cottonseed, are high in linoleic acid, (Dubois *et al*., 2007; Shingfield *et al*., 2013) whereas flaxseed and canola oils are rich in Alpha-linolenic acid (Salem & Eggersdorfer, 2015; Baker *et al*., 2016). Peixoto *et al.* (2014), has been demonstrated that adding fat supplements such as palm, coconut, and

corn oils to pasture increases the amount of carcass fat, the thickness of the fat covering the meat, and the amount of meat marbling. Ponnampalam *et al*. (2015); Ponnampalam (2017) reported that lambs fed the flaxseed supplement had a similar dry matter intake (DMI), but increased body weight and carcass yield compared to lambs fed the basal diet alone. Lambs receiving flaxseed while grazing annual pasture, either as whole seed or meal (10%, DM basis), exhibit better development performance than lambs feeding annual pasture alone, according to the findings of Ponnampalam *et al*. (2012). These variations can be predicted given that flaxseed functioned as an energy supplementation source to increase lamb growth response when the metabolizable energy (ME) requirements for a growing lamb were not met (Burnett *et al*., 2017). Okrouhlá *et al*. (2018), discovered that including 40 g/kg rapeseed oil in the four weeks before slaughter is sufficient for improving the FA profile without affecting the consistency of the backfat in pigs.

2.4 Chemical composition of feed

A rumen-simulation technique used in an in vitro investigation also showed that adding plant oils to diets at a rate of 3% of dry matter could improve the digestibility of EE and NDF (Vargas *et al*. 2017). The effect of oil supplementation, however, depends on the amount of oil provided. In the previous investigation, we found that dietary fat supplementation at 4% of DM had no significant influence on nutritional total tract digestibility. Following the addition of fat to the diet, both saturated and unsaturated, the whole tract apparent digestibility of DM, OM, CP, and NDF did not differ in calves. These findings agreed with those of Messana *et al*. (2012) and Pormalekshahi *et al*. (2020). The apparent digestibility of DM, OM, CP, and EE was higher in the fat supplemented diet compared to the control diet, but it did not affect the apparent digestibility of NDF / starch (Palmiquist and Conard, 1978). Behan *et al*. (2019) found that supplementing prilled fat (PF) changed the intake and digestibilities of dry matter (DM), organic matter (OM), crude protein (CP), and neutral detergent fiber (NDF), but not ether extract (EE) and crude fiber (CF). Shelke *et al*. (2012) studied the influence of inert fat / protected fat in the diet and inert protein / protected protein on milk yield, composition, and nutrient utilization in buffaloes (Murrah). Buffaloes in the CON group were fed chaffed concentrate mix, wheat straw, and chopped maize feed as needed. Buffaloes in the augmented

group (A group) were fed the same diet as the CON group but with the addition of 2.5% rumen inert fat / protected fat (on a DMI basis). For 60 days prior to 90 days following parturition, group A buffaloes received rumen inert fat / protected fat and inert protein / protected protein supplements. There was no significant difference in the digestibility coefficients (g/g) of dry matter (DM) and organic matter (OM) between the two groups. Ranjan *et al.* (2013) found that the digestibility of various nutrients, including DM, OM, CF, CP, EE, and NFE, was greater in treated groups fed 100 and 200 g/d of rumen inert fat/protected fat compared to controls, but there was no difference between the groups. Fat supplementation appeared to have a profoundly negative influence on OMD and DMD via the effect on fiber digestion if it contained more than 5-6% DMI. The fundamental idea behind fat protection/bypass was to counteract the negative effects of fat inclusion on fiber digestion and provide favorable results to increase the energy density of the allowance. According to Nawaz *et al*. (2012), there were no significant differences ($P>0.05$) in DMD detected in buffaloes supplemented with diets containing mustard oil or poultry fat in the control diet. The average DC (digestibility coefficients) for OM were found to be higher ($P<0.01$) in buffaloes fed diets supplemented with poultry fat and tallow than in control or mustard oil-fed diets. The nutrient intake of experimental animals fed varied doses of bypass fat is presented. Digestible crude protein (DCP) and total digestible nutrient (TDN) consumption remained statistically insignificant ($P>0.05$) among treatment groups. There was no influence on the digestibility of DM, CP, CF, and NFE.

2.5 Effect on growth performance

In high-concentrate feedlot finishing feeds, fats and oils make up generally 2.0 to 6.0% of the ration's dry matter (DM). To raise daily growth on average, increase feed utilization efficiency, and/or enhance carcass features, they increase diet energy and cow energy intake (Brethour *et al*, 1986; Zinn 1989a; Brandt and Anderson1990; Krehbiel *et al* 1995a). Fats and oils are typically included at 2.0 - 6.0% of ration DM in high-concentrate feedlot finishing rations. They increase diet energy and cattle energy intake in order to improve average daily gains, feed use efficiency, and/or carcass characteristics (Brethour *et al*, 1986; Zinn 1989a; Brandt and Anderson1990; Krehbiel *et al* 1995a). Teye *et al*. (2006), evaluated the effects of three dietary oils palm kernel (PKO), palm oil (PO), and soybean (SBO) as well as two

protein concentrations high protein (HP) and low protein (LP) were examined in a 3:2 factorial design with 60 pigs to assess how they affected growth performance, the composition, and content of muscle fatty acids, the carcass, meat, and eating qualities. They discovered that the type of oil had little bearing on growth and carcass quality. The polyunsaturated to saturated fatty acid (P:S) ratio in the longissimus muscle was considerably decreased by PKO. The LP diet raised intramuscular fat (IMF) from 1.7 g/100 g of muscle in HP to 2.9 g/100 g and increased tenderness and juiciness on a scale of 1-8, but at the expense of lower daily weight growth, lower feed conversion efficiency, reduced P:S ratio, and higher lipid oxidation. The findings point to PKO and PO as less expensive alternatives to SBO for the production of high-quality and healthy pigs in tropical developing nations, but their inclusion requirements must be established. Thiruvenkadan *et al.* (2009), conduct a ted study in the Central Cattle Breeding Farm, Alamadhi, Tamil Nadu, India, maintained live weight data on 590 Murrah buffalo calves (140 male and 450 female calves), born between 1990 and 2004. Least-squares techniques were used to analyze the data. Male and female calve's adjusted birth weights were 33.0±0.49 and 31.9± 0.27 kg, respectively, for a total weight of 32.4±0.30 kg. The mean body weight at three, six, nine, and twelve months of age was 62.0± 0.65, 87.9± 0.95, 112.4± 1.23, and 134.16±1.41 kg, respectively, pooled over periods, seasons, and sex. Calves born during the dam's second parity were generally heavier than those born during the dam's first parity. Males had a higher body weight than females across all age groups. Rahman *et al*. (2012), reported that with regard to growth performance, feed consumption, and FCR, broiler diets with 4% palm oil performed better than controls and diets with other degrees of supplementation. Tipu *et al*. (2014**)** studied the effects of palm kernel cake on development rate, feed intake, and digestibility in buffalo calves was undertaken in the Buffalo Research Institute Pattoki District Kasur. Twenty-five male calves, 18 months old and weighing 160 ±10 kg, were divided into five groups using a completely random design. Five iso-caloric and iso-nitrogenous concentrates designated A through E, were created by substituting 100, 75, 50, 25 and 0% of PKC for 0, 25, 50, 75, and 100% of cotton seed cake. daily weight gain was higher but intakes of digestible DM, CP, and NDF were lower in buffalo calves given PKC. so, it was concluded that PKC can substitute cotton seed cake without impairing male buffalo's ability to grow.

Ribadiya *et al.* (2015), reported that a study was conducted to see whether groundnut haulms (GNH) could successfully substitute expensive materials like maize and soybean meal in the meals of broiler chicks. The addition of GNH at a level of 6% in the concentrate mixture is concluded to have no negative effects on feed intake, growth, or FCR based on the study's findings. Long *et al.* (2018), conducted a study and found that dietary supplementation with a blend of 25% soybean oil, 15% corn oil, 10% coconut oil, 15% linseed oil, 20% palm oil, 15% peanut oil, and 10% linseed had positive effects on ADG, FCR, liver percentage, serum glucose, total serum protein, and meat quality, as well as higher SFA and PUFA deposition in breast muscle of broilers. This suggests that these two mixed plant oils can be used as better dietary energy Azmi *et al.* (2021), investigated the effects of 4% bypass fat and 26% concentrate supplementations on the longissimus thoracis slumbrous (LTL), supraspinatus (SS), and semitendinosus (ST) muscles of Murrah cross and swamp buffaloes, as well as on the carcass characteristics and the proximate and fatty acid composition of these muscles. In this study, two breeds, two diets, and four replicates of each treatment were used in a completely randomized 2×2 factorial design. Sixteen buffaloes, eight of each breed, weighing a combined 98.64±1.93 kg, were divided into two food groups at random. Before being killed, the buffaloes were fed for 730 days. The findings revealed that supplemented bypass fat increased pre-slaughter weight, hot and cold carcass weights, meat: fat ratio, pH at 24 h, moisture, and crude protein of LTL, ST, and SS, as well as ether extract of LTL and ST, and meat fatty acids of C16:0, C16:1, C18:1, PUFA n-6/n-3, and total MUFA. Decreased were the carcass yield and carcass fat percentages, the ash content in ST, the EE in the SS muscle, the meat fatty acid C18:3, total PUFA n-3, UFA/SFA, and PUFA/SFA. In addition, as compared to swamp buffaloes, Murrah cross demonstrated considerably ($p< 0.05$) larger pre-slaughter hot and cold carcass weights, carcass bone %, and total fatty acid, but significantly ($p <0.05$) lower meat: bone ratios, ash of LTL, and CP of LTL and ST. Finally, adding bypass and concentrated fats to the buffalo's diet may alter the nutrient composition of the meat without degrading the carcass quality, bringing about higher profit. Khaskheli *et al.* (2021) conducted a study, in which the experiment involved 200 birds, 200 of which were divided into two experimental groups, each of which received 10 replications of 10 birds: the control group and the group

that received crude palm stearin (CPS) treatment. The basic diet was all that was provided to the chicks in the control group; however, in the CPS-treated group, the basic meal was also supplemented with 3% CPS. Data on the major study parameters were collected throughout 42 days. ($p<0.05$) was used to evaluate whether differences were significant after doing a Student T-test on the data. The CPS-treated group had lower percentages of fillets, thick drumsticks, wings, dressing, feed conversion ratio, daily weight growth, and final body weight, according to the results. Lower weights were found for the gizzard, liver, spleen, and abdominal fat. Although CPS improves intestinal shape, it has negative effects on the quality of the meat, carcass production, and overall growth performance. Ahmed *et al*. (2021) conducted a study and found that supplementation of rumen bypass fat (RBF) at the rate of 2.35% per kg in total mixed ration did not improve dry matter intake, body weight gain, and body condition score but in blood metabolites, RBF supplementation significantly reduced blood glucose level and there is a significant increase in blood triglyceride and cholesterol levels in Nili-Ravi buffalo male calves.

2.6 Average daily weight gain

According to Zinn (1989a), cattle fed a steam-rolled barley finishing diet supplemented with 4.0% or 8.0% yellow grease or animal-vegetable fat blends showed linear improvements in weight gain, feed conversion, and carcass characteristics. Elbedawy *et al*. (2004), investigated that feeding growing lambs a diet containing dietary protected fat resulted in higher average daily gain (ADG) and higher carcass fats, but it did not affect the percentage of unsaturated fatty acid in carcass fat. The roughage level did not affect growth performance or carcass characteristics. The higher average daily gains and fatter carcasses may be attributed to the lambs fed calcium soaps of palm oil consuming more digestible energy. Azmi *et al*. (2007), observed that the addition of bypass fat was able to enhance the growth performance of Murrah cross and swamp buffaloes, including the average feed intake, body weight, and body condition score, which may further affect the carcass quality features. Rajput *et al.* (2016), determined that there were no appreciable differences in ADG and carcass traits between male and female buffalo calves. Male ADG values were higher than female ADG values, but, in terms of numbers. Buffalo calves might be saved from slaughter at a young age because they

had good fattening potential. Lei *et al*. (2018), analyzed the effects of dietary Essential-oils-cobalt (EOC) (0, 52 mg, and 91 mg daily) on cashmere goats, we can see that the EOC supplement boosted average daily gain and enhanced phenotypic (cashmere fiber traits, carcass weight, and meat quality). According to Yusriani *et al*. (2021), silage derived from palm fronds can increase cow body weight by 0.34 kg for local cattle and by 0.99 kg for Brahman cattle in the Aceh Tamiang region. To increase population and meat production and meet consumer demand, it showed that palm oil by-products are a very promising source of cow feed.

2.7 Factor affecting average daily weight gains

2.7.1. Seasonal effects: Season affected the ADG from birth to weight at 6 months in the Murrah and Egyptian buffalo population, according to Marai *et al*. (2009) and Sharma *et al*. (2021). A similar result was also found by Thevamanoharan *et al*. (2001) as the season has a substantial impact on swamp buffaloes from birth to 24 months of age. Elden *et al*. (2020), on the other hand, reported that the season had no significant impact on any age group.

2.7.2. Sexual effects: Sex had a substantial impact on daily weight growth before weaning, but not on daily weight gains post-weaning, according to Thevamanoharan *et al*. (2001). Similarly, according to Elden *et al*. (2020), buffaloes of all ages had a substantial effect on sex on their daily weight increase.

2.7.3. Period's effects: According to Thevamanoharan *et al*. (2001), and Elden *et al*. (2020), the pre-weaning period had a significant impact on daily weight gains in buffaloes of all ages. Similar considerable advances were found by Marai *et al*. (2009), Ahmad *et al*. (2002), and Akhtar *et al*. (2012).

2.8 Effect on carcass characteristics

Lough *et al.* (1993) reported that in fattening lambs, the addition of palm oil at 10.7% of the diet's dry matter intake enhanced the amount of fat in the carcass without changing the grade of the carcass. According to Zinn and Plascencia (1996) Supplemental fat (6.0% DM), considerably improved the marbling score and was enough to convert the average carcass

from high Select to low Choice, while also tending to raise the amount of kidney, pelvis, and heart (KPH) fat. This is consistent with other research that found adding fat to a diet raised marbling score (Zinn 1989a; Brandt and Anderson 1990), % KPH (Zinn 1988, 1989a, 1992a; White *et al*. 1992; Clary *et al*.1993), and fat thickness (Zinn 1988, 1989a, 1992a; Boucqué *et al*. 1990; Huffman *et al*. 1992). According to Rhule (1996), pig's dressing percentage, loin muscle area, and backfat thickness were all impacted by the diet's palm kernel meal addition. Uncertainty surrounds the impact of extra fat on the longissimus muscle region supplemental fat seems to affect carcass composition differently from live weight and live weight increase. Reviewing their findings, Doreau and Chilliard (1997) found that adding fat to ruminant diets causes an increase in the percentage of fat in carcasses regardless of the type of dietary lipids; nevertheless, the weight of all adipose tissue increases but not the percentage of fat in muscles. Dahlan *et al*. (1988), stated that an oil palm by-products diet, which contained more energy and protein than a grass diet, could improve the quality of buffalo meat. The former diet promotes the formation of intramuscular fat, which results in more tender buffalo meat. This study found that the use of oil palm by-products has the potential to produce high-quality buffalo meat in this country. Smink *et al*., (2008), studied that the use of palm oil in broilers had a positive influence on meat firmness. The addition of palm oil (10.7% dry matter) to fattening lamb diets increased carcass fatness while not affecting carcass quality (Lough *et al*., 1993). Ordoñez *et al*. (2017), evaluate that pig performance, carcass features, and meat quality were not negatively impacted by the inclusion of up to 10% crude glycerine from palm oil in the diets of growing pigs. So, it is okay to use crude glycerine from palm oil as a source of energy for pigs. Previous research with lambs showed that adding palm oil thickened the backfat (Lough *et al*., 1993; Solomon *et al*., 1992). Palm oil-fed Angus crossbred steers had higher marbling scores and somewhat thicker 12th rib fat compared to steers-fed soybean oil (Choi *et al*., 2013). Supplemental palm oil boosted lipogenic enzyme activity, adipocyte sizes, and lipid production in vitro in s.c. adipose tissue (Choi *et al*., 2013; Nestel *et al*., 1978). Don *et al*. (2018), stated that supplementing lipid-rich sources at or below 6% (DM basis) is unlikely to affect animal performance and the sensory qualities of the meat in iso-energetic and iso-nitrogenous diets. Alpha-linolenic acid (ALA) levels in lamb meat are anticipated to rise as a

result of alpha-linolenic acid-rich supplementation. However, some studies have noted an increase in n-3 LC-PUFA content as a result of alpha-linolenic acid (ALA) administration. Webb *et al*. (2022), reported that lambs' fatty acid profiles and meat quality indicators responded significantly to the addition of fibrinolytic enzymes and palm oil to high-forage diets.

2.9 Factor influencing carcass composition

The amount of fat in the carcass varies greatly depending on factors including breed, age, sex, nutrition, body weight, physiological state, and physical activity (Owen *et al*., 1978; Kirton, 1988), Several environmental factors and management practices influence meat production. Meat animal carcasses differ in composition due to genetics, animal age, sex, nutrition, and environmental factors. Carcass composition varies greatly between species in terms of carcass weight, fat, muscle, and bone percentages (Irshad *et al.*, 2013).

2.9.1 Genetic factor: There are breed and genotype differences in carcass qualities as well, although these traits have not been widely used in improvement projects as selection criteria (Goetsch *et al*., 2011). All farm animal species have breed-specific characteristics for growth and carcass composition (Irshad *et al*., 2013). According to Dhanda *et al*. (1999) and Getahun (2001), genotype has an impact on the various lean: bone, lean: fat, and meat: bone ratios. Many records show that cattle with "Zebu" blood produce a higher percentage of better-quality carcasses in hot, humid conditions (e.g., Queensland) than animals with entirely temperate blood (Colditz and Kellaway, 1972).

2.9.2 Influence of age: According to Irshad *et al*. (2013), the leanest carcasses are produced by young bulls, followed by culled cows and steers, with heifers often generating the fattest carcasses. The best-conforming carcasses are likewise produced by young bulls, followed by steers and then heifers. Cow corpses have very poor structures despite being quite slender. In the other three sex classes, excluding these cow carcasses, fatness and conformation are adversely correlated. Late-maturing breeds of beef cattle often have larger growth potential and fatten up later than earlier-maturing types or animals. The percentage of bone considerably reduced with age and weight, according to studies by Singh *et al*. (1991) and Dhanda *et al*. (1999).

2.9.3 Nutrition: Nutrition is important because changes in animal diets can improve both the quantity and quality of the final product (Geay *et al*., 2001). Fast growth rates caused by a high level of nutrition can result in an earlier onset of the fattening phase of growth. Males need more protein and energy than females, and when the calorie intake is changed at a specific ratio, this might result in changes between the sexes in the composition of the carcasses (Campbell and King, 1982). When compared to meat from semi-extensively reared spent male and female buffaloes, meat from young male buffaloes showed significantly ($p<0.05$) higher moisture, collagen solubility, sarcomere length, myofibrillar fragmentation index, tenderness, and connective tissue residue scores but lower collagen, insoluble collagen, and shear force values (Kandeepan *et al*., 2009) Regardless of gender, limiting nutrient intake increases lean tissue accretion and decreases fat deposition (Goetsch *et al*., 2011).

2.9.4 Sex: More intramuscular connective tissue is found in bovine males than in females (Irshad *et al*., 2013). Compared to female chicks, male chicks had heavier carcasses (Bogosavljevic-Boskovic, 2006). Irshad *et al*. (2013), studied that Males who have been castrated have fatter carcasses. In comparison to steers and wethers, short scrotum bulls and rams generate heavier carcasses with larger Longissimus dorsi muscle regions, less external and internal fat, and higher conformation scores. These impacts are connected to an animal's hormonal state. Compared to bulls, steers produce meat that is substantially more delicate and marbled.

2.9.5 Environment: The range of environmental temperatures that living things can withstand is 0 to 40 degrees Celsius, while certain species are accustomed to living at or below the freezing point (Irshad *et al*., 2013), According to (Pearse 1939), many animal's development is prolonged in low-temperature environments while it is usually slowed down in unadapted stock when temperatures are high. Temperatures that are not uniformly low or high have a higher stimulatory effect on metabolism (Ogle and Mills, 1933). Animals transported into warm climates should be able to provide meat due to their heat tolerance, and Indian cattle shouldn't be slaughtered in an effort to increase milk yields (Wright, 1954).

2.10 Carcass evaluation of live animals using ultrasonography

Ultrasonic assessments of the depth of fat and muscle could increase the accuracy of carcass composition predictions on live animals (Delfa *et al*., 1995). Also used as a tool for estimating beef cattle marbling (Haumschild and Carlson, 1983). Wild was the first to recognize the use of ultrasonics as a non-destructive and moral method of evaluating fat and muscle in living animals in 1950, according to Houghton and Turlington (1992). Ultrasonography may be the most dependable technology for determining the carcass merit of a live animal (Miller, 1996). According to Wallace *et al*. (1977), the area of the longissimus muscle could also be accurately estimated with ultrasonography when measuring the subcutaneous fat thickness in live beef steers over the rib, lumbar, and rump. According to Silva *et al*. (2012), real-time ultrasonography is anticipated to play a significant role in the meat business by giving precise information on carcass and meat properties in live animals. To determine the retail yield of carcasses and the quality of the meat, ultrasound measurements taken from live animals can be employed (Rhonda, 2017).

2.11 Economically important carcass traits

Ribeye area (REA), back fat (BF), rump fat (RF), and % intramuscular fat (PIMF) are among the features that are frequently assessed. Bullock *et al*. (1991) investigated the connections between the ultrasonic readings and the corresponding measurements of the carcass. For the rib eye area, 12 rib fat, shoulder fat, and rump fat, the correlation coefficients were 0.90, 0.79, 0.62, and 0.81, respectively. The average body weights, rib eye area (REA), and fat thickness (FT) between the lighter and heavier groups were 335.36 kg, 32.60 cm^2, 69.58 cm^2, and 0.17 and 1.08 cm, respectively. The average rib eye area and fat thickness for buffaloes with a mean (SD) live weight of 496.18 (38.56) kg were 66.81 (7.04) cm and 9.92 (3.00) mm, respectively, according to Jorge *et al*. (2007). Positive correlations between carcass measurements and ultrasound assessments of REA and FT (-0.96 for REA and r-0.99 for FT) were found. Andrighetto *et al*. (2009), a study on slaughtered animals that had been raised for 75, 100, 125, and 150 days was done. The average live weights and weight gain per day were, respectively, 328±13.6 kg and 1.01±0.05 kg/d;346±28.0 kg 0.86±0.17 kg/d; 356±23.6

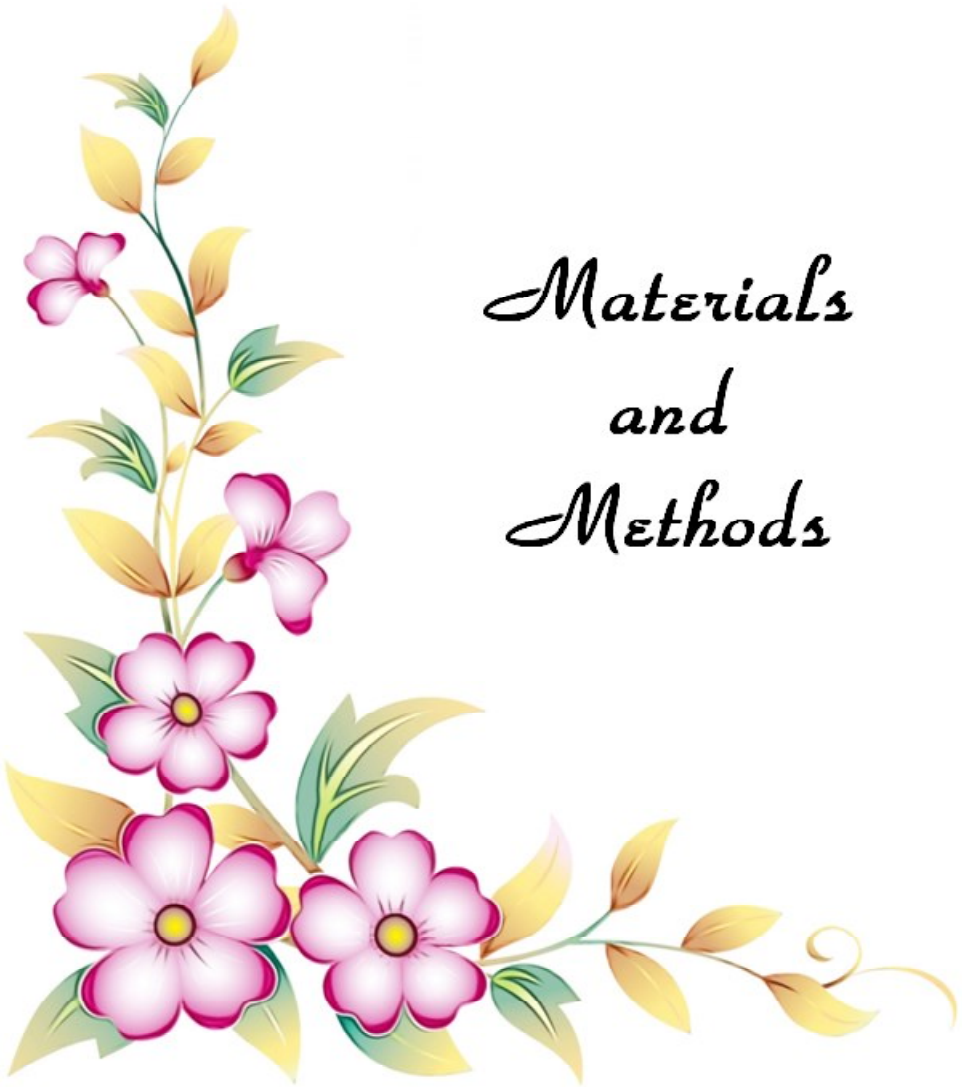
kg and 0.84±0.11 kg/d and 392±3.6 kg and 0.90±0.04 kg/d, respectively. The thickness of the ultrasound-measured rib eye area and back fat was 38.74±2.1 cm^2 and 5.0±0.7 mm at 75 days, 40.7±2.9 cm^2 and 5.1±1.1 mm at 100 days, 40.02.3 cm^2 and 6.6±1.6 mm at 125 days, and 45.4±1.9 cm^2 and 7.9±0.9 mm at 150 days, respectively. For rib eye and back fat thicknesses, there were correlations of 0.82 and 0.85 between ultrasonography and carcass values. According to Andrighetto *et al*. (2009), 18-month-old neutered male Murrah buffaloes with fattened animals kept in confinement had rib eye areas of 48.8 cm^2 and 50.26 cm^2 similar results found by (Rebak *et al*., 2010). Pena *et al*. (2014) reported that the average thickness of subcutaneous fat and the area of the loin muscle was 79.74 cm^2 and 0.39 cm for buffaloes weighing 534.96 kg. The carcass demonstrated a mild to significant positive connection (0.131 to 0.976) with the ultrasonic measurements of the 12 ribs for the same characteristic. Greiner *et al*. (2003a) evaluate, beef cattle ranging in slaughter weight from 354 to 731 kg, with a mean of 547 kg. With an average of 77 cm^2 and 1 cm, the rib eye area and fat thickness for the same ranged from 59.3 to 102.2 cm^2 and 0.23 to 2.01 cm, respectively. Suguisawa *et al*. (2003) reported that real-time ultrasonography was employed for the investigation to forecast ribeye area (REA) and subcutaneous fat thickness (FT) in live animals in comparison to data taken from carcasses. 115 yearling bull calves were employed, with an initial body weight of 329 kg. Four ultrasonographic measurements were taken every 28 days till slaughter. As animals neared slaughter, the predictive accuracy of ultrasonographic measurements rose, reaching maximum levels at the final measurement (R2=0.68 and 0.82 for REA and FT, respectively). Genetic group and live measures affected FT carcass measurements ($P< 0.05$).

2.12 Morphometric measurement

Rezende *et al*. (2017) calculated the phenotypic diversity in three different buffalo breeds, namely Murrah, Jaffarabadi, and Mediterranean buffaloes. Measurements of thoracic girth, body length, and height at withers yielded mean values of 204.36 cm, 147.00 cm, and 133.31 cm. Dhillod *et al*. (2017) found that Murrah buffaloes averaged 556.1±4.9 kg in body weight (BW), 214.6±1.2 cm in chest girth (CG), 226.3±4.8 cm in belly girth, 152.2±0.8 cm in body length (BL), 64.2±0.5 cm in the hip bone distance (HBD), and 135.8±0.5 cm in height at the withers (HW). Significant BW was linked with AG (0.47) and CG (0.35) ($P<0.01$).

Associations between the CG and BW, CG/HW, and CG/AG were significant (P<0.01). (0.35, 0.42, 0.36). Significant and positively linked relationships existed between BL and BW, CG, and HBD.

Using morphometric measurements, Yadav and Vijh (2022) investigated the body conformation characteristics of Murrah bulls. Paunch girth was calculated to be 226.4±1.28 cm, heights at the withers to be 144.2± 0.40 cm, body length to be 151.1± 0.50 cm, hip width to be 59.8± 0.25 cm, and heart girth to be 216.1± 0.93 cm as the mean value (CG). In Murrah bulls, the connection between BL and WH (0.73), CG with PG (0.71), BL (0.41), and WH (0.73) were all highly significant (0.41).



Materials and Methods

3 MATERIALS AND METHODS

The following materials and methods were used in the current study to achieve the objectives set out in the study.

3.1 Source of data

The necessary information was acquired based on observations of Murrah buffalo calves kept at the Cattle and Buffalo Farm of Livestock Production and Management, ICAR-Indian Veterinary Research Institute (IVRI), Izatnagar, Bareilly, Uttar Pradesh. This study comprised a of total twelve Murrah buffalo calves ranging in age from 10 to 14 months, which were divided into two groups. Relevant data on growth traits such as average daily weight gain, dry matter intake, final body weight, and feed conversion ratio were generated. During the current investigation, measurements of rib eye area and back fat thickness were taken on the available male and female animals to assess economically important traits using ultrasonography.

3.2 Location and climatic conditions.

The Cattle and Buffalo Farm, LPM Section, ICAR-IVRI, Izatnagar, Bareilly, Uttar Pradesh is situated at 28°22' North, 79°24' East, and 169.2 m above mean sea level. Around 21°C is the average annual temperature. The extreme temperature ranges from 5 to 40 degree Celsius, while the average monthly temperature fluctuates between 13 and 30 degrees Celsius in January and May. The average rainfall is 90 to 120 cm per year. The institution has 165 hectares of well-irrigated fodder-producing land to ensure a year-round supply of green fodder to these animals.

3.3 History of Herd

The Cattle and Buffalo Farm, Livestock Production and Management was established in October 1937, when several Hariana and Murrah buffaloes were transferred from the Cattle Breeding Farm in Karnal. The FAGS (Farm Animal Genetics Section) was established in 1945 and these animals were relocated to FAGS. Murrah buffaloes have been kept for research and education purposes since the founding of Cattle and Buffalo Farm. This unit was expanded into a Murrah buffalo improvement program as part of the AICRP on Buffalo Improvement/Network Project on Buffalo Improvement. In 1975, the Farm Animal Genetics Section was renamed Cattle and Buffalo Production Research. The previous Livestock Production Research (Cattle and Buffalo) with Swine Production Farm and Sheep and Goat Farm was recognized as Livestock Production & Management Section in October 1997.

3.4 Management of the herd

The institution has 165 hectares of well-irrigated Fodder Farm Section to ensure a year-round supply of green fodder. Stallfed animals were divided into groups based on their age and milk production. Murrah buffaloes were maintained in stalls with a loose housing system. There, they were sorted into groups based on their age, milk production level, physiological stages, and so on. For 18 hours a day, calves were housed in clean, dry, well-ventilated enclosures. The calves were also permitted out for 6 hours per day, from 9:00 AM to 3:00 PM, in a common open area for exercise and to ensure that the calf sheds were washed, cleaned, and dried. They had unlimited access to clean drinking water, calf starter, and green fodder. This is up to three months of age with close supervision and care. Young bulls were kept in separate sheds with open paddocks, as were calves aged 3-6 months, 6-12 months, and heifers aged one year until pregnancy. Each group of cows dry, lactating, and advanced pregnant buffalo had a separate shelter (with open paddocks). The pens where teaser bulls are kept have access to wide-open paddocks. According to the suggested farm plan, calves received routine vaccinations against infectious illnesses and parasite treatments. The immunizations for FMD, Brucellosis and HS were given to all animals on schedule. In the morning and evening, teaser bulls (vasectomized bulls) were used to detect buffaloes in heat.

With a few exceptions, buffaloes are typically dried 305 days after lactation and during the seventh month of pregnancy. The calves of Murrah buffaloes, however, were not weaned, which is an essential distinction. Hand milking, using suckling calves, is predicted in buffalo.

3.5 Nutritional management of experimental animal

A total of twelve animals were divided into two groups: the control group, which was fed a basal diet containing wheat bran, maize, de-oiled soybean meal, mustard oil cake, mineral mixture, and salt-based diets, and the treatment group, which was fed a basal diet with a 3% inclusion of palm stearin. The animals were housed in a loose housing system. Both the treatment and control groups will be fed for 120 days. The diets of the control and treatment groups were made iso-calorific and iso-nitrogenous. Since palm stearin contains high energy, the energy content of the treatment group diet is reduced slightly in comparison to the control diet to balance the additional amount of energy provided by palm stearin, and thus the effect of saturated fatty acid and triglycerides content of palm stearin added in the diet of the treatment group of buffalo calves were observed while assessing the growth performance rib eye area, and back fat thickness.

Table 3.1 Control group diet

Feed ingredients	Inclusion %	CP% in general	CP% in diet	TDN% in general	TDN% in diet
Concentrate					
Maize	35	10	3.5	85	29.75
Wheat bran	42	15	6.3	68	28.56
DSBM	10	46	4.6	78	7.8
MOC	10	35	3.5	74	7.4
Mineral mixture	2				
Salt	1				
Total			17.9 (Approx **18%**)		73.51 Approx **735g/ Kg DM**
Roughages	*ad-lib* green forage and wheat straw				

Table 3.2 Treatment group diet

Feed ingredients	Inclusion %	CP% in general	CP% in diet	TDN% in general	TDN% in diet
Concentrate					
Maize	29	10	2.9	85	24.65
Wheat bran	37	15	5.25	68	23.8
DSBM	15	46	6.9	78	11.7
MOC	10	35	4.2	74	8.88
Palm Stearin (PS)	6	0	0	Approx 180	10.89
Mineral Mixture	2				
Salt	1				
Total			19.15 (Approx 19%)		79.84 Approx **798g/Kg DM**
Roughages			*ad-lib* green forage and wheat straw		

3.6 Parameters to be recorded

A. Growth performance

Body weights of individual calves were recorded at bi-weekly intervals and the average daily gain was calculated by dividing the total weight gain by the number of days.

Dry matter intake (g/day): DMI from concentrate and green fodder were computed individually and then added to determine the total DMI for each calves. Each feed sample's dry matter (DM) content was evaluated by drying a known weight of the sample in a moisture cup overnight in a hot air oven at 100+2°C. Weight loss is estimated as moisture, and the balance is recorded as dry matter. From 10 to 14 months of age, dry matter intake (g/day) was measured at fortnightly intervals.

Feed conversion ratio (DMI g/ ADG g): The feed conversion ratio (FCR) was determined as the average daily dry matter intake (kg) per kg average daily growth (ADG). The following formula is used to determine the amount of DM required for each kilogram of weight gain.

$$\text{DMI/kg gain in weight} = \frac{\text{DM consumed (kg/day)}}{\text{Average daily weight gain (kg)}}$$

c. Average daily weight gain

$$\text{Average daily weight gain} = \frac{\text{Final body weight-initial body weight}}{\text{Days of interval}}$$

A. Morphometric Measurement

The body measurements, body length, height, heart girth and flank length or punch girth were measured in centimeters (cm) using a measuring tape**.**

Body length (BL): It was noted as the distance from the external occipital protuberance to the base of the tail in transactional/skewed orientation.

Height at withers (HW): Using the animal as a reference, we measured the distance between its withers and the platform's surface.

Hip bone (HB): The distance between the dorsal tops of the hip bones is measured by

Paunch girth (PG): The circumference of the stomach is taken before the hind limbs of an animal.

C. Estimation of proximate principles

The samples of feeds were analyzed for proximate principles as per standard procedures of the Association of Official Analytical Chemists (AOAC, 2000). A brief description of the method employed is given below:

Dry matter (DM): Representative sub-samples were taken in pre-weighed moisture cups and kept in a hot air oven at 100±2°C until constant weight was obtained. Dried samples were cooled in a desiccator, weighed, and DM was calculated as follows:

$$\text{DM (\%)} = (a/b) \times 100$$

Where,

a = Dry weight of sample

b = Fresh weight of sample

Crude protein (CP): The nitrogen/crude protein content of the sample was determined by the standard Kjeldahl method. One gram of the sample was taken in a Kjeldahl flask having 25 ml concentrated commercial sulphuric acid and it 3-5 g digestion mixture (sodium sulfate and copper sulfate, 9:1) was added as a catalyst. The flasks were heated on a digestion bench till the contents were free from carbon particles. The flask was then cooled to room temperature, and contents were transferred into a 250 ml volumetric flask, and volume was made up to mark by repeated washings with distilled water. A suitable aliquot (10 ml) of the digested sample was then distilled in a Micro-Kjeldhal distillation apparatus and a sufficient amount (about 10 ml) of 40% NaOH was added to make the content alkaline. Gaseous ammonia thus released was trapped in a conical flask containing 10 ml of 2% boric acid solution having Tashiro's indicator (0.1% methyl red and 0.1% bromocresol green in the ratio of 2:1 in absolute alcohol). Approximately 60 to 80 ml of the distillate was collected which was subsequently titrated against standard N/100 H_2SO_4. A blank was also run, the value of which was subtracted from the sample's reading. The normality of the acid was checked by titrating against sodium carbonate using methyl orange as an indicator. The crude protein content was determined as follows:

$$CP\ (\%) = \frac{100 \times Y \times (B\text{-}B1) \times 0.00014 \times 6.25}{X \times W} \times 100$$

Where,

Y = Volume (ml) made out of digested sample,

X = Volume (ml) of aliquot taken for distillation,

B = Volume (ml) of N/100 H2SO4 consumed for titration of samples,

B1 = Volume (ml) of N/100 H2SO4 consumed for titration of blank distillate,

W = Weight (g) of oven-dried sample taken for digestion, and

6.25 = Factor for converting nitrogen into the protein of the sample.

Ether extract (EE)/Crude fat: The ether extract/crude fat was determined by extracting a weighed quantity (about 2-3 g) of a ground moisture-free sample with petroleum ether (B.P. 60-80°C) in Soxhlet apparatus for 8-10 h. The extracted oil in the flask was dried to a constant weight of 80°C. The increase in weight of the oil flask was taken as ether extract and expressed in percent on a DM basis by the formula:

$$\text{Ether extract (\%)} = (y-x)/w \times 100$$

Where,

y = Weight of oil flask after extraction

x = Weight of oil flask before extraction

w = Weight of oven-dried sample

Total ash (TA): A known quantity of sample was taken in a pre-weighed silica crucible, decarbonized on the heater to make it smoke-free, and, ignited in a muffle furnace for ignition at 550±50°C for 3h. The weight of the residue left was expressed as the total ash content of the sample. The percent total ash was calculated from the following formula:

$$\text{Total Ash (\%)} = c - a / b - a \times 100$$

Where,

a = Empty weight (g) of silica basin,

b = Weight (g) of silica basin plus oven-dried sample, and

c = Weight (g) of silica basin plus ash,

Organic matter (OM): Percent, OM in feed samples was calculated by subtracting the total ash from 100 and expressed as percent on a DM basis, as follows

$$\text{OM (\%)} = 100 - \text{TA (\%)}$$

D. Biochemical Parameters

Serum was collected on 0^{th},30^{th},60^{th},90^{th},120^{th} day and use in analytical purpose

Plasma glucose: The glucose oxidase (GOD) and peroxidase (POD) methods described by Henry (1963) were used to calculate plasma glucose. Glucose was converted by glucose oxidase to gluconic acid and hydrogen peroxide. Peroxidase catalyzes the reaction of hydrogen peroxide with phenol and 4-amino antipyrine to generate a red-colored quioneimine dye complex. The intensity of the color development was evaluated at 505 nm and was directly related to the glucose levels (mg/dl blood plasma).

$$\text{Total Glucose mg/dl} = (AT/AS) \times 100$$

Cholesterol: Herbert *et al.* (1984) used the approach to detect cholesterol levels in serum samples. Cholesterol esters were degraded by Cholesterol Esterase (CE) to yield free cholesterol and fatty acids. Cholesterol Oxidase (CHOD) oxidized the 3-OH group of free cholesterol, releasing Cholest-4-en-3-one and Hydrogen Peroxide. In the presence of peroxidase (POD). When hydrogen peroxide reacts with 4-amino antipyrine (4-AAP) and phenol, it creates a red quinoneimine color. The absorbance of colored dye was measured at 505 nm and was proportional to the quantity of Total cholesterol content in the sample.

$$\text{Total cholesterol mg/dl} = (AT/AS) \times 200$$

Triglycerides

The triglyceride content of serum samples is determined using McGowan's (1983) enzyme (glycerol-3-phosphate oxidase; GPO) technique. The theory is based on the fact that triglycerides in the serum are acted upon by lipoprotein lipase, which produces glycerol and free fatty acids (FFA). In the presence of glycerol kinase, ATP then acts on the freed glycerol to produce glycerol-3-phosphate, which liberates an ADP molecule. The glycerol-3-phosphate then interacts with the GPO to form dihydroxyacetone phosphate, which releases hydrogen peroxide (H_2O_2). The freed H_2O_2 is then allowed to react with 4-aminoantipyrine in the presence of peroxidase (POD) to create the dye quinoneimine, the absorbance of which at 505 nm is directly proportional to the triglyceride concentration. Triglyceride (200 mg/dl) was the standard used.

$$\text{Triglycerides (mg/dL)} = (AT/AS) \times 200$$

E. Carcass traits

Carcass traits were measured on 0^{th},30^{th},60^{th},$90^{th}$and 120^{th} day.

Economically important carcass traits estimated in the present study were rib eye area (REA) and back fat thickness (FT). Ultrasound was used to acquire measurements from animals with respect to carcass traits. Ultrasound is a type of sound wave that has a frequency that is higher than what human ears can hear. Frequencies between 20-20,000 hertz are audible to humans. Ultrasound is defined as sound waves with a frequency greater than 20,000 hertz for tissue imaging or live animal examination ranging from 1-10 MHz. With a higher frequency,

we get more resolution but less tissue penetration. Carcass examination is usually done at a frequency of 3.5 MHz, whereas reproductive evaluation is done at a frequency of 5.0-7.5 MHz Aero scan, DS 50 PLUS, linear probe 6 cm, 2.5-10 MHz was utilized for an ultrasound examination.

Preparation of Animal: Animals were cleaned up after and had their hair clipped, especially if it was too long, to get decent photos. Dust, trash, and other foreign objects that could trap air bubbles or prevent the proper acoustic coupling of sound waves entering and leaving the animal were removed from the hide. Animals with hair longer than half an inch had it trimmed. The couplant/gel was applied to the transducer face and the animal's clean and/or trimmed hide at the 12–13 rib junction for ideal image translation between the two surfaces. Animals that were wet or muddy were dried off before a couplant or gel was applied for better image taking.

Placement of transducer: To keep the transducer, the final rib (number 13) was located by tactile contact. The transducer was placed halfway between the last rib (rib 13) and the next-to-last rib (12). The transducer was positioned close to the spine, parallel to the ribs. Proper placement is necessary for a precise evaluation of the area of the longissimus muscle and the thickness of the fat.

Rib eye area (REA): The longissimus dorsi of the animal make up the rib eye area (REA). The length of the longissimus dorsi muscle, which lies between the 12^{th} and 13^{th} ribs, served as the area's measuring tool. Inches squared were used as the unit of measurement. The method, which makes use of ultrasound, can be applied to living animals. The rib eye at the 12^{th} rib was imaged by a skilled technician. When an animal is scanned, further details like its age and weight were acquired. The rib eye's surface area was determined using a conventional formula. Three key factors are required for accurate live animal ultrasound measurement of the ribeye region: obvious and distinct medial and lateral end borders, not crossing any of the 12^{th} or 13^{th} ribs, and good transducer-animal contact. The transducer is correctly placed between the 12^{th} and 13^{th} ribs for this measurement if there are identifiable intercostal muscles under the longissimus dorsi. By positioning the ultrasonic transducer in the proper location, the ribeye area was measured.

Back fat thickness (BF): Using back fat thickness as a baseline, the external fat on the carcass was calculated. Over the longissimus dorsi, at three-fourths of the distance from the medial side of the spine to the lateral muscle side, was measured. Inches were used to measure each dimension. The distance between the medial end of the longissimus dorsi muscle (12^{th}–13^{th} rib interface) and the place where the fat thickness at the 12^{th}–13^{th} rib is measured are three-fourths of an inch apart. The point is also perpendicular to the surface of the hanging ribbed carcass. A linear-array transducer and standoff guide that follows the contour of the animal's back is required by the ultrasound scanning process to obtain an image between the 12^{th} and 13^{th} ribs.

3.7 Statistical analysis

All generated data was analysed using by two-way analysis of variance (ANOVA). Statistical analysis was performed with SPSS 26.0 software (International Business Machines Corporation, Armonk, New York). Significance was set at 95% probability level.

Results

4 RESULTS

The effect of palm stearin supplementation on growth performance, rib eye area, and back fat thickness in Murrah buffalo calves was investigated in this study. The study was conducted on two groups of six buffalo calves each, one as a control (given the baseline diet) and the other as a treatment (fed with the addition of 3% palm stearin). The feeding lasted 120 days. The findings of the present study are presented below.

4.1 Chemical composition of palm stearin (PS)

The proximate analysis results; the percentage of dry matter (%DM) in the experimental feed, indicated that the melting point (MP) of palm stearin (PS), which was 57 °C, further, 99.99% ether extract (EE), 0.001% crude protein (CP), 99.99% organic matter (OM), 0.06% total ash (TA), and 0.039% total CHO were identified in PS. Its gross energy (GE) value was 9.10 kcal/kg. The constitution of micronutrients of PS is 77.5% palmitic acid, 4.41% stearic acid, 12.95% oleic acid, and 2.4% linoleic acid. (Table)

4.1 Chemical composition of palm stearin

Attributes	Chemical Composition
DM	99.96±0.001
OM	99.94±0.007
CP	0.001±0.0001
EE	99.9±0.005
TA	0.06±0.003
GE (kcal/g)	9.10±0.20
Physicochemical properties of palm stearin	
Melting point, °C	57

4.2 Feed composition

The chemical composition (%DM) of wheat straw, treatment, control and green Napier grass is given in Table The feed composition of the control and treatment groups was 89.69 and 91.20 DM, 94.2 and 93.11 organic matter (OM), 18.37 and 18.55 crude protein (CP), 2.95 and 8.71 ether extract (EE), 5.80% and 6.89 total ash (TA), 1.26 and 1.32 calcium (Ca), and 0.80 and 0.99 phosphorus (P), respectively. Conversely, the composition of wheat straw and green Napier grass was found to be 92.52 and 25.40 DM and 2.96 and 8.32 CP, respectively. Green Napier grass had 52.52 and wheat straw has a content of 72.71 NDF (neutral detergent fiber).

Table 4.2 Chemical composition of feeds offered (% DM basis)

Attributes (%)	Dietary groups		Napier Grass	Wheat straw
	Control	Treatment		
DM	89.69±0.30	91.20±0.49	25.40±0.47	92.52±0.58
OM	94.2±0.15	93.11±0.18	88.85±0.18	94.1±0.20
CP	18.37±0.55	18.55±0.32	8.32±0.41	2.96±0.05
EE	2.95±0.17	8.71±0.11	3.03±0.19	0.94±0.14
TA	5.80±0.15	6.89±0.18	11.15±0.18	5.90±0.20
AIA	0.72±0.10	0.95±0.20	5.60±0.22	4.25±0.19
Total CHO	72.88±0.29	65.85±0.21	77.5±0.26	90.2±0.13
NDF	17.30±0.44	16.95±0.18	52.52±1.10	72.71±1.05
ADF	9.57±0.58	8.93±0.48	32.75±0.90	52.70±3.85
Hemi-cellulose	7.73±0.15	8.02±0.20	19.77±0.32	20.01±2.70
Cellulose	1.79±0.42	1.65±0.16	24.50±10.1	28.86±0.85
Ca	1.26±0.02	1.32±0.04	0.61±0.05	0.40±0.01
P	0.80±0.03	0.99±0.05	0.57±0.01	0.15±0.02

4.3 Effect of dietary inclusion of palm stearin on growth performance

4.3.1 Body Weight (BW)

Effect of dietary palm stearin supplementation on BW was expressed in kilograms at various stages of growth and was recorded fortnightly; In the control and treatment groups, the overall live body weights of the experimental animals were 294.01±4.25 and 294.67±4.31kg, respectively. There was no significant difference (P>0.05) between the control

and treatment groups. However, a significant (P<0.05) influence of time was identified, and BW rose with age. the statistically analyzed data is shown in

Table 4.3 Effect of dietary supplementation of palm stearin (PS) on live body weight in Murra buffalo calves

Interval Day	Dietary groups		Period mean (kg)	P value		
	Control (kg)	Treatment (kg)		T	P	T×P
0	255.83±5.97	255.83±5.97	255.83^{a}±4.03	0.000	0.108	0.975
15	262.46±5.98	262.85±6.05	262.66^{a}±4.06			
30	270.58±6.05	270.98±6.14	270.78^{ab}±4.11			
45	280.08±6.05	280.56±5.84	280.32^{bc}±4.01			
60	291.00±6.11	291.66±6.12	291.33^{bc}±4.12			
75	303.13±6.14	303.93±6.27	303.53^{de}±4.18			
90	315.56±5.94	316.93±6.41	315.97^{ef}±4.16			
105	327.66±6.08	328.66±6.30	328.16^{fg}±4.17			
120	339.83±5.94	341.16±6.47	340.50^{gh}±4.21			
Overall mean	**294.02±4.25**	**294.67±4.31**	**294.34±3.01**			

4.3.2 Average daily gain (ADG):

In the current study, ADG was expressed in grams and recorded fortnightly in a phase-wise manner, ie 0-15th,15-30th,30-45th,45-60th day,60-75th,75-90th,90-105th,105-120th day. The overall ADG: of the experimental animals in the control and treatment groups were 0.697±0.02 and 0.715±0.02 g/d, respectively. No statistically significant difference (P>0.05) between the control and treatment groups were observed. However, there was a substantial (P<0.05) rise in ADG with time in the treatment group compared to the control group animal, and ADG increases with age.

Table 4.4 Effect of dietary supplementation of palm stearin (PS) on average daily gain in Murra buffalo calves

Interval Day	Dietary groups		Period mean (kg)	P value		
	Control (kg)	Treatment (kg)		T	P	T×P
0-15	0.440±0.01	0.460±0.01	0.450^{a}±0.01	0.000	0.108	0.975
15-30	0.536±0.01	0.540±0.01	0.538^{b}±0.01			
30-45	0.630±0.01	0.635±0.05	0.632^{c}±0.02			
45-60	0.725±0.01	0.736±0.05	0.730^{d}±0.02			
60-75	0.806±0.00	0.815±0.05	0.810^{e}±0.02			
75-90	0.826±0.02	0.825±0.03	0.825^{e}±0.02			
90-105	0.803±0.01	0.810±0.04	0.809^{e}±0.02			
105-120	0.810±0.02	0.830±0.01	0.820^{e}±0.01			
Overall mean	**0.700±0.02**	**0.715±0.02**	**0.702±0.01**			

4.3.3 Feed conversion ratio (FCR):

The overall FCR values for the control and treatment groups were 10.19±0.30 and 9.84±0.31 kg, respectively, no significant difference was observed (P>0.05) between the control and treatment group animals. However, there was a significant (P<0.05) decline in FCR with time in the treatment group compared to the control group, and FCR decreased with age.

Table 4.5 Effect of dietary supplementation of palm stearin (PS) on feed conversion ratio in Murra buffalo calves

Interval Day	Dietary groups		Period mean (kg)	P value		
	Control (kg)	Treatment (kg)		T	P	T×P
0-15	14.17±0.49	13.23±0.30	13.70^{de}±0.31	0.000	0.108	0.975
15-30	12.25±0.09	11.84±0.20	12.05^{cd}±0.12			
30-45	11.08±0.24	10.52±0.95	10.80^{bc}±0.47			
45-60	9.55±0.11	9.28±0.79	9.41^{ab}±0.38			
60-75	9.11±0.24	8.93±0.51	9.02^{ab}±0.27			
75-90	8.55±0.29	8.54±0.39	8.54^{ab}±0.23			
90-105	8.48±0.11	8.31±0.40	8.40^{a}±0.20			
105-120	8.30±0.26	8.06±0.27	8.18^{a}±0.18			
Overall mean	10.19±0.30	9.84±0.31	10.01±0.21			

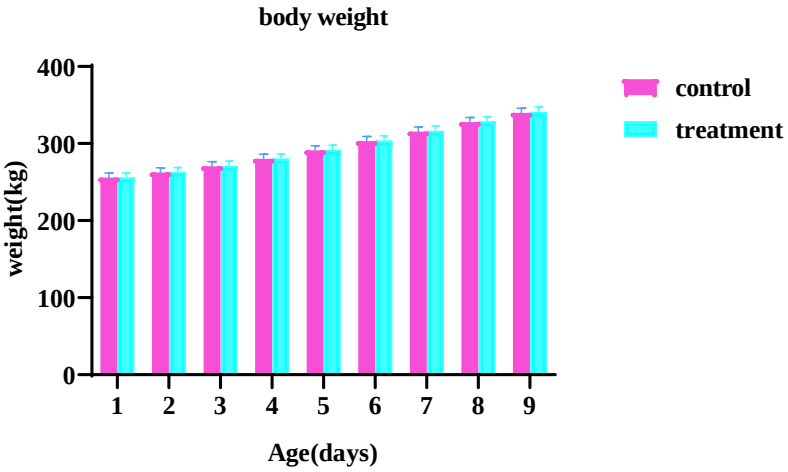


Fig. 1: live body weight in control and treatment group

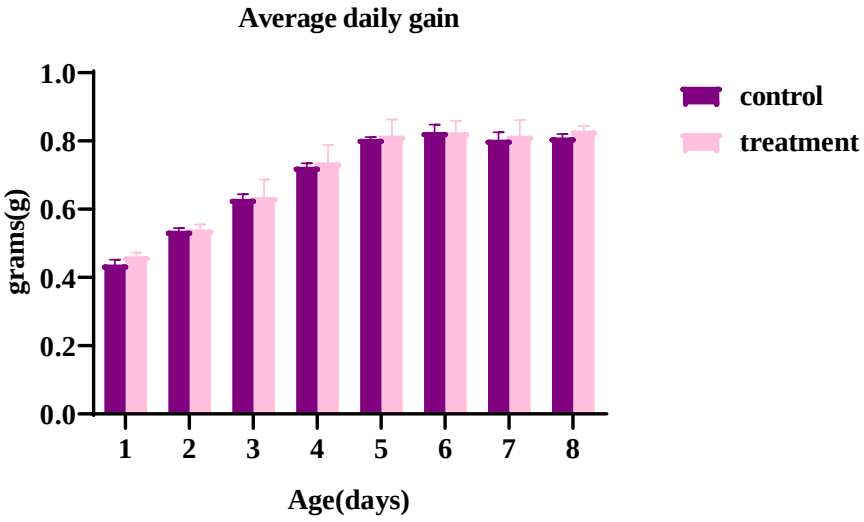


Fig. 2: Average daily gain in control and treatment group

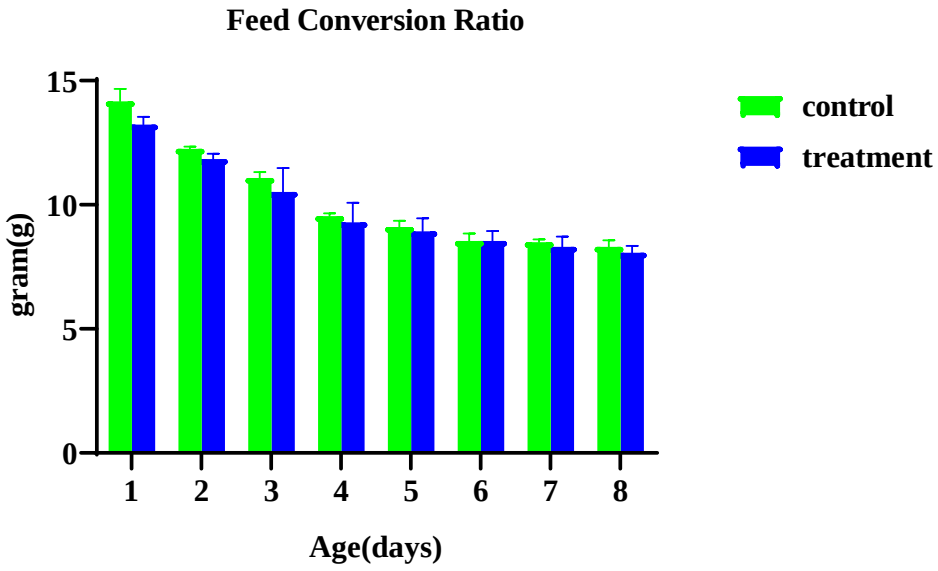


Fig. 3: Feed conversion ratio in control and treatment group

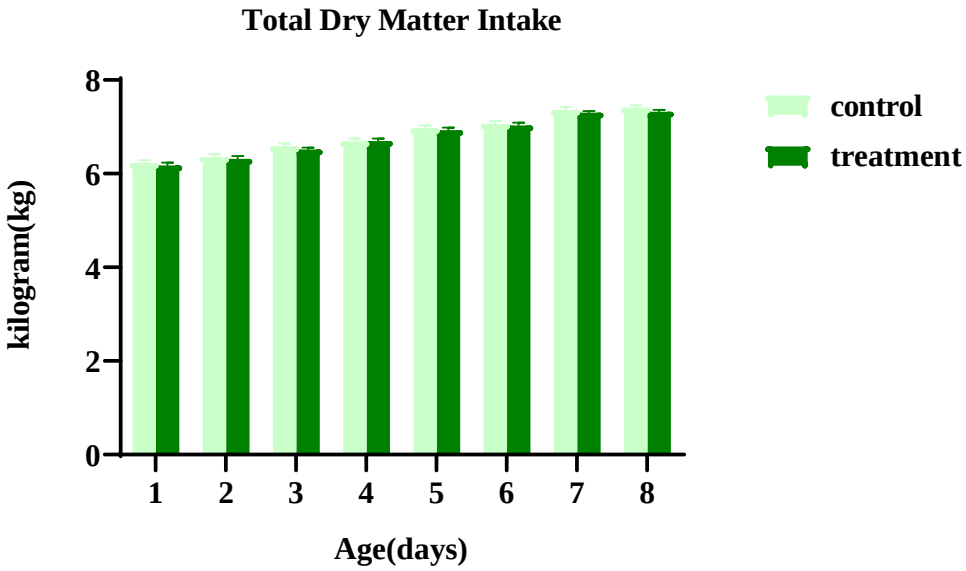


Fig. 4: Total dry matter intake in control and treatment group

4.3.4 Dry matter intake (DMI)

At the commencement of the experiment, the DMI value in the control and treatment groups were 6.23±0.6 and 6.17±0.06, respectively. There was no significant difference between the two groups (P>0.05).

Table 4.6 Effect of dietary supplementation of palm stearin (PS) on dry matter intake in Murra buffalo calves

Total DMI fortnightly	Dietary groups		Period mean	P value		
	Control	Treatment		T	P	T×P
0-15 Day	6.23±0.06	6.17±0.06	6.20^{a}±0.04	0.000	0.096	0.996
15-30 Day	6.36±0.06	6.31±0.06	6.33^{ab}±0.04			
30-45 Day	6.58±0.06	6.51±0.05	6.54^{bc}±0.04			
45-60 Day	6.69±0.06	6.68±0.05	6.69^{cd}±0.04			
60-75 Day	6.97±0.06	6.93±0.05	6.95^{de}±0.04			
75-90 Day	7.06±0.06	7.03±0.05	7.04^{de}±0.04			
90-105 Day	7.36±0.06	7.30±0.03	7.33^{ef}±0.03			
105-120 Day	7.41±0.06	7.32±0.04	7.36^{ef}±0.03			
Overall mean	6.83±0.06	6.78±0.06	6.81±0.04			

4.3.5 Morphometric measurement

4.3.5.1 Body Length (BL)

The BL values at the start of the trial were 95.16±1.51 and 95.83±1.56cm in the control and treatment groups, respectively. No significant (P>0.05) difference was observed between the two groups.

Table 4.7 Effect of dietary supplementation of palm stearin (PS) on body length value in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	95.16±1.51	95.83±1.56	95.50^{a}±1.04	0.000	0.051	0.929
30	96.50±0.99	97.00±0.77	96.75^{ab}±0.60			
60	98.33±0.98	99.99±0.63	99.16^{bc}±0.61			
90	100.66±1.40	102.50±0.43	101.58^{cd}±0.75			
120	102.03±1.02	104.00±0.36	103.02^{cd}±0.60			
Overall mean	**98.54±6.88**	**99.86±0.68**	**99.20±0.48**			

4.3.5.2 Height at wither (HW)

The HW at the start of the trial was 123.66±1.48 and 123.00±0.96 cm in the control and treatment groups, respectively. However, no significant difference (P>0.05) between the two groups.

Table 4.8 Effect of dietary supplementation of palm stearin (PS) on height at wither in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	123.66±1.48	123.00±0.96	123.33±0.85	0.000	0.103	0.760
30	125.56±2.09	126.66±0.71	126.11±1.06			
60	128.66±2.20	130.50±0.88	129.58±1.16			
90	131.66±1.87	133.83±0.65	132.75±1.00			
120	136.16±1.19	139.00±0.45	137.58±0.74			
Overall Mean	129.15±1.11	130.59±1.07	129.87±0.77			

4.3.5.3 Paunch Girth (PG)

The overall PG of the experimental animal was 179.70±0.86 in the control group and 180.86±0.84cm in the treatment group. There was no significant difference (P>0.05) between the control and treatment groups. However, time had a substantial (P<0.05) influence, and PG increased with age.

Table 4.9 Effect of dietary supplementation of palm stearin (PS) on paunch girth in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	175.33±1.35	175.00±1.26	175.16^{a}±0.88	0.000	0.090	0.826
30	175.83±1.10	177.50±0.88	176.66^{a}±0.72			
60	180.66±1.33	181.55±0.42	181.11^{b}±0.68			
90	181.83±1.22	183.56±0.48	182.70^{b}±0.68			
120	184.83±1.42	186.70±0.84	185.76^{c}±0.76			
Overall Mean	**184.83±0.86**	**180.86±0.84**	**180.28±0.60**			

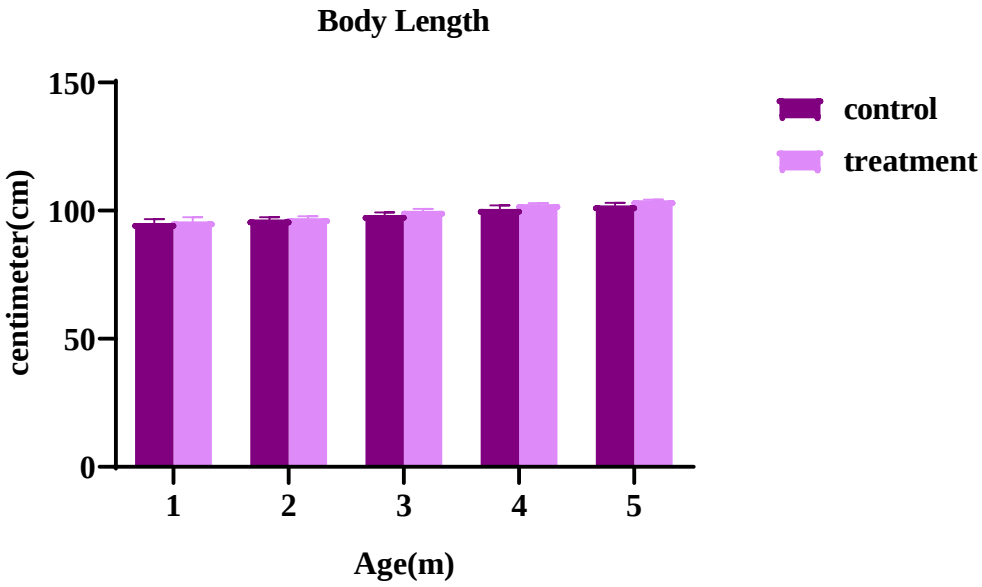


Fig. 5: Body length in control and treatment group

Fig. 6: Height at wither in control and treatment group

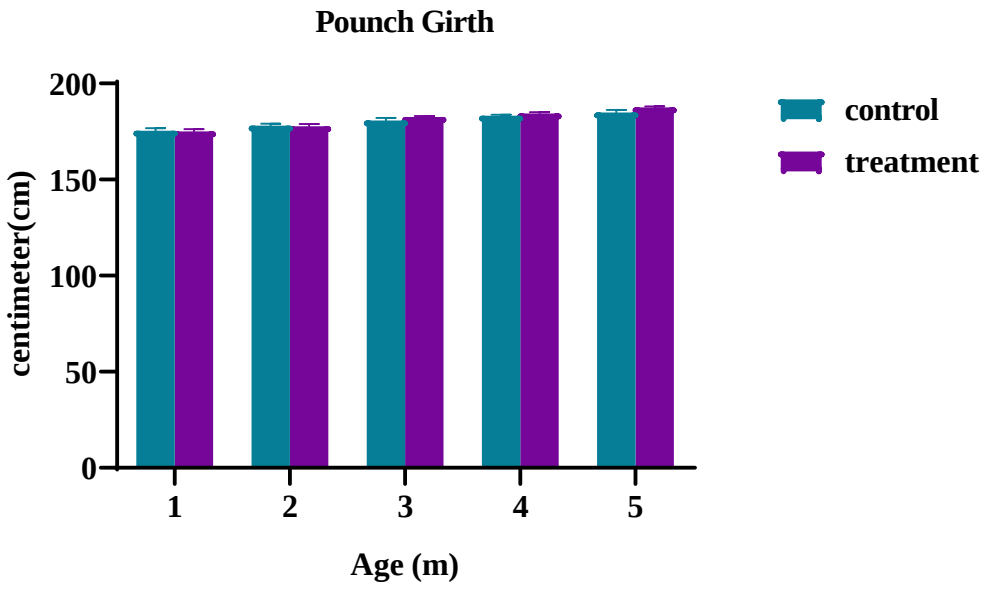


Fig. 7: Paunch girth in control and treatment group

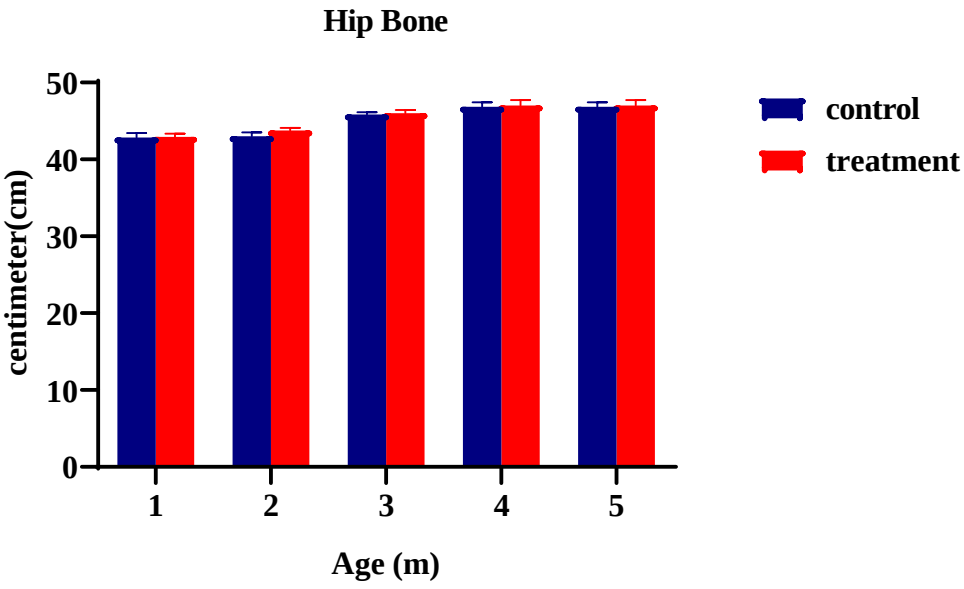


Fig. 8: Hip bone in control and treatment group

4.3.5.4 Hip Bone (HB)

There was no significant difference (P>0.05) in the values of HB between the control and treatment group animals.

Table 4.10 Effect of dietary supplementation of palm stearin (PS) on hip bone in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	42.83±0.58	42.91±0.45	42.87^{a}±0.35	0.000	0.845	0.994
30	44.00±0.34	43.75±0.36	43.37^{a}±0.24			
60	45.83±0.30	46.00±0.44	45.91^{b}±0.26			
90	46.83±0.60	47.00±0.73	46.91^{b}±0.45			
120	46.83±0.60	47.00±0.73	46.91^{b}±0.45			
Overall Mean	**45.26±0.36**	**45.33±0.39**	**45.30±0.26**			

4.3.5.5 Heart Girth (HG)

There was no significant difference in HG values between the control and treatment group animals.

Table 4.11 Effect of dietary supplementation of palm stearin (PS) on heart girth in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	161.00±1.43	161.00±1.29	161.00^{a}±0.92	0.000	0.099	0.902
30	162.00±1.41	163.13±0.70	162.56^{a}±0.77			
60	164.83±1.25	165.83±0.60	165.33^{b}±0.67			
90	167.16±1.25	168.75±0.40	167.96^{bc}±0.66			
120	170.83±1.49	172.98±0.24	171.91^{cd}±0.79			
Overall Mean	**165.16±0.87**	**166.34±0.84**	**165.75±0.60**			

4.4 Effect of dietary supplementation of palm stearin on carcass trait

4.4.1 Rib eye area (REA)

The REA of the Murrah buffalo calves was measured on days 0th, 30th, 60th, 90th, and 120th days. In the control and treatment groups, REA values were 24.07±1.38 and

26.96±1.12cm^2 respectively. There was a significant difference (P<0.05) between the two groups.

Table 4.12 Effect of dietary supplementation of palm stearin (PS) on rib eye area in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	14.90±0.97	14.85±0.63	14.88^a±0.55	0.000	0.00	0.186
30	18.23±0.62	19.80±0.41	19.01^b±0.42			
60	23.26±0.54	27.34±0.76	25.30^c±0.75			
90	28.54±0.61	33.88±1.86	31.21^d±1.24			
120	35.41±0.51	38.92±2.70	37.17^e±1.41			
Overall Mean	**24.07±1.4**	**26.96±1.76**	**25.51±1.12**			

4.4.2 Back fat thickness (BFT)

The BF was assessed in the Murrah buffalo calves on days 0, 30, 60, 90, and 120. The BF thickness of the calves in the control group was 0.11 cm, while for the calves in the treatment group, it was 0.12 cm. A significant difference (P<0.05) was observed between two groups.

Table 4.13 Effect of dietary supplementation of palm stearin (PS) on back fat thickness in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	0.083±0.00	0.085±0.00	0.08^a±0.00	0.000	0.000	0.021
30	0.098±0.00	0.11±0.00	0.10^b±0.00			
60	0.12±0.00	0.13±0.00	0.12^c±0.00			
90	0.13±0.00	0.15±0.00	0.14^d±0.00			
120	0.14±0.00	0.18±0.00	0.16^e±0.00			
Overall Mean	**0.11±0.87**	**0.13±0.00**	**0.12±0.00**			

4.5 Effect of dietary supplementation of palm stearin on biochemical parameters

4.5.1 Triglycerides levels

The overall values for the lipid indices triglycerides level in the control and treatment groups were 39.45±0.97 and 40.32±1.05 mg/dl, respectively. No discernible difference (P>0.05) was found between the two groups.

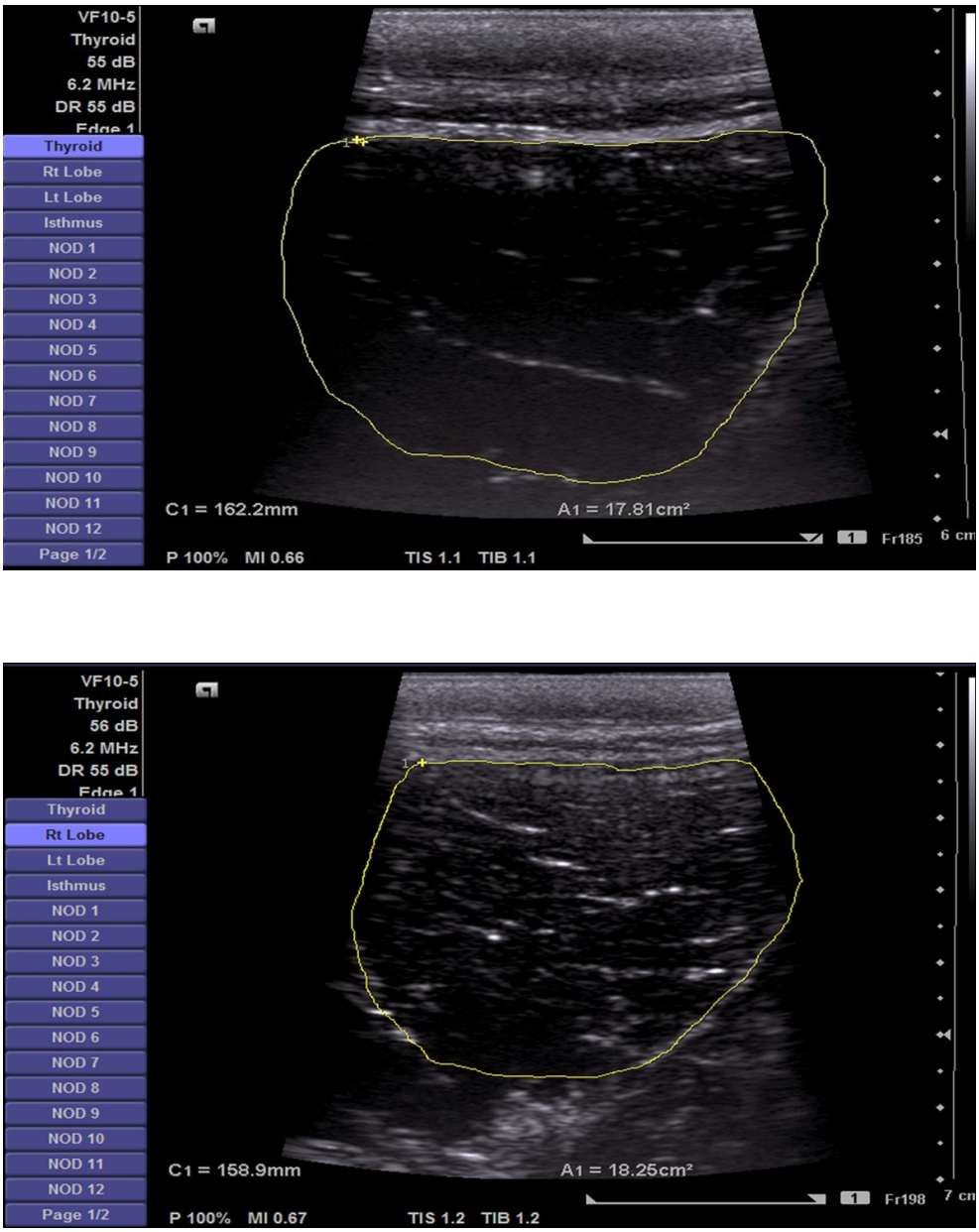
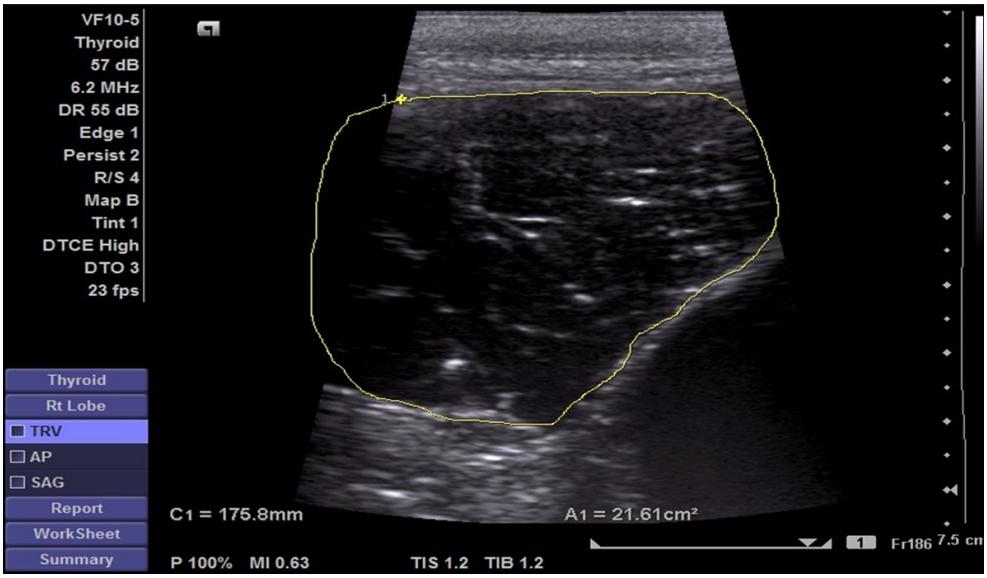


Fig. 16: Ultrasound image represents value of REA in control and treatment group (0^{th} day)



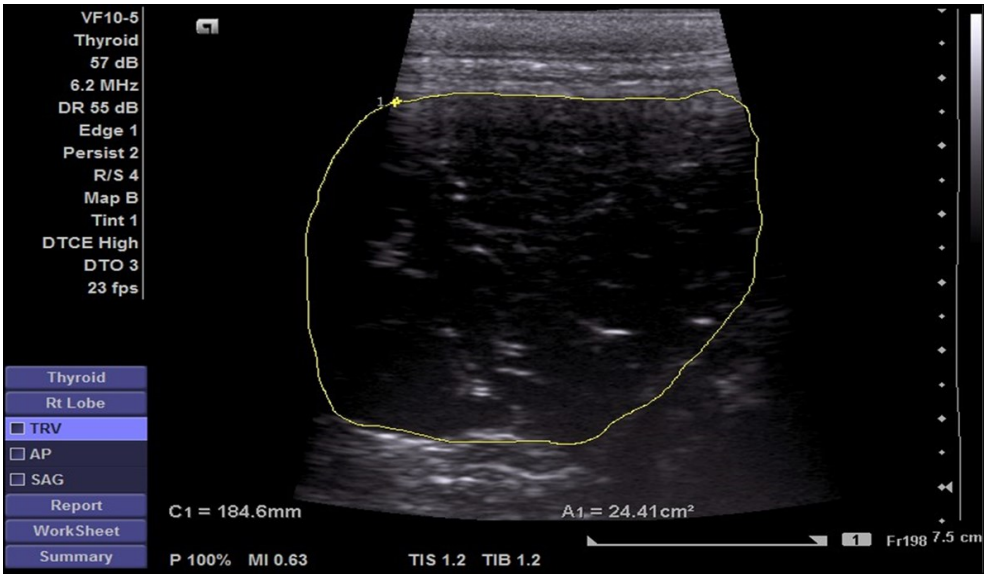


Fig. 17: Ultrasound image represents value of REA in control and treatment group (30th day)

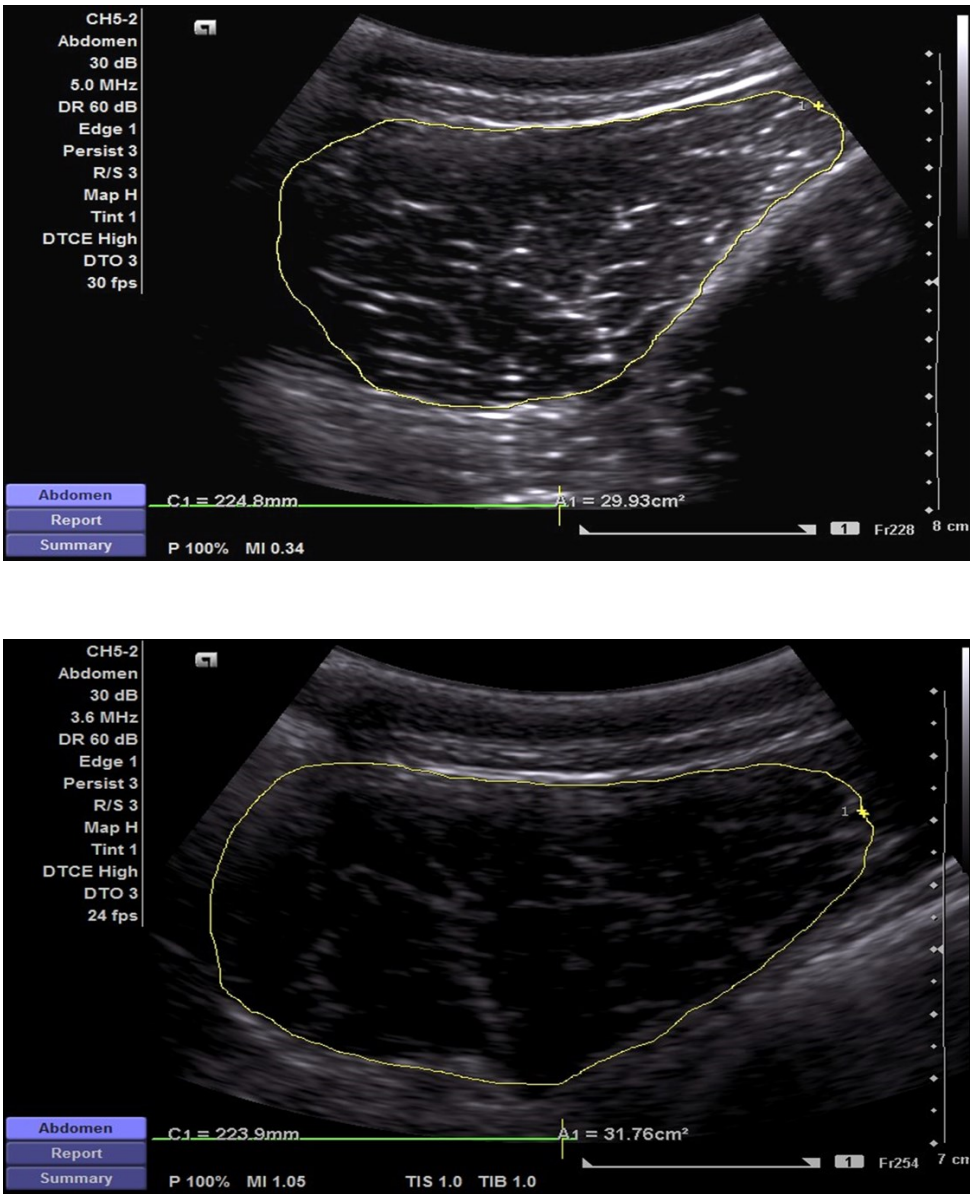
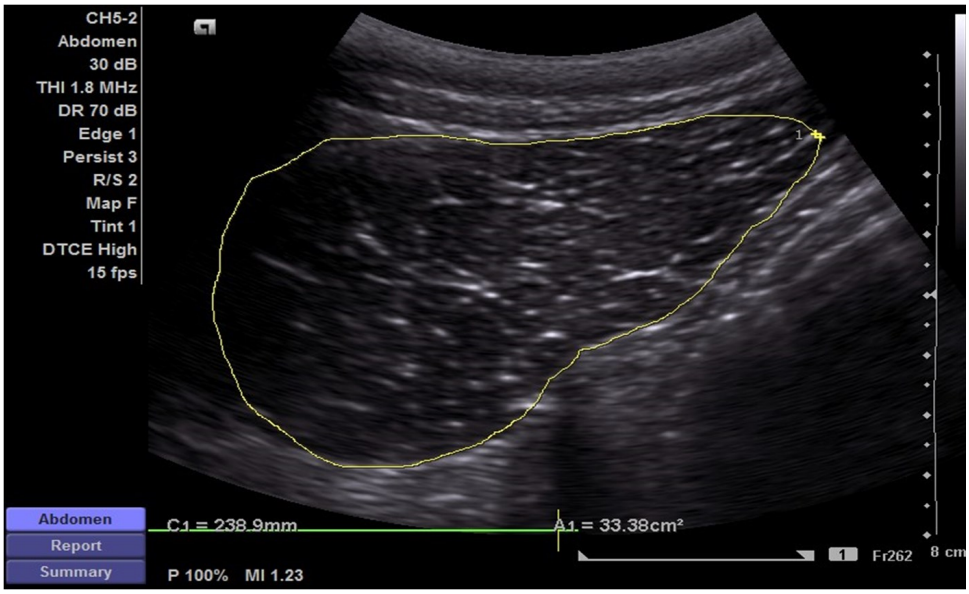


Fig. 18: Ultrasound image represents value of REA in control and treatment group (60^{th} day)



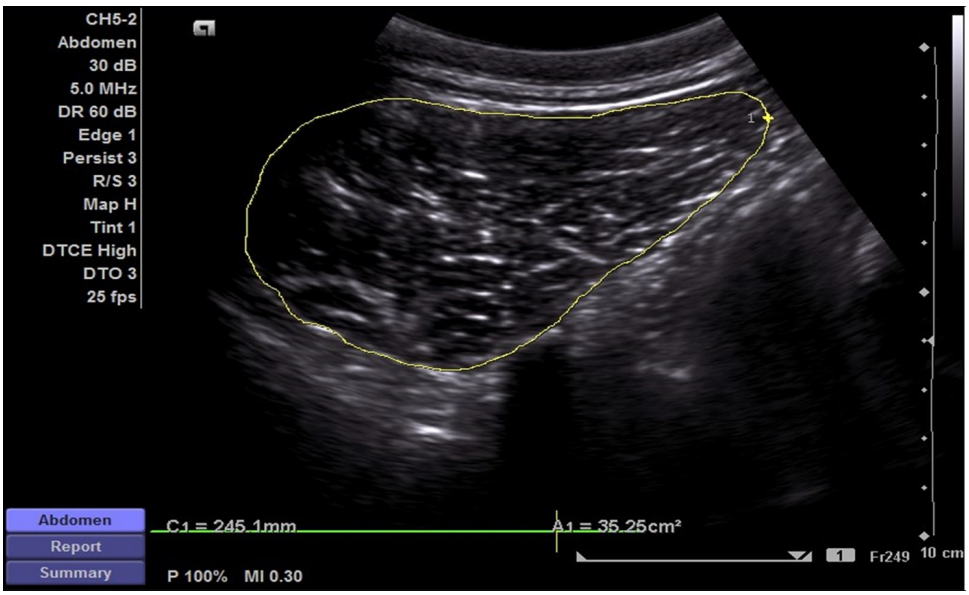


Fig. 19: Ultrasound image represents value of REA in control and treatment group (90th day)

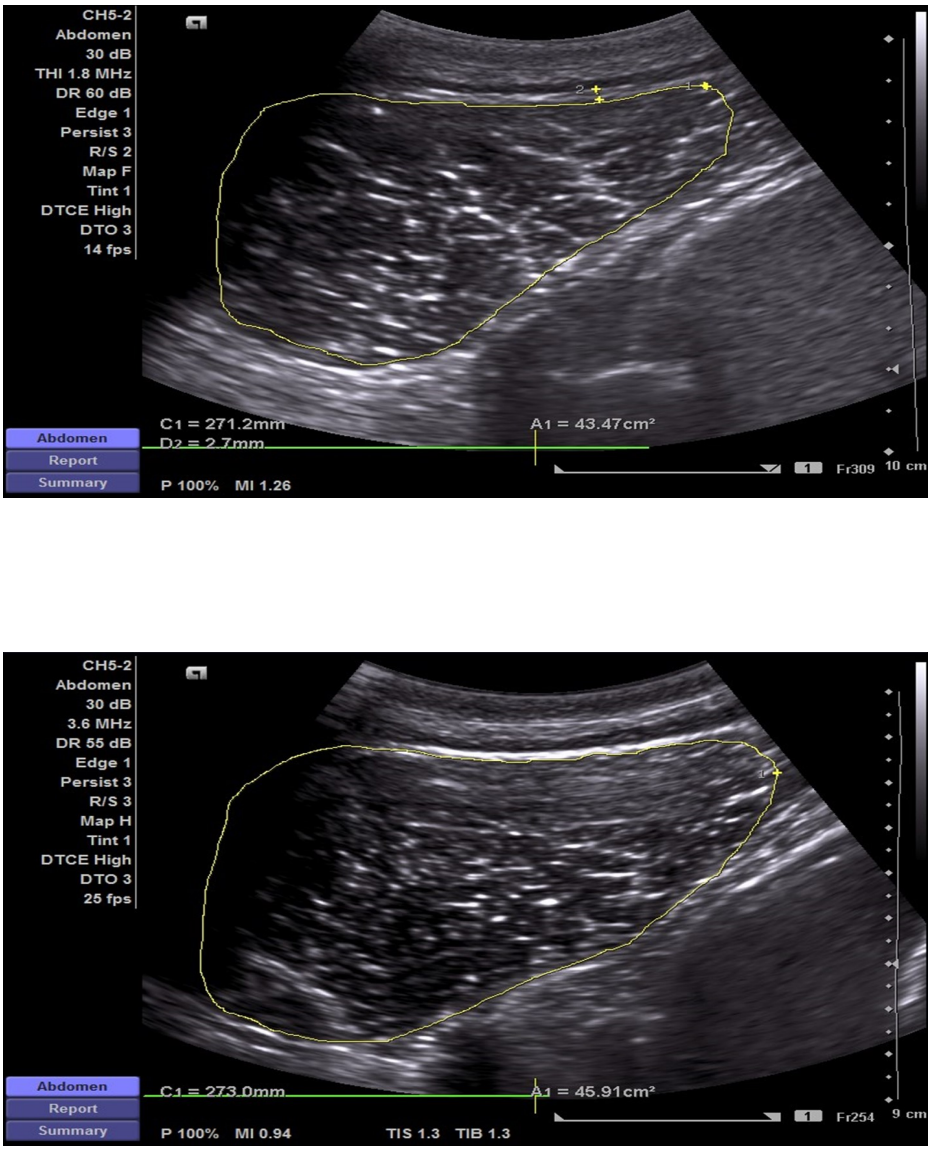
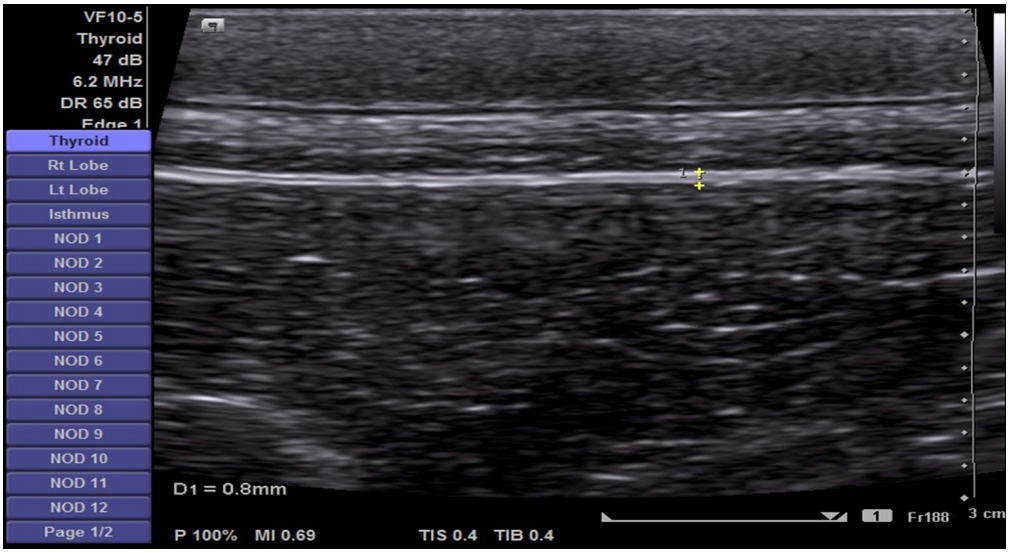


Fig. 20: Ultrasound image represents value of REA in control and treatment group (120th day)



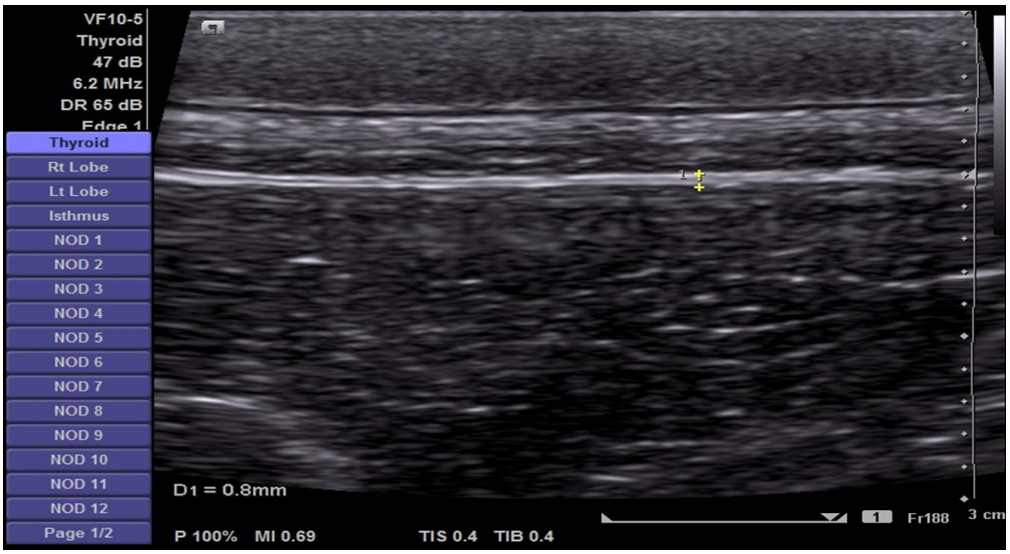
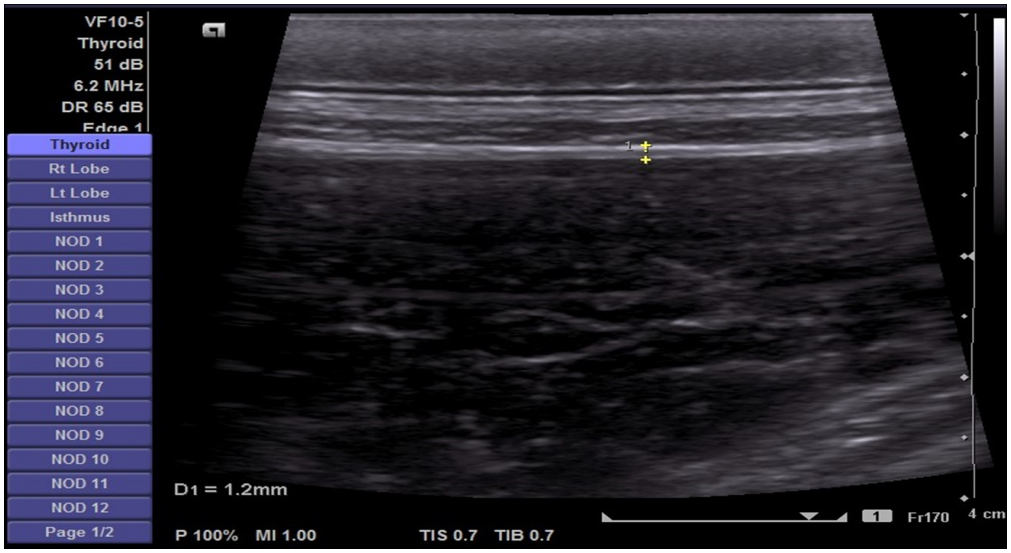


Fig. 21: Ultrasound image represents value of BFT in control and treatment group (0^{th} day)



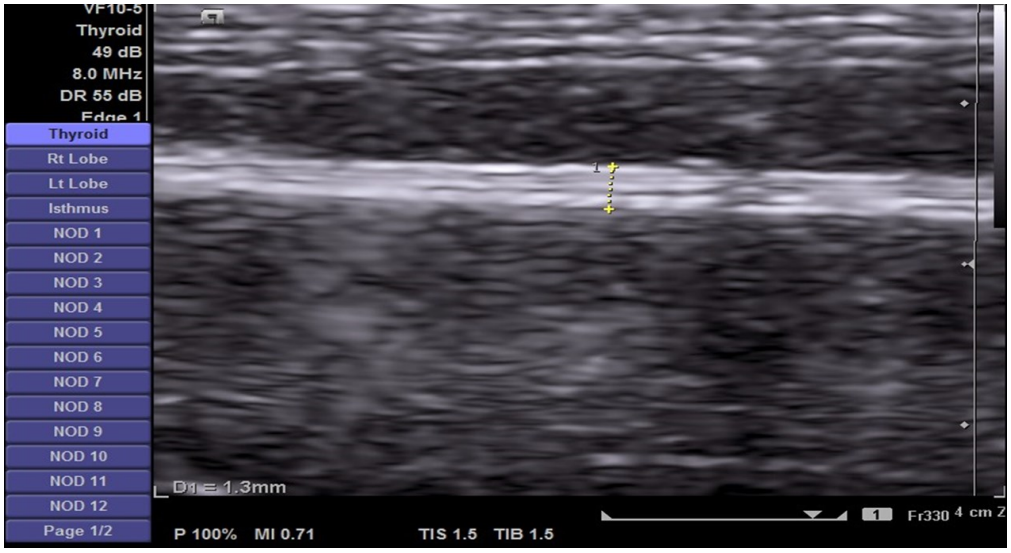


Fig. 22: Ultrasound image represents value of BFT in control and treatment group (30th day)

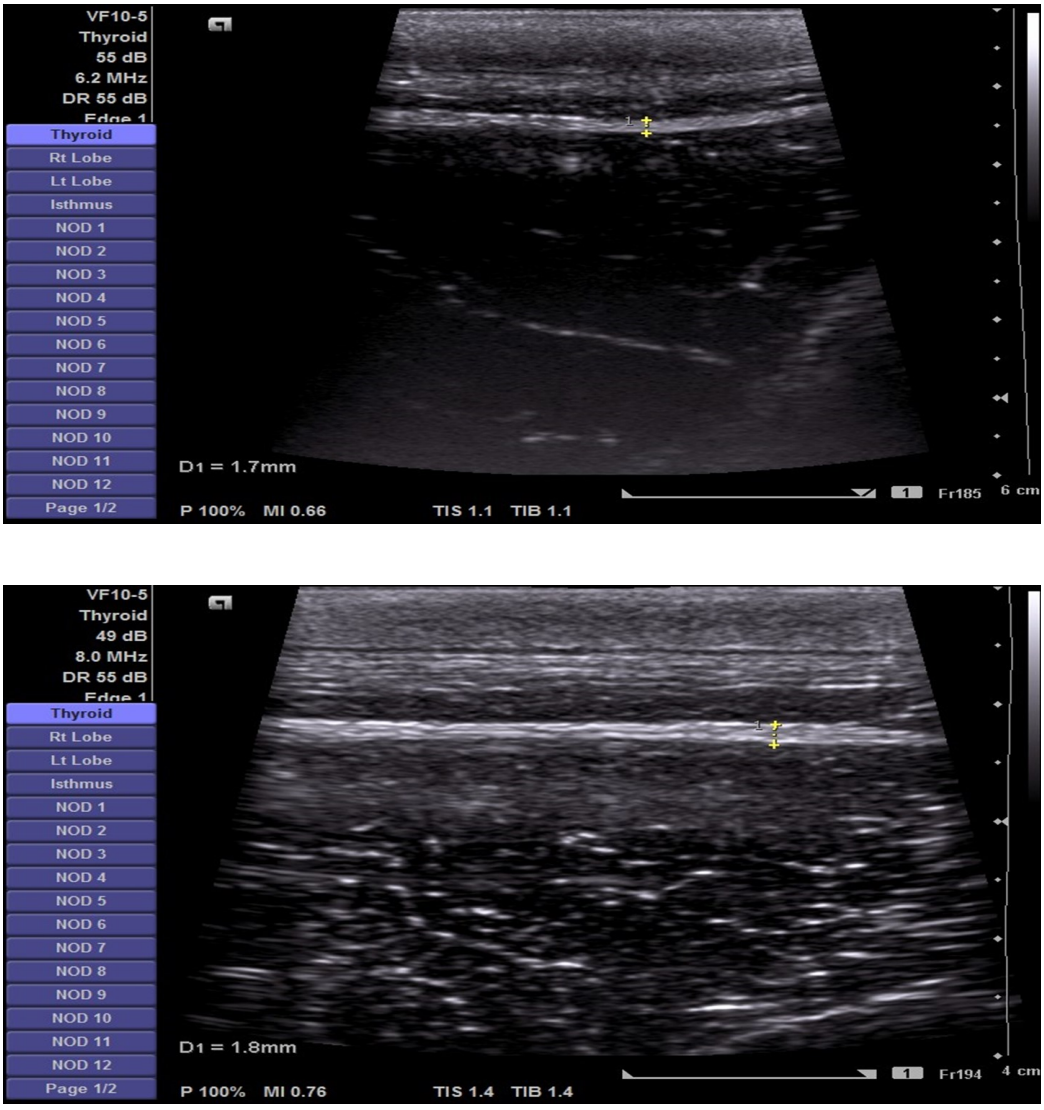
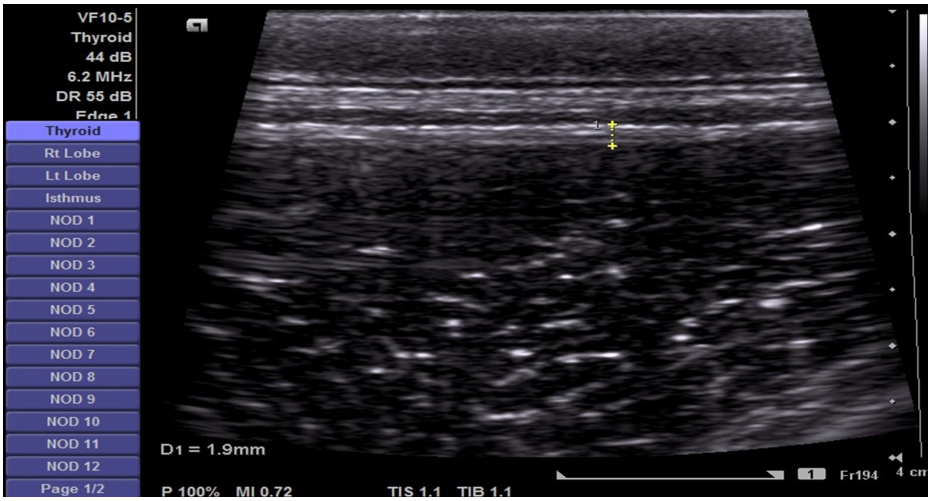


Fig. 23: Ultrasound image represents value of BFT in control and treatment group (60th day)



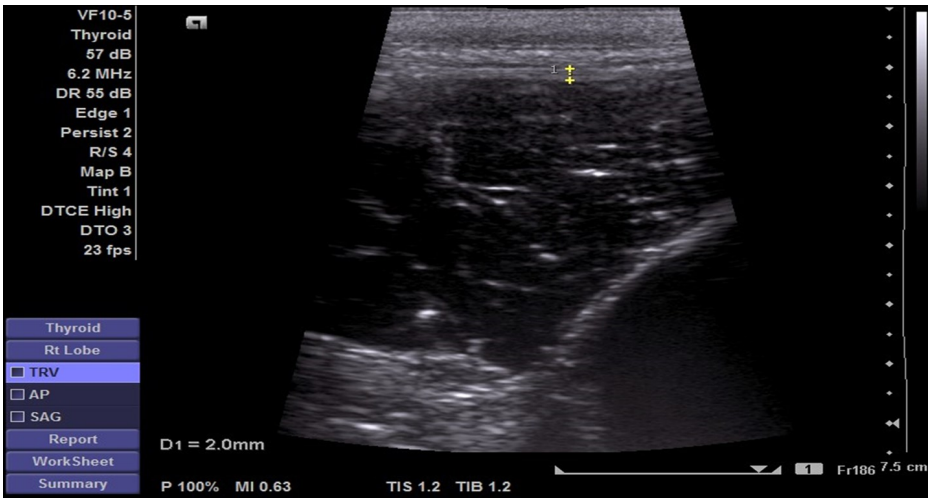
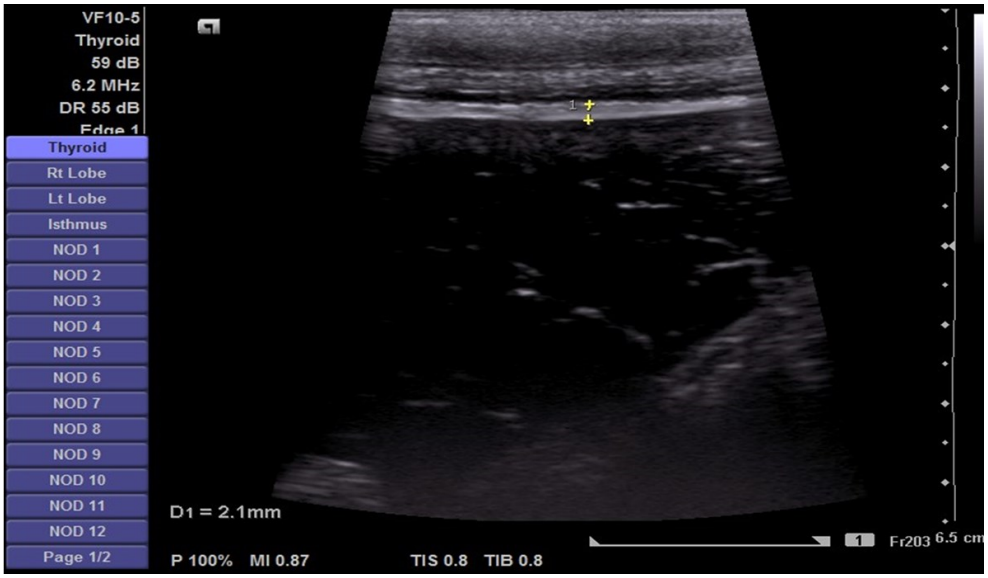


Fig. 24: Ultrasound image represents value of BFT in control and treatment group (90th day)



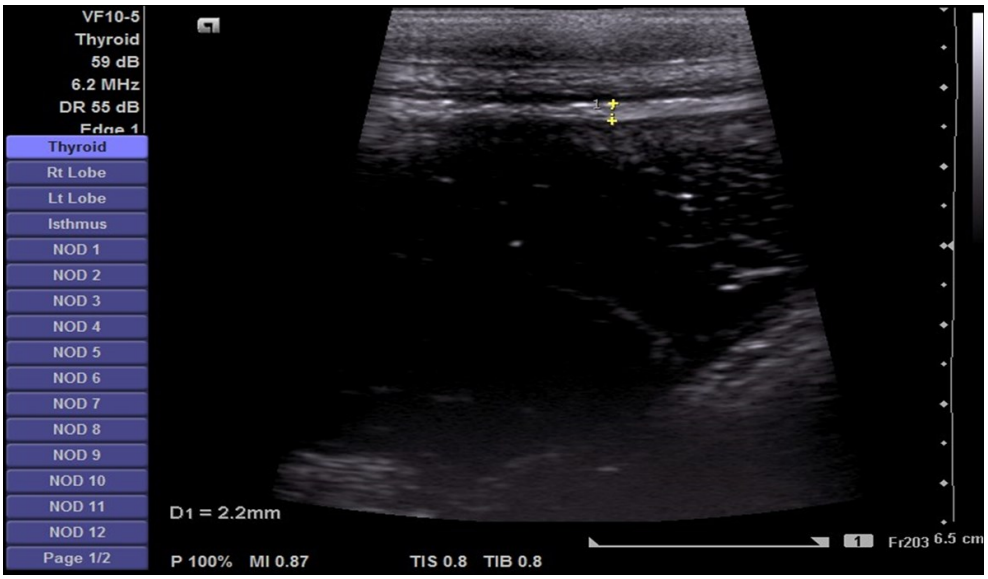


Fig. 25: Ultrasound image represents value of BFT in control and treatment group (120th day)

Table 4.14 Effect of dietary supplementation of palm stearin (PS) on triglycerides levels in Murra buffalo calves

Interval Day	Dietary groups		Period mean (cm)	P value		
	Control (cm)	Treatment (cm)		T	P	T×P
0	65.86±1.71	64.95±1.53	65.41^{a}±1.10	0.000	0.066	0.653
30	67.34±0.77	69.78±0.99	68.54^{b}±0.70			
60	74.19±0.66	76.33±1.86	75.26^{c}±0.99			
90	80.77±0.29	82.24±0.71	81.50^{d}±0.43			
120	89.27±0.86	91.66±1.97	90.47^{e}±1.09			
Overall Mean	**75.48±1.66**	**76.99±1.85**	**76.24±1.23**			

4.5.2 Cholesterol

The lipid values variables for cholesterol in the control and treatment groups, the values for cholesterol were 75.48±1.66, and 77.00±1.85 mg/dl, respectively. there was no significant difference between the two groups' cholesterol levels (P>0.05).

Table 4.15 Effect of dietary supplementation of palm stearin (PS) on cholesterol levels in Murra buffalo calves

Interval Day	Dietary groups		Period mean (mg/dl)	P value		
	Control (mg/dl)	Treatment (mg/dl)		T	P	T×P
0	32.44±0.62	32.76±0.78	32.60^{a}±0.48	0.000	0.000	0.021
30	35.82±0.75	36.24±0.83	36.03^{b}±0.53			
60	39.53±0.82	40.43±0.22	39.98^{c}±0.43			
90	43.00±0.68	44.02±0.68	43.51^{d}±0.48			
120	46.43±0.59	48.15±0.75	47.29^{e}±0.52			
Overall Mean	**39.45±0.97**	**40.32±1.00**	**39.88±0.72**			

4.5.3 LDL cholesterol levels:

The LDL cholesterol level in the treatment group was 44.71±2.85 mg/dl while it was 43.61±1.16 mg/dl in the control group. Although the values were non-significant (P>0.05).

Table 4.16 Effect of dietary supplementation of palm stearin (PS) on LDL cholesterol levels in Murra buffalo calves

Interval Day	Dietary groups		Period mean (mg/dl)	P value		
	Control (mg/dl)	Treatment (mg/dl)		T	P	T×P
0	22.36±0.70	44.94±1.00	45.78^{a}±0.67	0.000	0.066	0.653
30	31.73±0.47	56.37±0.80	56.11^{b}±0.66			
60	44.15±1.28	65.45±0.87	66.52^{c}±0.58			
90	56.51±1.19	73.94±0.66	74.54^{d}±0.71			
120	63.30±1.04	84.60±0.78	85.01^{e}±0.61			
Overall Mean	**43.61±1.16**	**65.06±2.57**	**65.59±1.81**			

4.5.4 HDL cholesterol

HDL cholesterol values for the calves in the control group were 66.12±2.58 and the calves in the treatment group were 67.56±2.65, respectively. HDL cholesterol value for the treatment group was significantly higher (P>0.05) than the control group.

Table 4.17 Effect of dietary supplementation of palm stearin (PS) on HDL cholesterol levels in Murra buffalo calves

Interval Day	Dietary groups		Period mean (mg/dl)	P value		
	Control (mg/dl)	Treatment (mg/dl)		T	P	T×P
0	46.61±0.82	47.44±0.75	47.02^{a}±0.54	0.000	0.011	0.714
30	55.85±1.11	57.54±0.55	56.69^{b}±0.64			
60	67.59±0.53	67.94±0.80	67.76^{c}±0.46			
90	75.15±1.29	76.77±0.82	75.96^{d}±0.77			
120	85.43±0.98	88.10±0.64	86.76^{e}±0.68			
Overall Mean	**66.12±2.58^{A}**	**67.56±2.65^{B}**	**66.84±1.83**			

4.5.5 Glucose

The glucose levels in the control group animal were 64.97±1.46 and those in the treatment group animal were 63.89±1.29, respectively. There was a non-significant difference observed between the two groups.

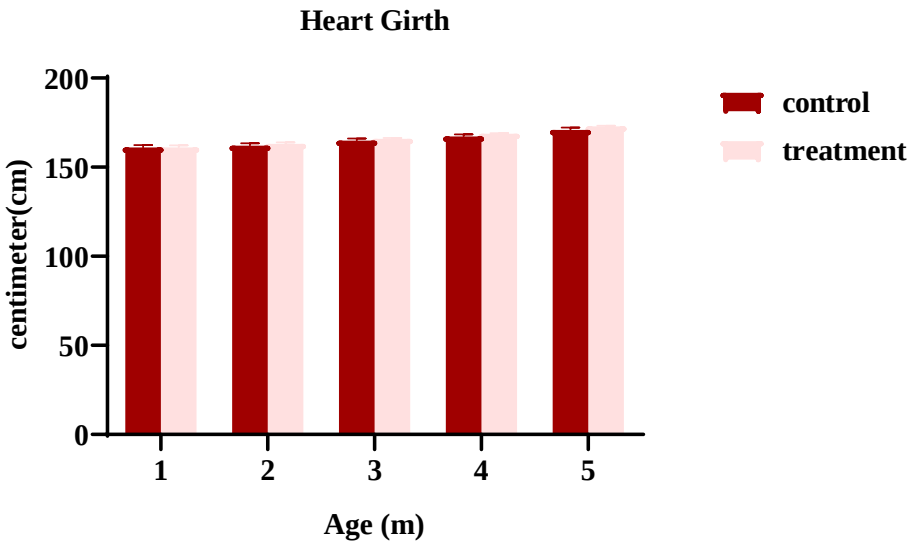


Fig. 9: Heart girth in control and treatment group

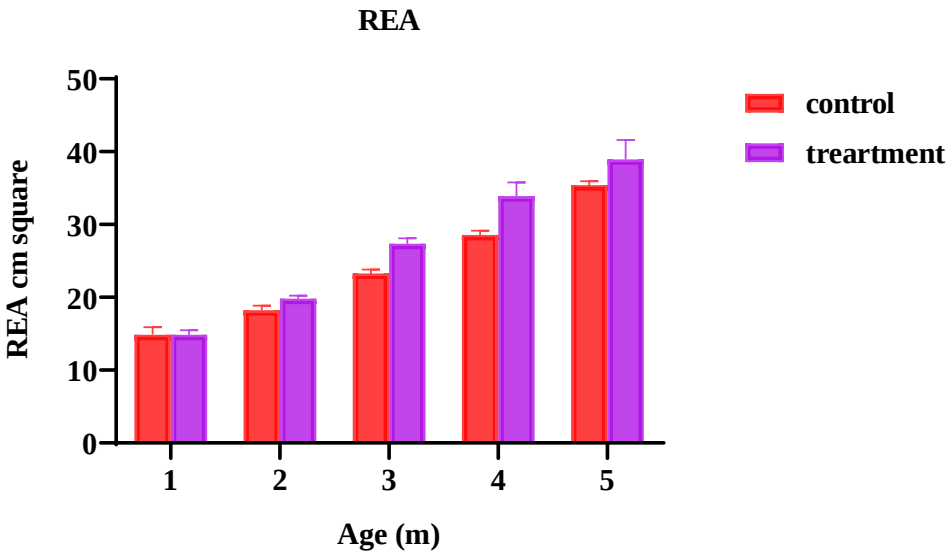


Fig. 10: Rib eye area in control and treatment group

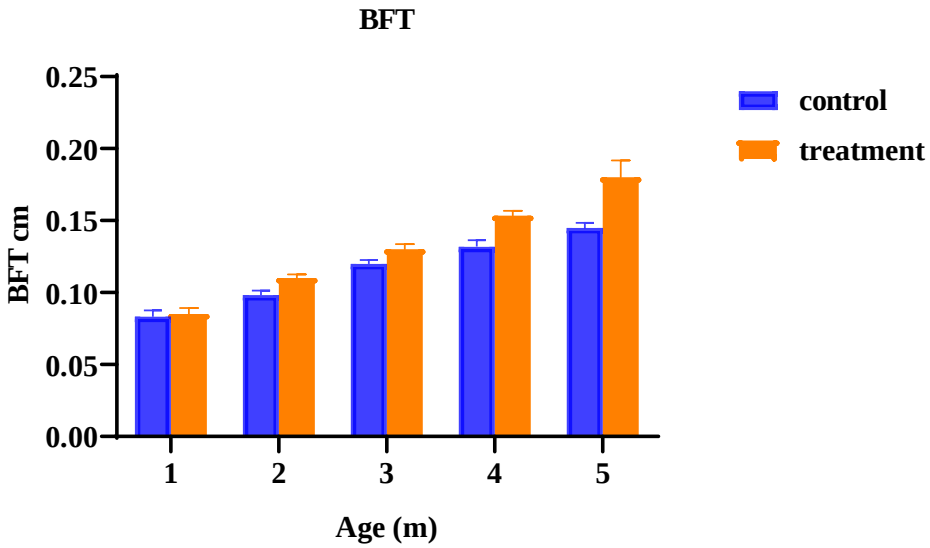


Fig. 11: Back fat thickness in control and treatment group

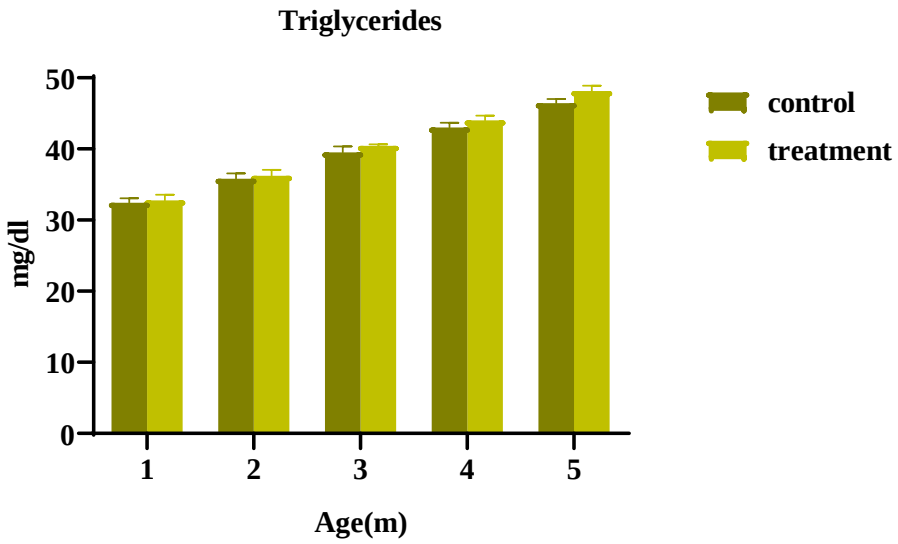


Fig. 12: Triglycerides levels in control and treatment group

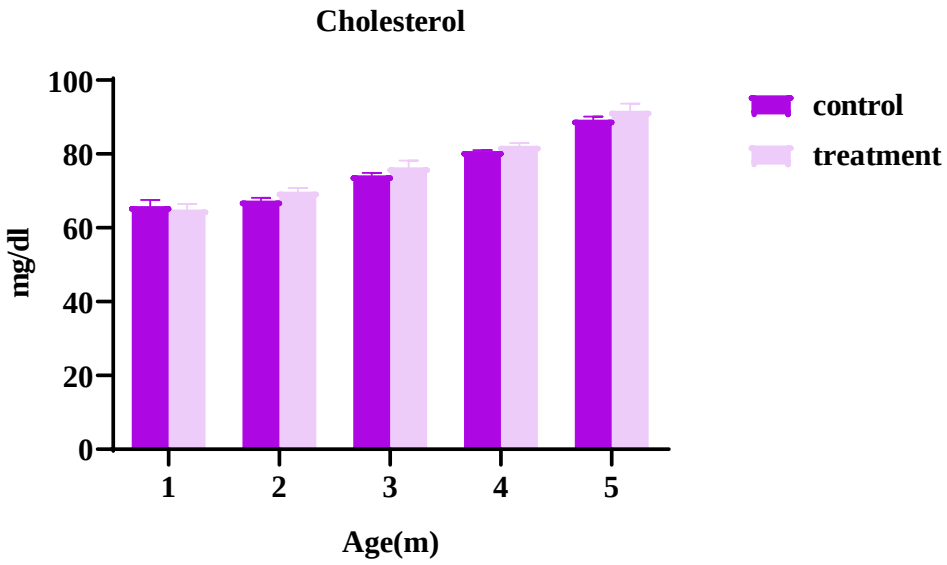


Fig. 13: Cholesterol level in control and treatment group

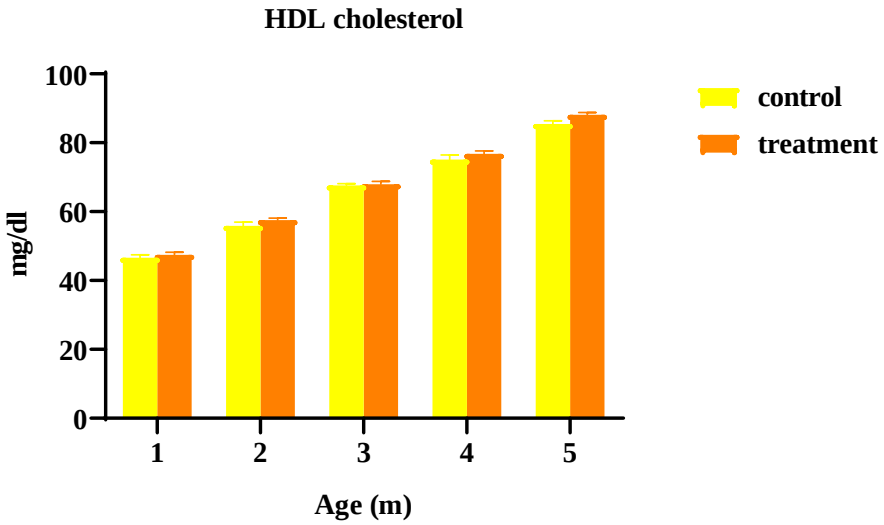


Fig. 14: HDL cholesterol in control and treatment group

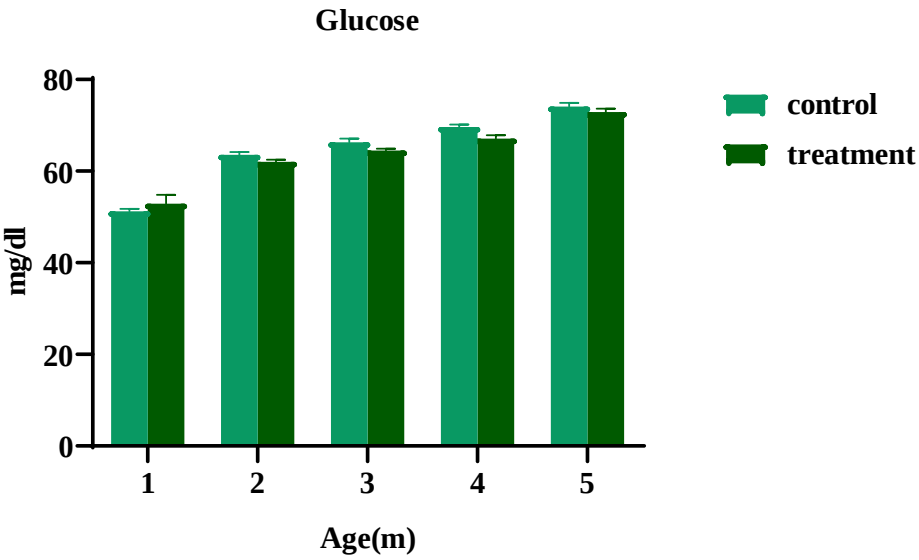


Fig. 15: Glucose values in control and treatment group

Table 4.18 Effect of dietary supplementation of palm stearin (PS) on glucose levels in Murra buffalo calves

Interval Day	Dietary groups		Period mean (mg/dl)	P value		
	Control (mg/dl)	Treatment (mg/dl)		T	P	T×P
0	51.24±0.52	52.91±1.93	52.08^{a}±0.98	0.000	0.053	0.152
30	63.59±0.58	62.04±0.44	62.82^{b}±0.42			
60	66.30±0.79	64.47±0.41	65.39^{c}±0.50			
90	69.66±0.52	67.10±0.75	68.38^{d}±0.58			
120	74.07±0.85	72.91±0.74	73.49^{e}±0.56			
Overall Mean	**64.97±1.46**	**63.89±1.29**	**64.43±0.97**			

Discussion

5 DISCUSSION

The current study aimed to determine the effect of dietary palm stearin supplementation on growth performance and economically important carcass parameters. The study included two groups: one for control and one for treatment (basal diet with 3% palm stearin inclusion), with six Murrah buffalo calves in each. Palm stearin was fed for 120 days.

5.1 Chemical composition of palm stearin

All of the concentrate mixes showed comparable chemical compositions: ether extract (EE), nitrogen-free extract (NFE), crude protein (CP), dry matter (DM), organic matter (OM), neutral detergent fiber (NDF), and total ash (TA). Previous research has proven that the nutritional composition of both the concentrate mixture and wheat straw fell within the defined range.

5.2 Growth parameters

Animal body weight is substantially affected by good nutritional management. According to Burque *et al.* (2008), livestock farmers in most developing tropical nations were driven to utilize the limited feed resources for their cattle, resulting in severe inefficiencies in ruminant metabolic processes. According to Mahmoudzadeh *et al*. (2009), this influences the average daily gain and feed conversion ratio, as well as body weight. So this is necessary to make energy based diet for improving growing buffalo calves.

5.2.1 Body weight (BW)

The effect of dietary palm stearin on BW in the two groups grows over time, although there was no significant difference ($P>0.05$) between the two groups. Our findings were

consistent with those of Ahmed *et al*. (2021), who found that Rumen Bypass Fat (RBF) supplementation did not result in significant body weight growth compared to calves fed the same meal without RBF supplementation. However, age and weight variance influenced body weight gain. Similarly, Khaskheli *et al*. (2021) reported that the use of crude palm stearin (CPS) in broiler chicks has no favorable effect on overall growth performance. Tipu *et al*. (2014) concluded that palm kernel cake (PKC) can be used in place of cotton seed cake (CSC) without compromising male buffalo growth. However, some research workers reported that fat supplementation did not affect feed intake (Palmquist *et al.,* 1978; Elliott *et a.,* 1993 and Maigo *et al*., 1995). Bolvar *et al*. (2014) conducted a study to investigate feed efficiency qualities in growing buffaloes. There was no difference in the beginning and final body weight, average daily gain, or relative growth rate. In contrast to what we found, Elbedawy *et al*. (2004) reported that increasing fat content in the diet boosted total body weight growth and average daily gain (ADG). The literature reviewed indicated that adding vegetable oils like palm oil and soybean oil to a broiler diet improved growth performance (Blanch *et al*., 1996; Zhao & Kim, 2017). Furthermore, compared to the soy oil, the palm oil treatment group significantly improved body weight gain ($P<0.05$). However, supplementing the feed with fat at a rate of 5-7% dry matter (DM) resulted in a 15% - 20% increase in lamb weight. Khaskheli *et al*. (2021), found that chicks in the CPS-treated group had significantly ($P<0.05$) lower values for final body weight, average daily weight gain, and feed intake than chicks in the control group. Nwoche *et al*. (2003), reported quite significant findings when offering varied quantities of palm oil to broiler diets. They reported that supplementing with 4% palm oil resulted in superior growth performance than supplementing with 2, 3, 5 and 6% palm oil. Cotton seed meal feeding has a substantial effect on daily weight gain in female calves (Shivakumar *et al*., 2005 and Ali *et al*., 2008) due to greater UDP (undegradable protein) content (Yunus *et al*., 2004).

5.2.2 Feed conversion ratio (FCR)

The FCR was non significantly different ($P>0.05$) between the control and treatment group animals. Similarly, According to Kheirabadi *et al*. (2022), DMI, final weight, daily weight growth, and FCR were not affected by supplementation with both levels of fat or

starch. Pimpa *et al*. (2021), reported that although supplementing cattle with bypass fat did not result in a substantial improvement in feed intake, digestibility, or feed conversion efficiency, ME intake was higher. Conversely, Matsuba *et al*. (2019), reported that cattle given a diet supplemented with 2.5% palm oil had an enhanced feed conversion ratio (FCR) and no negative effects on the fermentation of the rumen. Meanwhile, Kumar *et al*. (2007), reported that supplementation of bypass fat at 2.5% - 4% of dry matter intake increased the average daily gain and feed conversion ratio in buffalo calves and improved growth performance without an adverse effect on nutrient utilization.

5.2.3 Total dry matter intake (DMI)

In the present study, dry matter intake was non significantly different between the two groups (P>0.05). Our finding is consistent with Raval *et al*. (2017), who reported that bypass fat had a non-significant (P>0.05) effect on DMI. The literature reviewed indicated that (Kadkhoday *et al*., 2017; He *et al*., 2018) DMI was unaffected, and overall dry matter intake and average daily matter intake (DMI) were not increased by feeding more RBF, according to Ahmad *et al*. (2021). Conversely, to our findings, Brandt *et al*. (1990), reported that feeding young bulls with dietary FA supplementation enhanced their performance and feed efficiency. This could be because the rumen-protected fat supplementation did not affect the amount of dry matter intake. After all, the added inert fat was likely to be mostly unavailable in the rumen due to its low solubility and high melting point, which did not impair the digestibility of rumen fiber (Purushothaman *et al*., 2008). To boost the energy content of cattle feeds made with agricultural byproducts, fat supplements are frequently utilized. According to Mutsuba *et al*. (2019), palm oil had no detrimental effects on the most powerful rumen cellulolytic bacterium (Fibrobacter succinogenes), while coconut and soybean oils did. also, Allen *et al*. (2000), found that supplementing with fat lowered DMI.

5.2.4 Average daily gain (ADG)

The ADG was non significantly different (P>0.05) between the two groups. Reviewed literature (Cameron *et al*., 1968; Zinn *et al.,* 1989; White *et al*., 1992; Pinosa *et al*., 1992; Huffman *et al.,* 1992; Maiga *et al*., 1995; Chrzaszcz *et al*., 1995 and Wettestein *et al*.,

1999), indicate that adding fat to the diet had no discernible effect or reduced average daily gain. These findings were in close agreement with our findings. Likewise, supplementing cattle-fed grass-based total mixed ration (TMR) with bypass fat did not impact the cattle's ADG (Pimpa *et al.*, 2021). In contrast to the present study, Kang *et al*. (2019), found that fat supplementation increased the ADG of cattle-fed OPF but not that of a grass-based diet. It is possible, nevertheless, that the Napier grass, which is more easily digested than OPF, contributed a greater share of the overall amount of digestible energy from the diet, which diminished the benefit of the added fat for weight growth when compared to the more easily digested OPF diet. Crystal *et al.* (2015), reported that calves were older and heavier their average daily gain did not increase much since they were eating less feed. According to Elbedawy *et al*. (2004), the ADG and carcass fats increased fed with dietary protected fat

5.2.5 Morphometric Measurement:

The BL, HW, HG, HB and PG was non significantly different (P>0.05) between the two group. Salem *et al*. (2013), reported that male buffalo and Friesian crossbred calves' carcass qualities may be predicted using their body measures. The study found that carcass features including hot and cold carcass weights, 10th–13th fat weight, and carcass bone weight can be predicted using body parameters like heart girth, body length, and height at withers. (Shahin *et al.*, 1993) Buffaloes aged 12-18 months had an average wither height of 127.89 cm and a mean waist circumference was 181.24 cm. El-Feel *et al*. (1990) reported that after 76 weeks, the values for weight, heart girth, body length, hook width, height at withers, abdomen depth, and chest depth were 315.215.12 kg, 165.01.3 cm, 109.00.8 cm, 40.80.5 cm, 128.60.9 cm, 64.40.6 cm, and 65.70.6 cm, these values are consistent with the present study. Similarly, the average body measurements at 18–24 months were 129.9±2.61 cm for HW, 126.9±3.17 cm for BL, 171.8±4.74 cm for HG, 195.2±6.82 cm for PG, and 52.9±1.75 cm for HIP. For both sexes, the mean values were, respectively, 132+5.00 & 127.8±1.51 cm for HW, 123±6.07 and 130.8±1.83 cm for BL, 174±9.08 and 169.6±2.74 cm for HG, 193±13.06 and 197.5±3.94 cm for PG, and 53±3.35 & 52.8±1.01 cm for HIP. In contrast to the present findings, Sirohi *et al.* (1997) reported that body length, height at withers, and heart circumference, were lower than the present findings. Nonetheless, the present findings were

higher than those reported by Djaja *et al*. (2011) and Korejo *et al*. (2019). Brisket, ribs, pins, hooks, back, and tail head measurements for Nili-Ravi buffalo calves' initial and final body condition scores. No change in the BCS of Surti buffaloes fed RBF was noted by Raval *et al*. (2017), throughout their experiment. Similar findings were made by Long *et al*. (2014), who discovered no difference in BCS between beef heifers fed various RBF diets.

5.3 Biochemical parameters

5.3.1 Glucose

The present serum glucose levels are within the usual range for ruminants, ranging from 68.15 to 80.28 mg/dl. Tiwari *et al*. (2001) found that when growing buffaloes and Holstein cattle were fed an equal amount of concentrate and roughages, their normal glucose levels were 51 to 64 and 74 to 76 mg/dL, respectively. Calve's plasma glucose concentrations were within the range reported by Erjaei *et al*. (2012). In the present study, there was no significant difference ($P<0.05$) in serum glucose concentration between experimental groups. Present findings were consistent with Katiyarn *et al*. (2019) who reported that buffaloes given bypass fat supplements, showed no significant difference in blood glucose. Similar results were observed (Palmquist *et al*., 1978; DePeters *et al*., 1989). According to Kumar *et al*. (2007), there was no influence on blood glucose levels in different age groups of Murrah buffalo calves. The reason could be attributed to increased glucose utilization (high metabolic rate) and other factors (a homeostatic mechanism) in ruminants and other animals that regulate glucose levels (Tyagi *et al*., 2007). In contrast to our findings, Rashid et al. (2013) found that Nili-Ravi buffalo calves had significantly higher serum glucose levels ($P<0.05$). Seabrook *et al*. (2011) examined the impact of partially substituting dietary starch with Ca-salt lipids at 0, 4, 7, and 11% and reported that sheep receiving an 11% fat supplement had 9% lower plasma glucose concentration than those receiving supplemented treatment. Similarly, Ahmed *et al*. (2021), reported decreased ($P<0.05$) blood glucose levels in male Nili-Ravi buffalo calves.

5.3.2 Triglycerides and cholesterol

In the present study, the 3% inclusion of palm stearin supplementation has no significant ($P>0.05$) effect on triglyceride and cholesterol levels. Similar findings were reported by Tyagi

et al. (2010), who fed ration 2.5% RBF supplement (on a DMI basis) and found no significant difference (P>0.05) in cholesterol levels between groups of cows. It is possible that the level of RBF feeding (2.5% of DMI) was insufficient to elicit a rise in serum cholesterol levels. Fat supplementation did not affect triglyceride or VLDL levels. In contrast to the present study, this finding agreed with earlier studies that found dietary fat improved plasma cholesterol status (Choi *et al.,* 1996; Khorasani *et al*., 1998; Liu *et al*., 2017). In the present study, a significant (P<0.05) increase in HDL cholesterol levels was found between the two group. According to (Katiya *et al.,* 2019) Buffaloes fed supplement bypass fat had somewhat higher levels of high-density lipoprotein (65.55 vs. 57.22 mg/dL, respectively) than animals fed non-Bypass fat. Similarly, the HDL concentration in the animals fed a diet supplemented with high PUFA was the highest among the treatments. However, Dai *et al*. (2011) showed enhanced HDL concentrations by dietary supplemented PUFA. While a high-PUFA diet does enhance the production of cholesterol, this is not the primary mechanism by which PUFAs lower the concentration of plasma low-density lipoprotein cholesterol. Contrary to the present finding, Raval *et al*. (2017) reported that supplementing bypass fat raised blood cholesterol and triglyceride levels considerably (P<0.05). Increased dietary fatty acid absorption may be the cause of the elevated blood triglyceride and cholesterol levels observed (Fahey *et al*., 2002; Grewal *et al*., 2014). Similar findings were observed by (Grummer *et al*. 1996; Ghoorchi *et al*., 2006; Daneshvar *et al*., 2020), The addition of fat was found to significantly (P<0.05) increase the concentration of serum triglycerides. According to Sayed *et al*. (2003), Serum cholesterol levels increased significantly (P<0.05) with fat supplementation, increasing by 14.29 and 23.81% in 4% and 6%, respectively. The literature reviewed indicated (Palmquist *et al.* 1978; Jenkins *et al*. 1989; Lough *et al*., 1994; and Febel *et al*., 2002) similar results. The rise in blood cholesterol could be attributed to an obligatory reaction to aid in the transfer of higher levels of circulating fatty acids and total lipids (Sharma *et al*., 1978; Magdus *et al*., 1992). Increased blood triglyceride and cholesterol levels with increasing additional bypass fat feeding may be attributable to increased dietary fatty acid uptake (Fahey *et al*., 2002, Grewal *et al*., 2014). According to Matsuba *et al*. (2019), consuming palm oil elevated blood cholesterol levels. The level of LDL cholesterol did not significantly differ (P>0.05) between the two

groups in the current study. A similar study was published by Raval *et al*. (2017), which also found that there were no significant differences (P>0.05) in the average values of LDL cholesterol among the dietary groups.

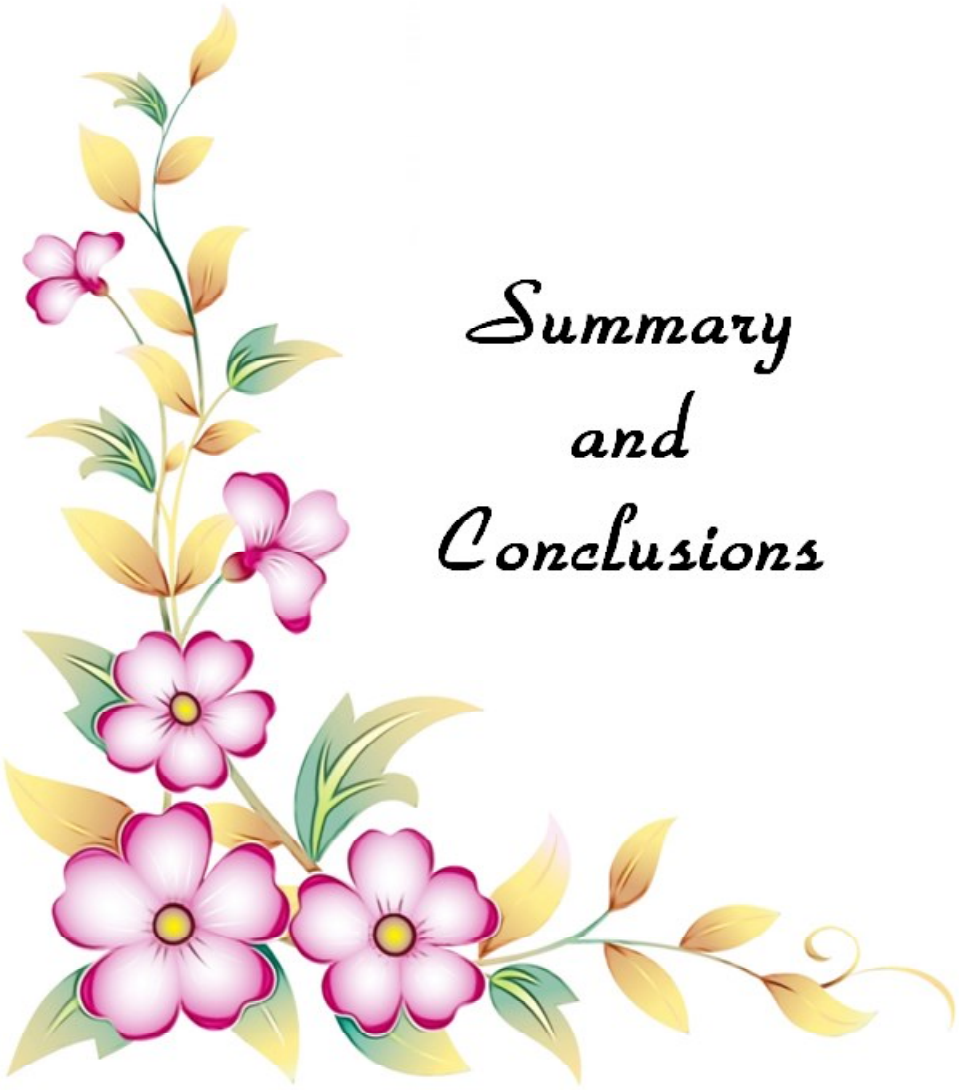
5.4 Economically important Carcass traits

Because it represents the amount of subcutaneous fat in the body, backfat thickness is employed as a measure of an animal's fatness or over-conditioning (Starke *et al*., 2010). In, growing calves given high concentrate levels are more likely to accumulate body fat. Elevated calorie intake leads to an increase in subcutaneous fat, the percentage of carcass fat, and a decrease in the amount of meat consumed (Arthoud, as cited by Khasrad and Ningrad, 2010). According to Khasrad and Ningrad (2010), there was a noticeable rise in REA with an increase in concentrate level. The back fat thickness (BFT) and rib eye area (REA) of the present investigation were significantly (P<0.05) enhanced by dietary supplementation of palm stearin.

Present findings were consistent with those of Singh *et al*. (2018). In the previous study's fat thickness of 1.20 mm(0.12cm) in animals slaughtered at 10 months of age corresponded with the findings of Rao et al. (2009). The carcass length and loin eye area observed in this investigation were lower than those reported by Lambertz *et al*. (2014), which is likely because the average body weight (kg) of animals in the latter's study was higher (385) than in the present (294.67). Pimpa *et al*. (2021) found that backfat thickness was greater in cattle supplemented with bypass fat (1.37 vs 1.30 cm, P < 0.05). This suggests that the extra energy from bypass-fat supplementation was used for the production of backfat thickness in the LD muscle, in addition to improving the color of the muscle, regardless of the type of fodder. Backfat thickness (1.25-1.46 cm) was similar to that reported for steers of similar breeds (Charolais Brahman crossbred) fed different TMR containing cassava chip and ground corn and those (1.2-1.3 cm) fed with Napier grass hay and rice straw with or without palm oil in the concentrate (Matsuba *et al*., 2019). Others have reported similar backfat thickness for other breeds, including Angus crossbred steers (1.20-1.30 cm) fed different oil-corn diets (Andrae *et al*., 2001) and Holstein steers (1.20-1.29 cm) fed diets containing 4 and 5 kg/day concentrate with pineapple stem by-product as roughage (Pintadis *et al*., 2020).

The largest ($p < 0.05$) Longissimus dorsi area (REA) was found in the carcasses of animals fed diets supplemented with Saturated Fatty Acid, according to Kheirabadi *et al*. (2022). The treatments did not affect other carcass features. In contrast to present findings regarding carcass attributes, other investigations (GómezCortés *et al*., 2014; Mapiye *et al*., 2013; Pewan *et al*., 2020) have also indicated that fat supplementation by various sources and quantities did not impact carcass qualities in the ruminants. Alternatively, Wanapat *et al*. (2011) examined the effects of various vegetable oils as UFA sources on ribeye areas and carcass quality and concluded that these characteristics were reduced in comparison to unsupplemented treatment. Buffalo meat could be improved in quality by following a diet high in oil palm byproducts, which is higher in protein and energy than a grass diet (Dahlan *et al*., 1988). There is more tender buffalo meat as a result of the earlier diet's promotion of intramuscular fat accumulation. This study discovered that this ration could generate high-quality buffalo meat with the usage of oil palm by-products. The usage of palm oil in broilers was found to positively impact the firmness of the meat by Smink *et al*. (2008). According to Choi *et al*. (2013), steers fed palm oil instead of soybean oil showed increased marbling scores and somewhat thicker 12th rib fat in their crossbred Angus cattle. More palm oil increased adipocyte size, lipid synthesis in vitro, and lipogenic enzyme activity in s.c adipose tissue (Choi *et al*., 2013; Nestel *et al*., 1978). According to Don *et al*. (2018), adding lipid-rich sources at or below 6% (DM base) has little effect on animal performance and meat sensory characteristics in iso-energetic and iso-nitrogenous diets. Between the lighter and heavier groups, the average body weights, rib eye area (REA), and fat thickness (FT) were 335.36 kg, 32.60 cm^2, 69.58 cm^2, and 0.17 and 1.08 cm, respectively. This value of BF and REA is consistent with the present finding. According to Jorge *et al*. (2007), the average rib eye area and fat thickness for buffaloes with a mean (SD) live weight of 496.18 (38.56) kg were 66.81 (7.04) cm and 9.92 (3.00) mm, respectively. These results exceed those of present study. This is a result of the animal's heavier body weight. A study on slaughtered animals that had been grown for 75, 100, 125, and 150 days produced results similar to those reported by Andrighetto *et al*. (2009). The daily averages for live weights and weight increase were: 328±13.6 kg and 1.01±0.05 kg/d; 346±28.0 kg and 0.86±0.17 kg/d; 356±23.6 kg and 0.84±0.11 kg/d; and 392±3.6 kg and 0.90±0.04 kg/d,

respectively. The rib eye area and back fat measured by ultrasound had thicknesses of 38.74±2.1 cm^2 and 5.0±0.7 mm at 75 days, 40.7±2.9 cm^2 and 5.1±1.1 mm at 100 days, 40.02.3 cm^2 and 6.6±1.6 mm at 125 days, and 45.4±1.9 cm^2 and 7.9±0.9 mm at 150 days, respectively. Andrighetto *et al*. (2009) reported that rib eye areas of 48.8 cm^2 and 50.26 cm^2 were seen in 18-month-old male Murrah buffaloes that had been neutered and kept in confinement. These results were comparable to those reported by Rebak *et al*. (2010) and aligned with present study. Pena *et al*. (2014) found that for buffaloes weighing 534.96 kg, the average thickness of subcutaneous fat and the area of the loin muscle was 79.74 cm^2 and 0.39 cm, respectively. These results are higher to the present findings. The preweaning growth performance of non-milk and dual-purpose buffaloes with initial average weights of 244.9±6.35 and 235.9±7.07 kg, respectively, and eye areas of 31.77±1.12 and 27.96±1.21 cm^2 was reported by Bolivar *et al*. (2012). In present investigation, the values of REA and BFT were greater for the same body weight due to the addition of palm stearin, a source of saturated fatty acid. The buffaloes with an average live weight of 338+49.7 kg had average rib-eye area values of 36.9±6.86 cm^2 and rump fat thickness values of 5.21±1.91 mm, respectively, value of rib eye area was consistent with the present study, but the back fat thickness is higher in this standard diet (Bolivar *et al*., 2014). According to Restrepo *et al*. (2012), buffaloes in the Colombian region that were younger than 36 months old had a live weight of 413 kg and a rib eye area of 39 cm^2.Cruz Rodriguez *et al*. (2001) reported that Jaffarabadi buffaloes exhibited a full dentition and a loin muscle area of 45.8 cm^2. According to Emenheise *et al*. (2014), the mean weight of the killed animals was 608 kg, with a range of minimum and maximum weights of 383 and 869 kg, respectively. The loin muscle area and fat thickness measured at 34.52 cm^2 and 108.84 cm^2, and 0.10 cm and 2.64 cm, were found for both weights. Similar to present observations.



Summary and Conclusions

6 SUMMARY AND CONCLUSIONS

The present study was carried out on Murrah Buffalo calves maintained at Cattle and Buffalo Farm of Livestock Production and Management, ICAR-Indian Veterinary Research Institute (IVRI), Izatnagar, Bareilly, Uttar Pradesh. Data on various parameters were collected from 12 Murrah buffalo calves to study the effect of dietary supplementation of palm stearin on growth performance REA and BF thickness. The effect of dietary palm stearin supplementation on growth performance, rib eye area, and back fat thickness in Murrah buffalo calves was investigated in this study. The study was done on two groups, one as a control (given the baseline diet) and the other as a treatment (fed with the addition of 3% palm stearin), with each group consisting of six buffalo calves. The feeding lasted for 120 days. The collected data were evaluated by using two-way ANOVA as the statistical method.

The findings acquired from the study were summarized below:

The effect of dietary palm stearin supplementation on growth parameters as BW was recorded fortnightly; overall live body weights of the experimental animals were 294.01±4.25 and 294.67±4.31kg, respectively. There was no significant difference ($P>0.05$) between the control and treatment groups. In the present study, ADG was recorded fortnightly i.e, 0-15th,15-30th,30-45th,45-60th day,60-75th,75-90th,90-105th,105-120th day. The overall ADG: of the experimental animals in the control and treatment groups were 0.697±0.02 and 0.715±0.02 g/d, respectively. No statistically significant difference ($P>0.05$) between the control and treatment groups were observed. However, there was a substantial ($P<0.05$) rise in ADG with time in the treatment group compared to the control group animal, and ADG increases

with age. The effect of dietary palm stearin supplementation on FCR, overall FCR values for the control and treatment groups were 10.19±0.30 and 9.84±0.31 kg, respectively, no significant difference was observed ($P>0.05$) between the control and treatment group animals. However, there was a significant ($P<0.05$) decline in FCR with time in the treatment group compared to the control group, and FCR decreased with age. Dry matter intake at the commencement of the experiment, the DMI value in the control and treatment groups were 6.23±0.6 and 6.17±0.06 kg, respectively. There was no significant difference between the two groups ($P>0.05$). No significant difference was observed in morphometric measurements (BL, HW, HG, HB and PG) of Murrah buffalo calves feeding with 3% inclusion of palm stearin.

Effect of dietary palm stearin on biochemical parameters, the glucose levels in the control group animal were 64.97±1.46 and those in the treatment group animal were 63.89±1.29, respectively. There was a non-significant difference observed between the two groups. The findings for lipid indices,the overall values for the lipid indices triglycerides level in the control and treatment groups were 39.45±0.97 and 40.32±1.05 mg/dl, respectively. No discernible difference ($P>0.05$) was found between the two groups. The lipid values variables for cholesterol in the control and treatment groups, the values for cholesterol were 75.48±1.66, and 77.00±1.85 mg/dl, respectively. there was no significant difference between the two groups' cholesterol levels ($P>0.05$). The LDL cholesterol level in the treatment group was 44.71±2.85 mg/dl while it was 43.61±1.16 mg/dl in the control group. Although the values were non-significant ($P>0.05$). HDL cholesterol values for the calves in the control group were 66.12±2.58 and the calves in the treatment group were 67.56±2.65, respectively. HDL cholesterol value for the treatment group was significantly higher ($P>0.05$) than the control group.

Effect of 3% inclusion of palm stearin on economically important carcass features are REA of the Murrah buffalo calves was measured on days 0^{th}, 30^{th}, 60^{th}, 90^{th}, and 120^{th} days. In the control and treatment groups, REA values were 24.07±1.38 and 26.96±1.12cm^2 respectively. There was a significant difference ($P<0.05$) between the two groups. The BF thickness was assessed in the Murrah buffalo calves on days 0, 30, 60, 90, and 120. The BF thickness of the calves in the control group was 0.11 cm, while for the calves in the treatment group, it was 0.12 cm. A significant difference ($P<0.05$) was observed between two groups.

Conclusions

- The present study revealed that dietary supplementation of 3% Palm stearin had no negative effects on the growth performance; or biochemical parameters of Murrah buffalo calves.
- Apart from feeding with forages, dietary supplementation with concentrate and 3% inclusion of palm stearin is one of the feeding strategies to enhance nutrient availability and improve buffalo performance and productivity.
- Based on the literature studies, it can be summarized that supplementation of concentrate and 3% inclusion of palm stearin in buffaloes may overcome nutritional problems and improve growth performance, health status, rumen environment, and economically important carcass features.


Mini Abstract

7 MINI ABSTRACT

Livestock plays an important role in the Indian economy. Buffaloes (*Bubalus bubalis*) are important to the lives of millions of people because they provide milk, meat, draught power, transportation, and on-farm waste in several developing countries in Asia, particularly India. Additionally, buffaloes have been noted for their adaptability to various housing, feeding, and management settings, excellent disease resistance, and flexible diets. The shortage and fluctuating quantity and quality of feed and fodder supply around the year is a major constraint to livestock production in developing countries. Better management and balanced nutrition can boost buffalo productivity. Dietary supplementation is one option for increasing the essential nutrient content of the buffalo diet and improving the animal's rumen metabolism. Supplementing concentrate and rumen-protected fat could alter growth performance and carcass traits without negatively impacting buffalo growth. Plant oils and oil seeds are the primary sources of supplemental fatty acids in ruminant diets. Palm stearin (PS) is the solid fraction of palm oil obtained by partial crystallization at controlled temperature (Fractionated fat) which is a superior and cost-effective fat source**.** It contains approximately 47-74% palmitic acid, 16-37% oleic acid, 4-6% stearic acid, 3-10% linoleic acid and 1-2% myristic acid**.** Meat quality improvement can improve economic development for livestock producers. Ultrasound technology is used to evaluate body composition traits. Real-time ultrasound is the term used to describe the ultrasound technology used to measure carcass traits. Estimation of carcass characteristics in live animals potentially allows for sorting and selecting livestock for carcass merit. Collectively, current and future applications of ultrasound hold tremendous potential to enhance management for improved carcass production efficiency in livestock. Based on the foregoing information, the proposed study may provide a superior dietary regimen for improving growth performance, rib eye area (REA), and back fat (BF) thickness, in Murrah buffalo calves thus, raising the farmer's income in the concerned area. The trial was carried out at Cattle and buffalo farm, ICAR-IVRI in twelve Murrah buffalo calves within the age range from 10 to 14 months. The animals were separated into two groups: control and treatment control group received a basal diet and the treatment group was provided with a baseline diet with a 3% inclusion of palm stearin for 120 days. The body weight (BW), average daily gain (ADG), and feed conversion ratio (FCR) and total dry matter intake (DMI) were not significantly ($P>0.05$) affected by the addition of 3% palm stearin to the basal diet. Similarly, a non-significant ($P>0.05$) effect was observed on glucose, triglyceride and LDL cholesterol levels. However, there was a significant ($P<0.05$) increase in the level of HDL cholesterol with the inclusion of 3% PS. The BF thickness and REA, measured using ultrasonography in live animals were significantly increased ($P<0.05$) in the treatment group. Conclusively, with no adverse effects on health, biochemical parameters and enhanced commercially significant carcass features, the inclusion of 3% palm stearin in the diet is a better alternative and affordable feed resource for buffalos.

लघु सारांश

8 लघु सारांश

भारतीय अर्थव्यवस्था में पशुधन एक महत्वपूर्ण भूमिका निभाता है। भैंस (*Bubalus bubalis*) लाखों लोगों के जीवन के लिए महत्वपूर्ण है क्योंकि वे एशिया के कई विकासशील देशों, विशेषकर भारत में दूध, मांस, भारोत्तोलन शक्ति, परिवहन और खेत पर अपशिष्ट प्रदान करते हैं। इसके अतिरिक्त, भैंसों को विभिन्न आवास, भोजन और प्रबंधन सेटिंग्स, उत्कृष्ट रोग प्रतिरोधक क्षमता और लचीले आहार के लिए अनुकूलनशीलता के लिए जाना जाता है। साल भर भोजन और चारे की आपूर्ति की कमी और मात्रा और गुणवत्ता में उतार–चढ़ाव विकासशील देशों में पशुधन उत्पादन के लिए एक बड़ी बाधा है। बेहतर प्रबंधन और संतुलित पोषण से भैंस की उत्पादकता को बढ़ावा मिल सकता है। भैंस के आहार में आवश्यक पोषक तत्वों की मात्रा बढ़ाने और पशु के रूमेन चयापचय में सुधार के लिए आहार अनुपूरक एक विकल्प है। सांद्रण और रुमेन–संरक्षित वसा की खुराक भैंस के विकास पर नकारात्मक प्रभाव डाले बिना विकास प्रदर्शन और शव के लक्षणों को बदल सकती है। पौधों के तेल और तिलहन जुगाली करने वालों के आहार में पूरक फैटी एसिड के प्राथमिक स्रोत हैं। पाम स्टीयरिन (PS) नियंत्रित तापमान पर आंशिक क्रिस्टलीकरण (फ्रैक्शनेटेड वसा) द्वारा प्राप्त पाम तेल का ठोस अंश है जो एक बेहतर और लागत प्रभावी वसा स्रोत है। इसमें लगभग 47-74% पामिटिक एसिड, 16-37% ओलिक एसिड, 4-6% स्टीयरिक एसिड, 3-10% लिनोलिक एसिड और 1-2% मिरिस्टिक एसिड होता है। मांस की गुणवत्ता में सुधार से पशुधन उत्पादकों के आर्थिक विकास में सुधार हो सकता है। अल्ट्रासाउंड तकनीक का उपयोग शरीर संरचना लक्षणों का मूल्यांकन करने के लिए किया जाता है। वास्तविक समय अल्ट्रासाउंड वह शब्द है जिसका उपयोग शव के लक्षणों को मापने के लिए उपयोग की जाने वाली अल्ट्रासाउंड तकनीक का वर्णन करने के लिए किया जाता है। जीवित जानवरों में शव की विशिषताओं का अनुमान संभावित रूप से शव योग्यता के लिए पशुधन को छांटने और चुनने की अनुमति देता है। सामूहिक रूप से, अल्ट्रासाउंड के वर्तमान और भविष्य के अनुप्रयोगों में पशुधन में बेहतर शव उत्पादन दक्षता के प्रबंधन को बढ़ाने की जबरदस्त क्षमता है। पूर्वगामी जानकारी के आधार पर, प्रस्तावित अध्ययन मुर्रा भैंस के बछड़ों में विकास प्रदर्शन, पसली आंख क्षेत्र (REA), और पीठ वसा (BF) की मोटाई में सुधार के लिए एक बेहतर आहार प्रदान कर सकता है, जिससे संबंधित क्षेत्र में किसान की आय बढ़ सकती है। परीक्षण मवेशी और भैंस फार्म, आईसीएआर–आईवीआरआई में 10 से 14 महीने की उम्र के बारह मुर्रा भैंस के बछड़ों पर किया गया था। जानवरों को दो समूहों में विभाजित किया गया था। नियंत्रण और उपचार नियंत्रण समूह को एक बेसल आहार प्राप्त हुआ और उपचार समूह को 120 दिनों के लिए पाम स्टीयरिन के 3% समावेश के साथ एक बेसलाइन आहार प्रदान किया गया। बेसल आहार में 3% पाम स्टीयरिन शामिल करने से शरीर का वजन (BW), औसत दैनिक लाभ (ADG), और फीड रूपांतरण अनुपात (FCR) और कुल शुष्क पदार्थ सेवन (DMI) महत्वपूर्ण रूप से ($P>0.05$) प्रभावित नहीं हुए। इसी तरह, ग्लूकोज, ट्राइग्लिसराइड और एलडीएल कोलेस्ट्रॉल के स्तर पर एक गैर–महत्वपूर्ण ($P>0.05$) प्रभाव देखा गया। हालाँकि, 3% पीएस के समावेश के साथ एचडीएल कोलेस्ट्रॉल के स्तर में उल्लेखनीय ($P>0.05$) वृद्धि हुई थी। उपचार समूह में जीवित जानवरों में अल्ट्रासोनोग्राफी का उपयोग करके मापी गई बीएफ मोटाई और आरईए में काफी वृद्धि हुई ($P<0.05$)। निर्णायक रूप से, स्वास्थ्य, जैव रासायनिक मापदंडों और व्यावसायकि रूप से महत्वपूर्ण शव विशेषताओं पर कोई प्रतिकूल प्रभाव नहीं होने के कारण, आहार में 3% पाम स्टीयरिन को शामिल करना भैंसों के लिए एक बेहतर विकल्प और किफायती चारा संसाधन है।

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