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Therapeutic response of dietary interventions to obesity in dogs

Dr. YK Meena, S Gupta, SP Pannu and R Tiwari

Abstract
The current study aimed to evaluate the therapeutic response of dietary interventions in obese dogs on the basis of a reduction in initial body weight and improvement in haemato-biochemical parameters after two months of treatment. The experiment was carried out with twenty-four dogs irrespective to breed divided in four groups – Group-I (obese dog treated with natural enzyme-based feed supplements, n=six), Group-II (obese dog treated with low fat and high fiber diet, n=six), Group-III (obese dog treated without any treatment as positive control, n=six), Group-IV (healthy dogs as negative control, n=six).The post-treatment mean values of body weight of the Groups-I and II were significantly lower as compare with dogs of Group-III whereas significantly higher with mean values of body weight of apparently dogs of Group-IV on sixty day. The post-treatment mean values of Hb, PCV, TEC and TLC in Groups-I and II were decrease non significantly as compare to pre-treatment mean values of corresponding groups and also with the mean value of Group-III on sixty day whereas significant difference was found in mean values of these parameters of Group-IV on sixty day. The post-treatment mean values of serum glucose, total protein, albumin, ALT and ALP in Groups-I and II were decrease significantly as compared to pre-treatment mean values of respective groups and also with the mean values of Group-III on sixty day. The post-treatment mean values of total cholesterol, total glycerides, HDL-C and LDL-C of the Groups-I and II were still significantly higher with mean values of these parameters on sixty day of the apparently healthy dogs of Group-IV. Greater rate of reduction in body weight was observed in low fat and high fiber diet in comparison to natural enzyme-based feed supplements, along with significant reduction in clinical parameters in both the groups. It is concluded that dietary intervention used in Group-II was better as comparison to Group-I and needed more time to achieved desired or ideal body weight of breed in obese dogs. it is advice to veterinarian to use dietary intervention method to treat obese dogs for reduction body weight and improving health and life longevity.

Keywords: obesity, dietary intervention, haematology, biochemical

1. Introduction

Amongst various canine disorders, obesity is an escalating global health problem and one of the greatest clinical challenges in contemporary veterinary medicine, which is increasing with a similar trend observed in humans (Scalett *et al*., 1994; McGreevy *et al*., 2005; Veiga *et al*., 2008) [46, 36, 55]. Obesity is most common nutritional disorder of companion animals which is due to the accumulation of excessive amounts of adipose tissues leading to a positive energy balance (Burkholder and Toll, 2000) [4], caused by an imbalance between energy intake and energy expenditure (German, 2006) [17]. A dog is considered to be obese when its body weight exceeds optimum weight for body size by fifteen per cent (Simpson *et al*., 1993; Laflamme, 2001) [50, 32]. Recent studies reported that 34–59% of dogs visiting veterinary practitioners are overweight among which 5–20% are obese (McGreevy *et al*., 2005; Colliard *et al*., 2006; Lund *et al*., 2006; Courcier *et al*., 2010) [36, 6, 34, 7]. Obesity could deteriorate the quality of life in pets as well shorten the life span (German *et al*., 2006) [17] by predisposing to several other diseases such as osteoarthritis, laminitis (Marshall *et al*., 2009) [35] chronic inflammation, hepatic lipidosis and diabetes mellitus (Ettinger *et al*., 2005; Kealy *et al*., 2002; Rand *et al*., 2004) [11, 28, 41]. In obesity, hyperlipidemia is a common finding and characterized by hypercholesterolemia a quantitative increase in circulating lipoproteins (LP) or by a higher lipid concentration in the various LP classes (Mori *et al*., 2011) [37]. There are increased levels of cholesterol, triglycerides, high density lipoproteins cholesterol (HDL-C), low density lipoproteins cholesterol (LDL-C), glucose and blood urea nitrogen along with increased levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and gamma glutamyl transferase (GGT) in overweight and obese dogs (Tribuddharatana *et al*., 2011) [53].

Obesity in dogs may be associated with dysfunction in multiple organ systems (Radin *et al*., 2009) [39], such as cardiopulmonary diseases (Kume *et al.*, 2009; Bach *et al*., 2007) [29, 1], glucose intolerance, oxidative stress (Laflamme, 2012) [33] and other endocrine disorders (Zoran, 2010) [57]. The main therapeutic option for obesity in dogs includes dietary intervention and increasing physical activity. Therefore, it is preferable to use formulated weight reduction diet, which generally are restricted in fat and energy, while being supplemented in protein and micronutrients and the use of high-fibre diets (to provide satiety). Additional dietary factors that may be benefited in weight loss includes L-carnitine supplementation (to maintain lean mass), conjugated linoleic acid (CLA), hydroxycitric acid (HCA). Manufactured low-calorie dietary formulas often have a high fibre content to provide bulk and may also decrease fat digestibility by modifying pancreatic lipase secretion and reducing binding of bile acids, as well as promoting faster passage through the intestines due to its higher water-holding capacity (Gentry, 1993) [14]. However, the satiety promoted by a high fibre diet alone is questionable and many owners dislike the typical increase in stool volume, which also reduces compliance (Jewell and Toll, 1996; Butterwick and Hawthorne, 1998; Jewell *et al*., 2000) [26, 5, 27]. Many pet owners do not know if the dog is obese, or reason for causative conditions, or do not know why it is dangerous for health of their pets, so they do not spontaneously seek veterinary advice and thus it becomes the duty of the veterinarian to increase the owners' awareness and knowledge about obesity and how the dog is kept at normal body condition, convince owner about ill effects of the obesity and its management and control. Keeping in view the above facts, the present study was carried out to evaluate therapeutic response of dietary intervention on obesity in dogs.

2. Materials and methods
2.1 Selection of Animals
The present study entitled was conducted on adult dogs presented for routine clinical examination/ vaccination in canine out-door of Veterinary Clinical Complex, College of Veterinary and Animal Science, Bikaner, Rajasthan, India. Dogs were considered as obese when body weight excess optimum weight for body size by fifteen per-cent (Simpson *et al*., 1993; Laflamme, 2001) [50, 32]. Body condition score were assigned as whole number value 1 to 9 at the time of visual examination and palpation system (Laflamme, 1990; Burkholder and Toll, 2000) [4, 31]. Four classes of BCS were considered: BCS 1 to 3 (Lean dogs), BCS 4 to 5 (ideal dogs), BCS 6 to 7 (overweight dogs) and BCS 8 to 9 (obese dogs) (Ricci *et al*., 2007) [43]. In present study dogs with BCS 8 to 9 were considered as obese.

The experiment was carried out with twenty-four dogs irrespective to breed divided in four groups – Group-I (obese dog treated with natural enzyme-based feed supplements, n=6), Group- II (obese dog treated with low fat and high fibre diet, n=6), Group-III (obese dog treated without any treatment as positive control, n=6), Group-IV (healthy dogs as negative control, n=6). Dogs in Group (I) were treated with the natural enzyme based feed supplement Calories (Vivaldis Animal Health) at dose rate 5 gm for small dogs (up to 10 kg b.wt), 10-15 gm for medium dogs (11 to 20 kg b.wt), 15-20 gm for large dogs (21 to 40 kg b.wt) and 25-30 gm for extra-large dogs (above 40 kg b.wt), orally for 60 days. During the treatment type of food was unchanged but amount of food was reduced up to 40 per cent (Laflamme, 1990).[31] Each 10 gram of this natural enzyme-based feed supplement was containing *Garcinia cambogia* 32mg, Lipase (50000 units) 16mg, EnQ10 8mg and Excipient Q.S. Dogs in Group (II) were placed on a special high fiber diet (Hill's Prescription Diet, Weight Reduction, R/D) to reduce weight in dogs. This group was fed only this Prescription Diet, for weight reduction for 60 days. The diet was mainly composed of 34.6% protein, 8.2% fat, 38.2% carbohydrate (nitrogen-free extract) and 13.1% crude fiber. The diet presented 25.7% of total dietary fiber (1.6% soluble fibre and 23.5% insoluble fibre; composition by dry matter). The amount of this diet was given as under based on manufacturer recommendations (Hill, 2009).[20] Obese dogs in Group (III) were kept as positive control, whereas apparently healthy normal weight dogs of were kept as negative control (Group-IV).

Body Weight (Kg)	10-15	15-20	20-25	25-30	30-35	35-40	40-45	Above 45
Quantity of feed (Gm)	125	150	200	250	300	350	400	450

Final body weight and blood samples were obtained from all groups of dogs after two month and compared with the initial body weight and haemato-biochemical parameters to evaluate therapeutic response of dietary intervention on obesity.

2.2 Haematological examinations
The blood samples were subjected for estimation of some of the haematological parameters viz. haemoglobin (Hb), packed cell volume (PCV), total erythrocyte count (TEC), total leucocyte count (TLC). These parameters were analysed as per standard haematological methods cited by Schalm's veterinary haematology (Jain, 1986) [24].

2.3 Biochemical estimations
Biochemical analysis of serum were carried out to estimate some of the biochemical parameters viz. serum glucose, serum total protein, albumin, globulin, serum creatinine, blood urea nitrogen (BUN), alkaline phosphatase (ALP), total cholesterol, High density lipoprotein cholesterol (HDL-C) and triglyceride concentrations, and the activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase by the standard method. Serum low density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C) concentrations was calculated by Friedewald formula. All the above biochemical parameters were estimated by using the IDEXX Vet Test Chemistry Analyzer. The principles, reagents required, procedure, calculation and precautions used for each of them were followed as per operator's manual.

2.4 Statistical analysis
The data obtained in the present research work was statistically analyzed and compared using standard formulas given for mean, standard error, one way analysis of variance (ANOVA) and t- test as per the procedures explained by Snedecor and Cochran (2004).[51]

3. Results and Discussion
3.1 Body weight
Pre-treatment (Mean ± SE) values of body weight (Kg) in

Group-I, II, III and Group-IV were 49.83±1.37, 51.50±1.83, 51.17±1.51 and 32.87±0.85, respectively and post-treatment (Mean ± SE) values of body weight (Kg) in Group-I, II, III and Group-IV were 45.67±1.11, 43.50±1.48, 51.50±1.68 and 33.25±0.82, respectively (Table1). The pre-treatment mean values of body weight in in Group-I, II, III were significantly higher ($p<0.05$) than those of in Group-IV. The post-treatment mean values of body weight in Group-I and Group-II dogs were decrease significantly ($p<0.05$) as compared to pre-treatment mean values of their respective groups. The post-treatment mean values of body weight of the Group-I and II were significantly lower as compare with dogs of Group-III whereas significantly higher with mean values of body weight of apparently healthy dogs of group-IV on 60th day.

Table 1: Pre and post-treatment (mean ± SE) values of body weight (kg) in groups (G-I, G-II G-III and G-IV)

S. No.	Group	Pre-treatment	Post-treatment
1.	Group-I	49.83±1.37^{bA}	45.67±1.11^{cB}
2.	Group-II	51.50±1.83^{bA}	43.50±1.48^{cB}
3.	Group-III	51.17±1.51^{bA}	51.50±1.68^{bA}
4.	Group-IV	32.87±0.85^{aA}	33.25±0.82^{aA}

Means having different superscript in a row (A, B) differ significantly ($p<0.05$) and means having different superscript in a column (a, b, c) differ significantly ($p<0.05$)

The findings of present study are in accordance with findings of Borne *et al*. (1996), Jackson *et al*. (1997), Heymsfield *et al*. (1998), Diez *et al*. (2004), Yamka *et al*. (2006), Roudebush *et al*. (2009), Toromanyan *et al*. (2007), Fritsch *et al*. (2010), German *et al*. (2010), Sethi, (2011) and Semwal *et al*. (2015) [2, 23, 19, 9, 56, 44, 52, 13, 48, 47] who also found reduction in body weight of dogs were fed with the extract as well as hydroxy citric acid (HCA), an active component of the fruit rind of *Garcinia cambogia*and high fibre diet during weight reduction study. The extracts as well as hydroxy citric acid (HCA), an active component of the fruit rind of *Garcinia cambogia*, exhibited anti-obesity activity including reduced food intake and body fat gain by regulating the serotonin levels related to satiety, increased fat oxidation and decreased de novo lipogenesis (Hayamizdu *et al*. 2003, Sethi, 2011 and Semwal *et al*. 2015) [18, 48, 47]. The dietary fiber provides a satiety effect and causing a voluntary reduction in total calorie consumption in dogs offered food in excess of energy needs resulting decrease body weight (Jackson *et al*. 1997) [23]. Fekete *et al*. (2001) [12] reported that fibre can be used to dilute or reduce the calorie density of foods, which can aid in calorie restriction for weight loss.

3.2 Haemoglobin (Hb)

Pre-treatment (Mean± SE) values of haemoglobin (g/dl) in Group-I, II, III and Group-IV were 15.57±0.89, 15.10±1.10, 15.04±0.99 and 11.98±0.68, respectively and post-treatment (Mean ± SE) values of haemoglobin (g/dl) in Group-I, II, III and Group-IV were 14.00±0.80, 14.53±0.74, 15.05±0.97 and 11.71±0.50, respectively. The post-treatment mean values of haemoglobin in Group-I and Group-II dogs were decrease non significantly as compare to pre-treatment mean values of corresponding groups and also with the mean value of Group-III on 60th day whereas significant difference ($p<0.05$) was found with the mean values of haemoglobin of Group-IV on 60thday.

3.3 Packed Cell Volume (PCV)

Pre-treatment (Mean ± SE) values of PCV (%) in Group-I, II, III and Group-IV were 46.64±2.84, 46.47±3.24, 46.17±2.14 and 33.67±1.58, respectively and post-treatment (Mean ± SE) values of PCV (%) in Group-I, II, III and Group-IV were 43.83±2.91, 42.88±2.67, 44.00±2.67 and 34.00±1.79, respectively. The post-treatment mean values of PCV in Group-I and Group-II dogs were decrease non significantly as compare to pre-treatment mean value of Group-I and Group-II and also with the mean value of group-III on 60th day whereas significant difference ($p<0.05$) was found with the mean values of PCV of group-IV on 60th day.

3.4 Total Erythrocyte Count (TEC)

Pre-treatment (Mean ± SE) values of TEC ($\times 10^6 \mu l$) in Group-I, II, III and Group-IV were7.25±0.44,7.12±0.38, 7.15±0.31 and 5.59±0.12, respectively and post-treatment mean ± SE values of TEC ($\times 10^6 \mu l$) in Group-I, II, III and Group-IV were 6.63±0.35, 6.25±0.48,7.18±0.35 and 5.38±0.31, respectively. The post-treatment mean values of TEC in Group-I and Group-II dogs were decrease non significantly as compare to pre-treatment mean value of corresponding groups and also with the mean value of Group-III on 60th day whereas significant difference ($p<0.05$) was found with the mean values of TEC of group-IV on 60th day.

3.5 Total Leucocyte Count (TLC)

Pre-treatment (Mean ± SE) values of TLC ($\times 10^3 \mu l$) in Group-I, II, III and Group-IV were 12.92±0.82, 12.64±0.78, 12.35±0.98 and 9.40±0.30, respectively and post-treatment (Mean ± SE) values of TLC ($\times 10^3 \mu l$) in Group-I, II, III and Group-IV were `11.75±0.48,10.57±1.21, 12.31±0.87 and 9.32±0.32, respectively. There was non-significant difference observed in the post-treatment mean values of TLC in the treated groups-I and II as compared to their pre-treatment values. The post-treatment mean values of TLC of the groups-I and II were differ non significantly with the group-III on 60th day whereas, significantly differ with the apparently healthy dogs of group-IV on 60th day.

3.6 Glucose

Pre-treatment (Mean ± SE) values of serum glucose (mg/dl) in Group-I, II, III and Group-IV were 120.00±5.47, 120.50±5.55, 120.84±5.50 and 88.17±4.44, respectively and post-treatment (Mean ± SE) values of serum glucose (mg/dl) in Group-I, II, III and Group-IV were 99.17±4.16, 100.00±4.47, 118.85±6.45 and 87.42±4.22, respectively (Table 2). The post-treatment mean values of serum glucose in Group-I and Group-II dogs were decrease significantly ($p<0.05$) as compare to pre-treatment mean values of corresponding groups and also with the mean value of Group-III on 60th day. The post-treatment mean values of serum glucose of the groups-I and II were non-significantly differ with mean values of serum glucose of the apparently healthy dogs of Group-IV on 60th day.

Table 2: Pre and post-treatment mean ± SE values of glucose (mg/dl) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No	Group	Pre-treatment	Post-treatment
1.	Group-I	120.00±5.47^{bA}	99.17±4.16^{aB}
2.	Group-II	120.50±5.55^{bA}	100.00±4.47^{aB}
3.	Group-III	120.84±5.50^{bA}	118.85±6.45^{bA}
4.	Group-IV	88.17±4.44^{aA}	87.42±4.22^{aA}

Means having different superscript in a row (A, B) differ significantly (p<0.05) and means having different superscript in a column (a, b) differ significantly (p<0.05)

The possible reason of decrease serum glucose in treated group-I obese dogs may be the *Garcinia combogia* crude extract or constituents from the plant which reported to have hypolipidemic and antidiabetic activities in *in vitro* and *in vivo* models (Semwal *et al*. 2015) [47]. The present findings are in agreement with Yamka *et al.* (2006), German *et al.* (2007), Bouthegourd *et al.* (2009), Diez *et al.* (2004) and De Marchi *et al.* (2018) [56, 15, 3, 9, 8] who also found lower glucose value in weight reduction programme by using high fibre and high protein diet.

3.7 Total protein
Pre-treatment (Mean ± SE) values of serum total protein (g/dl) in Group-I, II, III and Group-IV were 7.82±0.36, 7.97±0.29, 7.99±0.17 and 6.52±0.42, respectively and post-treatment (Mean ± SE) values of serum total protein (g/dl) in Group-I, II, III and Group-IV were 6.77±0.33, 6.85±0.29, 7.78±0.17 and 6.88±0.22, respectively (Table 7). The post-treatment mean values of serum total protein in Group-I and Group-II dogs were decrease significantly (p<0.05) as compare to pre-treatment mean values of corresponding groups and also with the mean value of Group-III on 60th day. The post-treatment mean values of serum total protein of the Groups-I and II were non-significantly differ with mean values of serum albumin on 60th day of the apparently healthy dogs of group-IV.

3.8 Albumin
Pre-treatment (Mean ± SE) values of serum albumin (g/dl) in Group-I, II, III and Group-IV were 4.04±0.27, 3.89±0.12, 4.14±0.16 and 3.42±0.12, respectively and post-treatment (Mean ± SE) values of serum albumin (g/dl) in Group-I, II, III and Group-IV were 3.28±0.26, 3.48±0.37, 4.17±0.17 and 3.32±0.16, respectively (Table 8). The post-treatment mean values of serum albumin in Group-I and Group-II dogs were decrease significantly (p<0.05) as compare to pre-treatment mean values of corresponding groups and also with the mean value of Group-III on 60th day. The post-treatment mean values of serum albumin of the Groups-I and II were non-significantly differ with mean values of serum albumin on 60th day of the apparently healthy dogs of Group-IV.

3.9 Globulin
Pre-treatment (Mean ± SE) values of serum globulin (g/dl) in Group-I, II, III and Group-IV were 3.79±0.16, 4.08±0.24, 3.85±0.09 and 3.10±0.35, respectively and post-treatment (Mean ± SE) values of globulin (g/dl) in Group-I, II, III and Group-IV were 3.48±0.21, 3.37±0.28, 3.61±0.09 and 3.56±0.31, respectively (Table 2). There was non significant difference were found in the post-treatment mean values of serum globulin in the treated Groups-I and II as compared to their pre-treatment values and also with the mean values of globulin of Group-IV apparently healthy dogs whereas, the post-treatment mean values of globulin of the Groups-I and II were significantly differ with mean values of globulin of the obese dogs of Group-III on 60th day.

Table 3: Pre and post-treatment mean ± SE values of Globulin (g/dl) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No	Group	Pre-treatment	Post-Treatment
1.	Group-I	3.79±0.16^{bA}	3.48±0.21^{aA}
2.	Group-II	4.08±0.24^{bA}	3.37±0.28^{aA}
3.	Group-III	3.85±0.09^{bA}	3.61 ±0.09^{bA}
4.	Group-IV	3.10±0.35^{aA}	3.56±0.31^{aA}

Means having different superscript in a row (A, B) differ significantly (p<0.05) and means having different superscript in a column (a, b) differ significantly (p<0.05)

The findings of present study is in accordance with Yamka *et al.* (2006) [56] who reported a significant decrease in total protein, albumin and non-significant difference in serum globulin value when fed Prescription Diet® r/d® dry or canned for 90 days during weight loss study in dogs. Diez *et al*. (2002) and De Marchi *et al.* (2018) [10, 8] who also found significantly decrease in serum total protein value after weight reduction.

3.10 Alanine aminotransferase (ALT)
Pre-treatment (Mean ± SE) values of ALT (IU/L) in Group-I, II, III and Group-IV were 73.42±7.86, 73.50±8.82, 70.34±8.33 and 54.67±5.29, respectively and post-treatment (Mean ± SE) values of ALT (IU/L) in Group-I, II, III and Group-IV were 56.82±5.98, 58.12±5.04, 71.27±8.78 and 57.18±5.25, respectively (Table 4). The post-treatment mean values of ALT in Group-I and Group-II dogs were decrease significantly (p<0.05) as compare to pre-treatment mean value of corresponding groups and also with the mean value of Group-III on 60th day. The post-treatment mean values of ALT of the Groups-I and II were non-significantly differ with mean values of ALT of the apparently healthy dogs of Group-IV on 60th day.

Table 4: Pre and post-treatment mean ± SE values of ALT (IU/L) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No	Group	Pre-treatment	Post-Treatment
1.	Group-I	73.42±7.86^{bA}	56.82±5.98^{aB}
2.	Group-II	73.50±8.82^{bA}	58.12±5.04^{aB}
3.	Group-III	70.34±8.33^{bA}	71.27±8.78^{bA}
4.	Group-IV	54.67±5.29^{aA}	57.18±5.25^{aA}

Means having different superscript in a row (A, B) differ significantly ($p<0.05$) and means having different superscript in a column (a, b) differ significantly ($p<0.05$)

Similar finding was also noted by Yamka *et al*. (2006) [56] who also found lower value of ALT during weight reduction program by using high fibre and high protein diet in dogs.

3.11 Aspartate aminotransferase (AST)
Pre-treatment (Mean ± SE) values of AST (IU/L) in Group-I, II, III and Group-IV were 27.64±2.14, 26.82±2.10, 27.10±2.08 and 25.44±3.28, respectively and post-treatment (Mean ± SE) values of AST (IU/L) in Group-I, II, III and Group-IV were 27.00±1.27, 26.90±1.75, 27.02±1.41 and 24.83±2.48, respectively. There was non-significant difference were found in the post-treatment mean values of AST in the treated Groups-I and II as compared to their pre-treatment values and similarly the post-treatment mean values of AST of the Groups-I and II were differ non-significantly as compared to mean value of Group-III and apparently healthy dogs of Group-IV on 60th day.

3.12 Alkaline phosphatase (ALP)
Pre-treatment (Mean ± SE) values of ALP (IU/L) in Group-I, II, III and Group-IV were 126.00±17.96, 127.50±17.79, 127.33±18.10 and 70.84±2.44, respectively and post-treatment (Mean ± SE) values of ALP (IU/L) in Group-I, II, III and Group-IV were 108.41±16.64, 108.33±14.64, 122.27±19.88 and 72.50±0.89, respectively (Table 5). The post-treatment mean values of ALP in Group-I and Group-II dogs were decrease significantly ($p<0.05$) as compare to pre-treatment mean value of same groups and also with the mean values of Group-III on 60th day. The post-treatment mean values of ALP of the Groups-I and II were non-significantly differ with mean values of ALP of the apparently healthy dogs of Group-IV on 60th day.

Table 5: Pre and post-treatment mean ± SE values of ALP (IU/L) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No	Group	Pre-treatment	Post-Treatment
1.	Group-I	126.00±17.96^{bA}	108.42±16.64^{aB}
2.	Group-II	127.50±17.79^{bA}	108.33±14.64^{aB}
3.	Group-III	127.34±18.10^{bA}	122.27±19.88^{bA}
4.	Group-IV	70.84±2.44^{aA}	72.50±0.89^{aA}

Means having different superscript in a row (A, B) differ significantly ($p<0.05$) and means having different superscript in a column (a, b) differ significantly ($p<0.05$)

The present findings are in agreement with Kutsunai *et al*. (2014) [30] and De Marchi *et al*. (2018) [8] who also found significantly lower values of ALP after weight reduction with calorie restriction diet and contrary to Yamka *et al*. (2006) [56] who also reported non-significant decrease values of ALP during weight reduction program by using high fibre and high protein diet.

3.13 Blood urea nitrogen
Pre-treatment (Mean ± SE) values of BUN (mg/dl) in Group-I, II, III and Group-IV were 15.19±1.03, 15.64±1.32, 14.82±1.21 and 14.72±1.18, respectively and post-treatment (Mean ± SE) values of BUN (mg/dl) in Group-I, II, III and Group-IV were 15.25±0.95, 15.72±1.02, 15.07±1.20 and 14.97±0.96, respectively. There was non significant difference were found in the post-treatment mean values of BUN in the treated Groups-I and II as compared to their pre-treatment values and similarly the post-treatment mean values of BUN of the Groups-I and II were differ non-significantly as compared to mean values of group-III and apparently healthy dogs of Group-IV on 0th and 60th days.

3.14 Creatinine
Pre-treatment (Mean ± SE) values of serum Creatinine (mg/dl) in Group-I, II, III and Group-IV were 0.98±0.17, 0.96±0.12, 0.97±0.05 and 0.90±0.08, respectively and post-treatment (Mean ± SE) values of creatinine (mg/dl) in Group-I, II, III and Group-IV were 0.98±0.14, 0.99±0.07, 1.04±0.06 and 1.02±0.02, respectively. There was non significant difference were found in the post-treatment mean values of creatinine in the treated Groups-I and II as compared to their pre-treatment values and similarly the post-treatment mean values of creatinine of the Groups-I and II were differ non significantly as compared to mean values of Group-III and apparently healthy dogs of group-IV on 0th and 60th days. The present findings are agreement with Yamka *et al.* (2006),[56] Diez *et al*. (2002) [10] and De Marchi *et al*. (2018) [8] who also found no significant difference in BUN and creatinine value after weight reduction program by using high fibre and high protein diet.

3.15 Total Cholesterol
Pre-treatment (Mean ± SE) values of total cholesterol (mg/dl) in Group-I, II, III and Group-IV were 287.50±18.02, 285.00±16.08, 283.50±16.54 and 158.04±22.02, respectively and post-treatment (Mean ± SE) values of total cholesterol (mg/dl) in Group-I, II, III and Group-IV were 229.83±12.60, 220.83±5.69, 285.30±16.63 and 158.37±21.69, respectively (Table 6). The post-treatment mean values of total cholesterol in Group-I and Group-II dogs were decrease significantly ($p<0.05$) as compare to pre-treatment mean value of their respective groups and also with the mean value of Group-III on 60th day. The post-treatment mean values of total cholesterol of the treated Groups-I and II were still significantly higher with mean values of total cholesterol on 60th day of the apparently healthy dogs of Group-IV.

Table 6: Pre and post-treatment mean ± SE values of Total Cholesterol (mg/dl) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No	Group	Pre-treatment	Post-Treatment
1.	Group-I	287.50 ± 18.02^{bA}	229.83 ± 12.60^{cB}
2.	Group-II	285.00 ± 16.08^{bA}	220.83 ± 5.69^{cB}
3.	Group-III	283.50 ± 16.54^{bA}	285.30 ± 16.63^{bA}
4.	Group-IV	158.04 ± 22.02^{aA}	158.37 ± 21.69^{aA}

Means having different superscript in a row (A, B) differ significantly (p<0.05) and means having different superscript in a column (a, b, c) differ significantly (p<0.05)

3.16 Total triglyceride

Pre-treatment (Mean ± SE) values of total triglyceride (mg/dl) in Group-I, II, III and Group-IV were 142.50±12.57, 142.34±11.08, 140.67±11.13 and 91.80±8.38, respectively and post-treatment (Mean ± SE) values of total triglyceride (mg/dl) in Group-I, II, III and Group-IV were 107.62±9.85, 111.50±8.84, 140.52±11.14 and 91.75±8.43, respectively (Table 7). The post-treatment mean values of total triglyceride in Group-I and Group-II dogs were decrease significantly (p<0.05) as compared to pre-treatment mean value of corresponding groups and also with the mean value of Group-III on 60th day. The post-treatment mean values of total triglyceride of the treated Groups-I and II were still significantly differ with mean values of total triglyceride on 60th day of the apparently healthy dogs of Group-IV.

Table 7: Pre and post-treatment mean ± SE values of total triglyceride (mg/dl) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No	Group	Pre-treatment	Post-Treatment
1.	Group-I	142.50 ± 12.57^{bA}	107.62 ± 9.85^{cB}
2.	Group-II	142.34 ± 11.08^{bA}	111.50 ± 8.84^{cB}
3.	Group-III	140.67 ± 11.13^{bA}	140.52 ± 11.14^{bA}
4.	Group-IV	91.80 ± 8.38^{aA}	91.75 ± 8.43^{aA}

Means having different superscript in a row (A, B) differ significantly (p<0.05) and means having different superscript in a column (a, b,c) differ significantly (p<0.05)

3.17 High density lipoprotein cholesterol (HDL-C)

Pre-treatment (Mean ± SE) values of HDL-C (mg/dl) in Group-I, II, III and Group-IV were 120±11.03, 124.34±12.26, 123.5±10.53 and 91.17±8.25, respectively and post-treatment (Mean ± SE) values of HDL-C (mg/dl) in Group-I, II, III and Group-IV were 102.33±8.65, 106.00±8.41, 133.50±7.25 and 95.00±5.53, respectively (Table 8). The post-treatment mean values of HDL-C in Group-I and Group-II dogs were decrease significantly (p<0.05) as compare to pre-treatment mean value of corresponding groups and also with the mean value of Group-III on 60thday.The post-treatment mean values of HDL-C of the Groups-I and II were non-significantly higher (p<0.05) with mean values of HDL-C of the apparently healthy dogs of Group-IV on 60th day.

Table 8: Pre- and post-treatment mean ± SE values of HDL-C (mg/dl) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No.	Group	Pre-treatment	Post-Treatment
1.	Group-I	120.00 ± 11.03^{bA}	102.33 ± 8.65^{aB}
2.	Group-II	124.34 ± 12.26^{bA}	106.00 ± 8.41^{aB}
3.	Group-III	123.50 ± 10.53^{bA}	133.50 ± 7.25^{bA}
4.	Group-IV	91.17 ± 8.25^{aA}	95.00 ± 5.53^{aA}

Means having different superscript in a row (A, B) differ significantly (p<0.05) and means having different superscript in a column (a, b) differ significantly (p<0.05)

3.18 Low density lipoprotein cholesterol (LDL-C)

Pre-treatment (Mean ± SE) values of LDL-C (mg/dl) in Group-I, II, III and Group-IV were 139.00±14.41, 132.20±21.31, 131.86±23.12 and 48.50±15.53, respectively and post-treatment (Mean ± SE) values of LDL-C (mg/dl) in Group-I, II, III and Group-IV were 105.97±12.00, 97.53±13.74, 123.69±17.97 and 45.01±17.44, respectively (Table 9). The post-treatment mean values of LDL-C in Group-I and Group-II dogs were decrease significantly (p<0.05) as compare to pre-treatment mean value of their respective groups and also with the mean value of Group-III on 60th days. The post-treatment mean values of LDL-C of the Groups-I and II were still significantly higher (p<0.05) with mean values of LDL-C on 60th day of the apparently healthy dogs of Group-IV.

Table 9: Pre- and post-treatment mean ± SE values of LDL-C (mg/dl) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No.	Group	Pre-treatment	Post-Treatment
1.	Group-I	139.00 ± 14.41^{bA}	105.97 ± 12.00^{CB}
2.	Group-II	132.20 ± 21.31^{bA}	97.53 ± 13.74^{cB}
3.	Group-III	131.86 ± 23.12^{bA}	123.69 ± 17.97^{bA}
4.	Group-IV	48.50 ± 15.53^{aA}	45.01 ± 17.44^{aA}

Means having different superscript in a row (A, B) differ significantly (p<0.05) and means having different superscript in a column (a, b, c) differ significantly (p<0.05)

3.19 Very low-density lipoprotein cholesterol (VLDL-C)

Pre-treatment (Mean ± SE) values of VLDL-C (mg/dl) in Group-I, II, III and Group-IV were 28.50±2.51, 28.47±2.22, 28.14±2.23 and 18.36±1.68, respectively and post-treatment (Mean ± SE) values of VLDL-C (mg/dl) in Group-I, II, III and Group-IV were 21.52±1.97, 22.30±1.76, 28.10±2.23 and 18.35±1.69, respectively (Table 10). The post-treatment mean values of VLDL-C in Group-I and Group-II dogs were decrease non significantly ($p<0.05$) as compare to pre-treatment mean value of their respective groups and also with mean value of Group-III and Group-IV on 60th days. In the present investigation there was significant decrease in the post-treatment mean values of total cholesterol, total triglycerides, HDL-C and VLD-C in Group-I as compared to their pre-treatment values. These findings are in confirmatory with findings of Hayamizu *et al*. (2003),[18] Satio *et al*. (2005) [45] Semwal *et al*. (2015) [47] and Raina *et al*. (2016) [40] who also reported significant reduction in these parameters when obese dogs were fed extracts as well as hydroxy citric acid (HCA), an active component of the fruit rind of *Garcinia cambogia* feed supplement during weight reduction studies.

Table 10: Pre and post-treatment mean ± SE values of VLDL-C (mg/dl) of dogs of obese groups (G-I, G-II and G-III) and apparently healthy dogs (G-IV)

S. No	Group	Pre-treatment	Post-Treatment
1.	Group-I	28.50±2.51[bA]	21.52±1.97[abA]
2.	Group-II	28.47±2.22[bA]	22.30±1.76[abA]
3.	Group-III	28.14±2.23[bA]	28.10±2.23[bA]
4.	Group-IV	18.36±1.68[aA]	18.35±1.69[aA]

Means having different superscript in a row (A, B) differ significantly ($p<0.05$) and means having different superscript in a column (a, b) differ significantly ($p<0.05$)

The possible reason for significant improvement in group-I with *Garcinia cambogia* is due to its active component hydroxy citric acid (HCA). Hydroxycitric acid (HCA) is a competitive inhibitor of adenosine triphosphate-citrate lyase, the enzyme that catalyzes the extra mitochondrial cleavage of citrate to oxaloacetate and acetyl-coenzyme A thus limiting the availability of two carbon units required for fatty acid and cholesterol biosynthesis and suppresses de novo fatty acid synthesis. (Jena *et al*., 2002; Hayamizu *et al*., 2003; Semwal *et al*., 2015; Raina *et al*., 2016) [25, 18, 47, 40].

In the present study there was significant decrease in the post-treatment mean values of total cholesterol, total triglycerides, HDL-C and VLD-C in group-II as compared to their pre-treatment values. Similar findings were also observed by Diez *et al*. (2004), Yamaka *et al*. (2006), Bouthegourd *et al*. (2009) Diez *et al*. (2002) and De Marchi *et al*. (2018) [9,56,3,10,8] in obese dogs when fed high fiber diet during weight reduction programme. Yamaka *et al*. (2006) [56] have also reported the use of a diet rich in fibre is suitable for performing effective and safe weight loss program and during the study obese dogs showed a significant reduction in glucose, cholesterolemia, serum alkaline phosphatase. The crude extract or constituents of fruit rind of *Garcinia cambogia* also exerted hypolipidemic, antidiabetic, anti-inflammatory, anticancer, anthelmintic, anticholinesterase and hepatoprotective activities *in vitro* and *in vivo* models (Semwal *et al*., 2015) [47].

4. Conclusions

The present study was conducted to evaluate haemato-biochemical changes and therapeutic response of dietary intervention in dogs suffering with obesity. Evaluation of therapeutic response of dietary interventions on obesity was estimated on the basis of reduction in initial body weight, and improvement in haemato-biochemical parameters of the obese dogs after treatment. Greater rate of reduction in body weight was observed in low fat and high fiber diet in comparison to natural enzyme-based feed supplements, along with significant reduction in glucose, total protein, albumin, ALT, ALP, total cholesterol, total triglycerides, HDL-C and LDL-C in both the groups. It is concluded that dietary intervention used in Group-II was better as comparison to Group-I and needed more time to achieved desired or ideal body weight of breed in obese dogs.

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