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Relevance of probiotic, prebiotic and synbiotic supplementations on hemato-biochemical parameters, metabolic hormones, biometric measurements and carcass characteristics of sub-tropical Noemi lambs

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ABSTRACT

The effects of probiotic, prebiotic and synbiotic preparations on hemato-biochemical parameters, metabolic hormones, biometric measurements and carcass characteristics of growing lambs were studied. Twenty four growing Noemi male lambs were randomly allocated into 4 groups (n=6/group) in a complete randomized design and blocked according to their initial weights. Lambs in the first group were orally given 50 ml of physiological saline (0.9% NaCl) and served as control (CON), while lambs in other three groups were orally given 50 ml of aqueous dandelion extract (PRE) or fermented cow's milk supplemented with lactic acid bacteria (PRO) or their mixture (1:1, SYN) every other day for 8 consecutive weeks. The results indicated that treatment had no effects on hematological parameters, except leukocytes number which was elevated ($P<0.05$) in all treated lambs compared to CON-lambs. Treatments had no effect on blood serum cholesterol, whereas treatment with PRO and SYN increased ($P<0.05$) blood serum glucose. Blood serum insulin and IGF-I concentrations were higher ($P<0.05$) in lambs given SYN than lambs in other groups. Different supplementations improved ($P<0.05$) finishing weight of lamb compared to control. There were no significant differences in carcass weight and dressing percentage among treatments. Values of most carcass measurements were not affected by treatment except a significant

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increase in chest depth in all supplemented lambs compared to control. Regarding to eye muscle area, as an indicator of tissue growth, there was a tendency of increase in the carcass of PRO and SYN lambs as compared to those of PRE and CON-lambs. Most offal weights were not affected by treatment, however a significant increase in weight of digestive tract was observed for PRO-group compared with CON, but other treatments did not show a significant effect. Yield of commercial cuts was not affected by treatment except for breast and loin cuts. The heaviest breast weight was found in carcass of lambs given PRO ($P<0.05$) and the heaviest weight of loin cut was in favor of those given SYN. The meat in carcass of control and PRE was lower than that of PRO and SYN with no significant differences. In conclusion, supplementing probiotics fermented cow's milk to growing lambs improves their metabolic status and thus growth efficiency without a significant change in their carcass traits.

Keywords: Sheep, dandelion extract, lactobacillus bacteria, synbiotic, metabolism, carcass, hematology.

1. Introduction

In tropical and sub-tropical zones, scarcity of good feed sources and harsh environmental conditions, particularly high ambient temperature and humidity are the major constraining cues for optimal animal productivity (Hashem et al., 2016). These environmental factors coupling with metabolic heat production create difficulties in maintaining thermal balance resulting in an elevated body temperature, which in turn initiate compensatory and adaptive mechanisms to re-establish homeothermy and homeostasis. These include behavioral and physiological changes

such as depression in feed intake and utilization and disturbances in metabolism, mineral balances, enzymatic reactions and hormonal secretions, thus negatively affecting animal performance (Marai et al., 2007).

Under field scale, nutritional management presents an efficient, less costive, applicable measure for alleviating heat stress effects. Feed additives including prebiotics, probiotics and synbiotics are widely believed to improve productive and reproductive performances of different farm animals (Zeitoun et al., 2014).

Prebiotics are non-digestible substances that provide a beneficial physiological effect on the host by optimizing the eubiosis, improving the digestion capacity and increasing the healthy status of animal (Wenk, 2003). Dandelion or Chicory (*Taraxacum spp.*) is used in many traditional and modern herbal medical systems, as particularly has been documented in Asia, Europe, and North America. It is used as a source of soluble fibers (prebiotic). The major soluble fiber found abundantly in dandelion is inulin, a fructo-oligosaccharides (FOS), in addition to substantial amounts of sucrose, cellulose, protein and ash (Wilson et al., 2004). In ruminants, inulin supplementation has been reported to improve synthesis of microbial protein, maintain rumen pH and improve intestinal fermentation leading to an increase in body weight gain (Samanta et al., 2013).

Probiotics are naturally occurring live microbes (bacteria or yeast). These microorganisms can compete with the pathogenic microbes and improve nutrient utilization due to their positive influence on gut microflora. Addition of probiotics in the lamb's diet has been reported to improve feed utilization and growth performance of the animals. These may be through different modes of action; i.e. they might work synergistically with the ruminal microbes, or they increase the growth of cellulolytic bacteria or nitrogen flow towards lower digestive tract (Khalid et al., 2011). Of probiotics, lactobacillus bacteria are commonly used as useful bacteria for producing

fermented milk products for human consumption and are also included in many commercial feed additive products for animal use (Anon, 2004).

A mixture of probiotics and prebiotics as a single product is called synbiotics. It is a form of synergism that improves and optimizes the nutrient digestion and absorption. Results on *in vivo* trials are promising, showing a synergistic effect coupling probiotics and prebiotics in the reduction of food-borne pathogenic bacterial populations (Bomba *et al.*, 2002). Recent research in animal production promoted the supplementation of combined prebiotics with probiotics to male and female ruminants (Abdel Salam *et al.*, 2014; Zeitoun *et al.*, 2014). Considering the above-mentioned observations, the present work attempted to investigate the impact of a common herb, dandelion aqueous extract as a source of prebiotic, *Lactobacillus* bacteria in fermented cow's milk as a probiotic and their combination on hemato-biochemical parameters, biometric measurements, finishing weight, and carcass characteristics of fattening *Noemi* lambs under tropical conditions.

2. Materials and methods

2.1. Animals and management

This experiment was carried out during the period of September, 2012 till February, 2013. Twenty four *Noemi* growing male lambs, 4-5 month of age, weighing 29.89 ± 1.12 kg were used. Animals were housed in semi-shaded yards at Qassim University Experimental Farm. Animals were fed alfalfa hay and barley at the recommended requirement according to NRC (2007). All animals were equally divided into 4 experimental groups, group 1 (CON) animals were considered as control in which each lamb was orally given 50 ml physiological saline (0.9% NaCl), group 2 (PRE) animals were orally given an aqueous extract of dandelion leaves and roots (6%) at a dose of 50 ml, group 3 (PRO) animals were orally given 50 ml of probiotic fermented cow's milk enriched with lactic acid bacteria and group 4 (SYN) animals

were orally given a mixture of PRE and PRO (1:1). The treatment was applied every other day for 8 consecutive weeks.

2.2. Feed additives preparation

2.2.1. Dandelion aqueous extract (prebiotic)

Dried dandelion (*Taraxacum officinalis*) leaves and roots were purchased from local market. Aqueous extract of dandelion containing prebiotic ingredients (prebiotic extract) has been carried out using a method described by Melendez and Caprilesa (2006). The plant material was pulverized in a grinder. Sixty grams of the pulverized material have been dissolved and extracted with 1000 ml hot distilled water in an electric blender which left running for 15 min. Afterwards, the suspension was left at room temperature for 1 hour, then filtered twice, first through cheese-cloth (50% cotton:50% polyester) and then through filter paper (Whatman No.2, Cam. lab., Cambridge, UK). The clear aqueous extract was kept frozen (-20°C) in sterile dark bottles (500 ml) until further use.

2.2.2. Probiotic fermented cow's milk

Preparation of probiotic fermented milk was carried out according the methods of traditional fermented manufacturing described by Tamime and Robinson (1999). Fresh cow's milk have been standardized to achieve about 12% total solid content, and then heated at 85°C for 15 min, cooled to 40°C , inoculated with probiotic bacteria (2%, $\sim 1 \times 10^{10}$) and then incubated for 4-8 h at 42°C . After coagulation, the curd has been tested for pH, then stirred in an electric blender and stored refrigerated (5°C).

2.2.3. Synbiotic preparation

Synbiotic syrup was prepared by combining equal volumes (1v:1v) of probiotic fermented milk with aqueous extract of dandelion.

2.3. Blood sampling and analyses

Two blood samples were collected via a jugular venipuncture in sterile tubes once per week before feeding, one sample was collected in a heparin-containing tube for blood hematological

parameters and the second was collected in plain tube for serum separation. Blood for serum was centrifuged (3000 rpm/10 min/5°C) and sera were harvested and deep frozen (-20°C) until assayed. Hematological parameters including red blood cells count (RBCs), hemoglobin (Hb), packed corpuscular volume (PCV) and white blood cells count (WBCs) were determined according to Feldman et al. (2000). Concentrations of blood serum glucose and cholesterol were determined according to Barham and Trinder (1972) and Gordon *et al.* (1977), respectively. Insulin in blood serum was quantified by a commercial ELISA kit (Biot Blue Gene, China) while insulin-like growth factor-1 (IGF-I) was measured by a commercial ELISA Kit (Cusabio, USA).

2.4. Live weight and biometric measurements

Body weight of each lamb was recorded weekly during the period of supplementation (8 consecutive weeks). At the finishing period, the live body weight (finishing weight) and the biometric measurements were obtained the day before the slaughter including height at withers (HW), body length (BL), pelvic length (PL), chest depth (CD), chest width (CW), chest circumference (CC), rump height (RH) and tibia length (TL).

2.5. Evaluation of carcass traits

Lambs were slaughtered (to complete bleeding) according to Islamic rules. At slaughter, weights of viscera, carcass, subcutaneous fat, abdominal fat and tail fat and offals were recorded. Also, carcass length, leg length, heart girth, chest depth (CD), chest width (CW) and chest circumference (CC) were recorded. The carcasses were chilled at 1 °C during 24 h; then, the left half of the carcass was completely dissected into two parts including forequarters and hindquarters. The forequarters were cut into four joints including neck, breast, hotel rack and shoulders. The hindquarters were also cut into leg, loin and flank. The different joints were weighed separately with bone and after deboning.

2.6. Statistical analysis

Data of hematological parameters and hormonal profile were analyzed using two way ANOVA of the general linear model (PROC GLM of SAS 2001). The fixed model included treatment, week and their interaction as main factors. Results of biometric measurements and carcass traits were analyzed using one way ANOVA of GLM procedure. Duncan Multiple Range Test (DMRT) was performed to determine differences among means, at 5% significant level (Steel and Torrie, 1980). All results were expressed as mean \pm standard error. The differences between treatment means were considered significant at $P < 0.05$.

3. Results

3.1. Effects of treatment on hemato-biochemical traits and metabolic hormones

Table 1 illustrates mean values of hemato-biochemical parameters after treatment with prebiotic, probiotic or symbiotic. There was no obvious effect ($P > 0.50$) due to treatments on the RBCs, hemoglobin levels and hematocrit value. However, numbers of WBCs were increased in the treatment groups compared to control. The mean values of cholesterol did not differ among the treatment groups. On the contrary, blood serum glucose levels were increased ($P < 0.05$) in the PRO-group and SYN-group than the CON-group, while it was intermediate in the PRE-group. Blood serum insulin tended to elevate in the PRE and PRO-groups with non-significant differences compared to control. However, lambs given SYN had higher ($P < 0.05$) blood insulin and IGF-I compared to other groups.

3.2. Effects of treatment on finishing weight and biometric measurements

Effects of treatment on finishing weight and biometric measurements are presented in Table 2. Lambs given PRE, PRO and SYN supplementations had heavier ($P < 0.05$) finishing weight compared to control. There were no

significant differences in biometric measurements between treatment groups and control. Even though, there appeared a tendency of increase in pelvic length, chest depth and body length in treated than control lambs.

3.3. Effects of treatment on carcass traits

There were no significant differences in carcass weight and dressing percentage between all treatments (Table 3). Values of most carcass measurements were not affected by treatment except a significant increase in chest depth in all treated lambs compared to control (Table 3). With respect to eye muscle area which is considered as an indicator of tissue growth, there was a numerical increase in the area in carcasses of lambs orally given PRO or SYN than those of PRE and CON lambs. Most offal weights were not affected by treatment, however treatment with PRE and SYN decreased ($P<0.05$) weight of lamb skin compared to control, while PRO showed intermediate value. Compared to control, a significant increase in weight of digestive tract was observed in PRO lambs, but other treatments did not show a significant effect.

Results of wholesale cuts yield are presented in Table 4. Yield of commercial cuts was not affected by treatment except for breast and loin cuts. The heaviest breast weight was found in carcasses of lambs given PRO ($P<0.05$) and the heaviest weight of lion cut was in favor of those given SYN. The total meat in carcasses of control and PRE was lower than that of PRO and SYN with no significant differences.

4. Discussion

4.1. Treatment effects on the hemato-biochemical parameters

Blood analysis gives the opportunity to investigate the presence of several metabolites and other constituents and helps detect conditions of stress, which can be nutritional, environmental or physical (Afolabi *et al.*, 2010).

In the current study, levels of RBCs, hemoglobin (Hb) and hematocrit value (PCV) were not different among treatments. This indicates the homeostatic impact of these treatments on the treated animals. Scarcity of research on the effects of prebiotic fibers, probiotic and their mixture on hematological traits of animals is a challenging point for explanation of such results.

A study on pigs indicated that supplementing growing pigs with fluvic acid, probiotic or their combination didn't alter RBCs count and Hb concentration than control (Kunavue and Lien, 2012). On the other hand, Sarwar *et al.* (2011) reported that supplementing *Kajli* lambs with probiotics increased Hb, PCV and RBCs than control. Consistent to the previous study, Hussein (2014) found positive effects of probiotic supplementation on weaned *Najdi* lamb's hematological traits. The differences in the microorganisms of the probiotics and their ingredients might constitute the limiting factor of the probiotic. Results of the present study show that supplementing prebiotic, probiotic and synbiotic elevated number of WBCS. This finding matches with that obtained by Attia *et al.* (2014) who reported that inulin (prebiotic) administration to rabbit diets increased hyperplasia of spleen white pulp indicating an increase in lymphopioesis which lead to increase in cellular immunity (lymphocyte). Also, probiotics have been found to enhance immunity (Aattouri *et al.*, 2001) by promoting the antibodies, IgA, and cytokines production (Trebichavsky and Splichal, 2006).

Unlike what was expected that dandelion reduces blood cholesterol, lambs given dandelion extract had similar cholesterol as that found in control. This unexpected response of dandelion on blood cholesterol might be attributed to the daily dose given which might be below the physiological dose required for ruminants. The lamb ruminal ecology might have detrimental effects on the dandelion ingredients. The sole study that revealed a hypocholestermic effects was found in rabbits (Choi *et al.*, 2010).

fed a high-cholesterol diet, not to normal rabbits at 1% (w/w) of the diet. This supplement to the rabbit diet is far above what we applied in the current research study (0.003%) as far as grams dandelion per Kg body weight. Above that, we must take into account the differences of the mechanism of dandelion function in the digestive tract between monogastrics (rabbits) and ruminants (growing lambs). Also, the effects of various parts of the plant can't be neglected, since Grela *et al.* (2014) found that dandelion root extract was more potent in reducing blood lipids than plant leaves when supplemented to fattener pigs. Likewise, probiotic and synbiotic didn't decrease blood cholesterol in the current study. Similarly, Hillal *et al.* (2011) found no significant change due to probiotic supplementation to growing lambs on the blood metabolites (i.e. cholesterol, total protein, albumin, AST and ALT). Parallel to this, in their study on yearling lambs, Abas *et al.* (2007) didn't obtain a change in blood cholesterol due to supplementing diet with a microbial mixture.

Blood glucose levels were only higher by about 13% in lambs received probiotic or synbiotic than in control. Mukhtar *et al.* (2010) showed similar finding in growing lambs fed on concentrate with or without ionophores and probiotics. The higher glucose levels in probiotic-supplemented lambs might be ascribed to the enhancement of gluconeogenesis due to the increased propionate concentration or due to the action of *Lactobacillus plantarum* which splits certain carbohydrates into simpler substances like glucose, resulting in a maintenance of glucose level in the circulating blood and providing energy required for growth (Khalid *et al.*, 2011). Furthermore, it has been found that serum glucose was quite high in yeast-based diets in ruminants (Abou El-Nor and Kholif, 1998).

4.2. Treatment effects on metabolic hormones

Administration of prebiotic and probiotic tended to elevate blood insulin with non-significant

differences than control. However, lambs given synbiotic gave higher ($P<0.05$) blood insulin exceeding the control by about 27 %. Dandelion extract or probiotic alone revealed no significant effect on pancreatic islets of Langerhans, however combining dandelion extract with probiotic might enhance the efficiency of lactic acid bacteria leading to better insulin secretion. In the current study, synbiotic treatment not only increased insulin secretion (+ 27 %) but it also raised blood glucose level (+15.5 %) than control. The anabolic effects of synbiotic confirm the point of the necessity of fructooligosaccharides (FOS) existing in dandelion for the integrity of the bacterial wall in the coexisting probiotic which enhance the gut immunity and host health (Schley and Field, 2002). In monogastrics (i.e., mice, rats and rabbits) dandelion was reported to lower blood glucose (hypoglycemic), however in ruminants (i.e. lambs) this phenomenon was opposite. Rumen fermentation and ruminal ecology might change the natural structures of the active ingredients of dandelion. Abo El-Nor and Kholif (1998) reported higher blood glucose concentration in cows fed diets containing probiotic. The parallel increases of insulin and glucose in peripheral blood concurrently with the increase of body weight in synbiotic-fed lambs might confirm that this combination of pre- and probiotic enhanced the efficiency of lactic acid bacteria during its passage through rumen area. In a relatively recent study by French researchers a modulation in the intestinal microbiota and some metabolic parameters including increased blood insulin was found as a consequence to the supplementation of the short-chain FOS (Respondek *et al.*, 2013).

Only synbiotic supplementation increased ($P<0.05$) IGF-I by about 35% compared to control. There is an evidence that the FOS improves the secretion of growth factors like IGF-I (Saleh *et al.*, 2014), this was clear in broilers. On the other hand, dandelion FOS didn't show similar enhancement on IGF-I in lambs, however combining the dandelion with

probiotic revealed an increase of IGF-I by about 35% in lambs given synbiotic. Again, this finding could shed some light on the integrative roles that could be played by these prebiotic fibers on the stimulation of lactic acid bacteria to pass the fermentation processes of the lamb rumen and improve the metabolic absorption in the small intestine (self-explanation).

4.3. Treatment effects on finishing weight and biometric measurements

In the current study, supplemented lambs had higher finishing weights than control. This enhancement in prebiotic and probiotic-supplemented lambs may be related to the increased digestive system weight and thus improved nutrients absorption. In synbiotic group this enhancement in finishing weight may be ascribed to the anabolic effect of metabolic hormones as both insulin and IGF-I were improved in this group. In this context, Gadekar *et al.*, (2014) illustrated that the higher pre-slaughter weight of lambs fed diet supplemented with probiotic may be due to an increase of microbial protein synthesis.

The lambs supplemented with probiotic had higher pelvic length, wither height and body length (non-significant). Results of Alessawi and Al-Wazeer (2011) on Awassi lambs, showed that there were increases in chest, hip girth and length of body in lambs given probiotics and black seeds compared with control lambs. The same trend was observed on calves where Chandra *et al.* (2009) found that probiotic supplementation resulted in an increase in withers height as compared with control calves. Also, Noori *et al.* (2016) reported that there were increases in Holstein calves body length, wither height and hip depth when partial substitution of milk by yogurt and they attributed their results to an increase in mineral bioavailability.

4.4. Treatment effects on carcass traits

Most of carcass traits determined in this study were not affected by the treatments. Similarly, Dobiri *et al.* (2016) reported that all carcass traits were not affected by probiotic levels. Also,

Issakowicz *et al.* (2013) found that addition of live yeast to diet of Texel lambs reduced dressing percentage and they stated that this reduction may be due to the enlargement of the digestive tract as a result of increasing dry matter intake. The present results are in agreement with those of Whitley *et al.* (2009) and Gadekar *et al.* (2014) who found that supplementation of probiotic or lactate-producing bacteria did not influence cut weights in goats and sheep, respectively. In their study on goats, Yusuf *et al.* (2014) reported that there were significant differences in the viscera (rumen and intestines) as consequences of the supplementation with leaves or whole plant of *Andrographis paniculata* and they pointed out their results as a reflection of pathway nutrients to internal visceral development rather than building of muscles. The present results are in accordance with results of Issakowicz *et al.* (2013) who pointed out that there were higher correlations between carcass weight and widths and girth measurements. In addition, Gadekar *et al.* (2014) found that no difference in carcass length, width and depth of lambs fed diet supplemented with probiotic and that of control lambs.

5. Conclusion

The usefulness of utilizing probiotics, prebiotics and synbiotics in ruminants is a promising field of research. The combination of dandelion extract with cow's fermented milk could be of beneficial importance for young lambs exerting stimulatory effects on metabolic hormones and health wellbeing. However, caution must be taken into account when using such compounds in ruminants, as their mechanisms completely differ than in monogastrics on carcass characteristics.

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Table 1 Effect of prebiotic, probiotic and synbiotic supplementations on hemato-biochemical parameters of *Noemi* lambs

Parameter	Treatment			
	Control	Prebiotic	Probiotic	Synbiotic
Hematological parameters				
RBCs (10 ⁶ / mm ³)	8.08±0.9	7.97±0.7	8.33±0.6	8.39±0.7
Hb (g/dl)	10.13±1.1	10.04±1.3	12.5±1.4	10.39±2.1
PCV (%)	25.43±2.3	24.71±2.1	25.49±1.9	25.78±1.8
Total leukocytes	9.82±0.8 ^c	12.35±0.7 ^a	11.32±0.8 ^b	11.77±0.6 ^{ab}
Bio-chemical parameters				
Glucose, mg/dl	66.00±2.64 ^b	70.62±3.22 ^{ab}	73.62±	76.14±
Cholesterol, mg/dl	56.76±2.02	57.00± 2.65	57.62± 2.32	59.33 ±2.48
Insulin, ng/ml	10.53±1.22 ^b	12.95± 1.78 ^b	12.44±2.22 ^b	13.42±2.02 ^a
IGF-I, ng/ml	8.04± 1.96 ^b	7.62± 1.71 ^b	7.23±2.42 ^b	10.80±3.72 ^a

Means in the same row with different superscripts significantly differ (P<0.05).

RBCs: red blood cells count, Hb: hemoglobin, PCV: packed corpuscular volume.

Table 2: Effect of prebiotic, probiotic and synbiotic supplementations on finishing body weight and biometric measurements (cm) of *Noemi* lambs at the end of the finishing period

Trait	Treatment			
	Control	Prebiotic	Probiotic	Synbiotic
Initial weight (kg)	29.00±1.67	31.50±0.89	29.17±0.79	29.50±0.9
Finishing weight (kg)	59.0±1.2 ^b	63.7±3.9 ^a	64.0±1.0 ^a	64.3±3.8 ^a
Total weight gain (kg)	30	32.7	34.9	34.8
Biometric measurements				
Tibia length	33.0±1.2	30.20±0.1	31.67±1.8	28.83±2.5
Pelvic length	21.50±8.5	27.43±1.7	31.83±1.2	28.43±0.3
Chest depth	32.00±5.0	39.33±2.4	38.17±2.6	33.00±0.6
Chest width	21.0±2.1	18.87±0.1	17.50±2.0	18.43±0.6
Chest circumference	100.00±4.2	96.33±3.5	96.50±1.5	96.00±3.0
Wither height	68.57±1.2	66.77±2.3	70.50±4.0	66.33±2.2
Rump height	73.17±2.3	71.57±1.6	71.50±1.2	70.83±0.9
Body length	64.87±5.9	71.67±2.0	74.37±0.5	71.67±2.9

Means in the same row with different superscripts significantly differ (P<0.05).

Table 3: Effect of prebiotic, probiotic and synbiotic supplementations on carcass characteristics of *Noemi* lambs

Trait		Treatment			
		Control	Prebiotic	Probiotic	Synbiotic
Carcass measurements					
Carcass weight (kg)		28.1±1.5	28.9±2.7	30.2±0.7	29.7±2.4
Dressing %		47.7±1.9	45.3±1.9	47.2±1.3	46.1±2.2
Carcass length		62.67±0.001	63.33±1.4	63.33±1.7	60.93±2.1
Leg length		27.00±1.0	27.07±1.8	27.50±2.0	26.40±1.1
Heart girth		64.50±0.8	66.33±1.5	65.17±1.0	67.40±2.1
Chest circumference		85.40±0.001	81.67±1.9	85.03±0.6	81.83±1.5
Chest width		14.15±0.1	15.50±0.8	14.33±1.2	17.57±0.4
Chest depth		23.07±1.0 ^b	31.60±0.7 ^a	30.10±1.4 ^a	30.00±1.0 ^a
Eye muscle area (cm ²)		25.13±2.6	25.70±4.0	26.97±2.9	26.27±1.9
Offal weights (kg)					
Head		4.15±0.18	4.74±0.28	4.20±0.19	4.67±0.32
Skin		6.42±1.08 ^a	4.28±0.06 ^b	4.75±0.25 ^{ab}	4.26±0.01 ^b
Feet		1.01±0.07	1.03±0.07	0.97±0.06	1.037±0.08
Tail		2.90±0.15	2.88±0.82	4.16±0.82	3.29±0.48
Kidneys		0.273±0.04	0.257±0.03	0.320±0.05	0.417±0.11
Testes		0.372±0.08	0.470±0.07	0.440±0.03	0.450±0.05
Liver		0.84±0.51	0.74±0.04	0.73±0.01	0.71±0.02
Digestive tract		8.32±0.48 ^b	9.37±0.91 ^{ab}	11.03±0.69 ^a	7.93±0.48 ^b
spleen		0.093±0.01	0.090±0.01	0.080±0.01	0.087±0.01
Lungs		0.673±0.03	0.677±0.03	0.643±0.02	0.760±0.08
Heart		0.207±0.01 ^{ab}	0.220±0.01 ^a	0.193±0.01 ^b	0.203±0.003 ^{ab}
Kidney fat		0.120± 0.09	0.083± 0.03	0.200± 0.05	0.263± 0.12
Gut fat		0.335± 0.21	0.820± 0.31	0.553± 0.12	0.740± 0.19
Tail fat		2.70± 0.11	2.74± 0.79	4.01± 0.82	3.14± 0.49

Means in the same row with different superscripts significantly differ (P<0.05).

Table 4: Effect of prebiotic, probiotic and synbiotic supplementations on wholesale cuts of *Noemi* lambs

Trait	Treatment			
	Control	Prebiotic	Probiotic	Synbiotic
Wholesale cuts weights (kg)				
Fore quarter	13.5±0.8	13.85±0.9	13.9±0.2	13.87±1.0
Neck	2.24±0.1	2.56±0.3	2.48±0.1	2.32±0.1
Breast	2.81±0.1 ^{ab}	2.53±0.2 ^b	3.31±0.2 ^a	2.75±0.3 ^{ab}
Hotel rack	3.70±0.7	3.69±0.6	2.87±0.1	3.80±0.8
Shoulder	4.70±0.1	5.01±0.6	5.19±0.02	5.00±0.4
Hind quarter	11.19±0.9	11.49±0.9	11.45±0.3	11.64±0.7
Leg	6.75±0.4	6.47±0.6	7.05±0.3	6.29±0.5
Loin	3.27±0.4 ^{ab}	3.83±0.3 ^{ab}	2.71±0.1 ^b	4.21±0.4 ^a
Flank	1.17±0.2	1.20±0.2	1.68±0.3	1.13±0.1
Wholesale deboned cuts weights (kg)				
Fore quarter	8.780±0.7	8.633±0.8	9.467±0.3	9.253±0.8
Neck	1.473±0.1	1.730±0.3	1.787±0.2	1.647±0.1
Breast	1.693±0.3 ^{ab}	1.22±0.1 ^b	2.133±0.1 ^a	1.667±0.3 ^{ab}
Hotel rack	2.013±0.3	1.810±0.3	1.640±0.1	2.247±0.3
Shoulder	3.600±0.1	3.870±0.5	3.907±0.2	3.693±0.3
Hind quarter	8.740±0.9	9.153±1.0	9.053±0.3	9.013±0.7
Leg	5.007±0.3	5.07±0.5	5.213±0.1	4.827±0.4
Loin	2.560±0.5	2.890±0.3	2.160±0.1	3.053±0.3
Flank	1.173±0.2	1.200±0.2	1.680±0.3	1.133±0.1
Total meat	17.520±1.6	17.786±1.8	18.520±0.6	18.266±1.5

Means in the same row with different superscripts significantly differ (P<0.05).