DIETARY INCORPORATION OF COOKED BARLEY AND SPENT GRAPES AS ENERGY SOURCE IN LARGE WHITE YORKSHIRE SOWS

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(16-MVM-034)

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THESIS

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DEPARTMENT OF ANIMAL NUTRITION
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DECLARATION

I hereby declare that this thesis entitled **“Dietary incorporation of cooked barley and spent grapes as energy source in Large White Yorkshire sows”** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **"Dietary incorporation of cooked barley and spent grapes as energy source in Large White Yorkshire sows"** is a record of research work done independently by **Sachin Tripura (16-MVM-034)** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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CERTIFICATE

We, the undersigned members of the advisory committee of **Dr. Sachin Tripura (16-MVM-034),** a candidate for the degree of **Master of Veterinary Science in Animal Nutrition**, agree that this thesis entitled **“Dietary incorporation of cooked barley and spent grapes as energy source in Large White Yorkshire sows”** may be submitted by **Dr. Sachin Tripura (16-MVM-034)** in partial fulfillment of the requirement for the degree.

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EXTERNAL EXAMINER

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Mannuthy **Dr. Sachin Tripura**

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1. INTRODUCTION

In the present scenario, world agriculture had a great economic impact by pig production. Compared to other livestock species, pig rearing is considered to be more advantageous due to its low investment for farming, quick returns, better feed conversion efficiency, higher fecundity, short generation interval and significance in improving socio economic status of weaker section of the society. Pork is an important source of protein, energy and vitamins and is one of the most widely consumed red meat in the world. As per ICMR (2009), out of 60g of daily protein requirement, about 20g should be from animal protein source.

The total number of pigs in India is 10.29 million which contributes around 2.01 per cent of the total livestock population (19th livestock census, 2012). The population of pigs in the world is 986 million (FAO, 2014). The total meat production in the country is 7.4 million tonnes in the year 2016-17 and pig contributes 6.41 per cent of total meat production (BAHS, 2017). There was a decline of 7.54 per cent in pig population from 2007 livestock census (11.133 million) to 2012 livestock census (10.294 million) in India. This decrease in population can be mitigated by better feeding practices and management of piglets and sows.

Feed cost comprises about 75 per cent of the variable costs of pig production. There is a huge reduction in availability of feed resources for livestock and the cost of ingredients is increasing day by day. Due to urbanization and reduction of land availability for cash crop cultivation, alternate feed resources are the need of the hour. The energy portion of pig diets represent the largest and most expensive portion of the diet and also has a major influence on pig performance (Stein and Shurson 2009). Cereal grains form the major source of energy in the swine feed. The lower availability and increasing price of maize, necessitate an alternative energy source for incorporation in the swine feed.

Many such ingredients are available in plenty as by-products of ayurvedic pharmaceuticals in Kerala, which are otherwise wasted. These energy rich by-products can be utilized effectively as livestock feed to reduce the cost of production. Cooked barley waste and spent grapes are two such products that can be explored for their use as feed ingredient in swine ration. Hence this study is aimed at evaluating the performance of LWY sows by inclusion of ayurvedic by-products such as cooked barley and spent grapes in diets of sows with the following objectives:

1. To study nutrient utilization
2. Litter performance at birth
3. Pre weaning growth performance of piglets
4. Techno economics of production

2. REVIEW OF LITERATURE

2.1 ENERGY REQUIREMENT OF PIGS

Energy is one of the costliest factors in commercial pork production. In commercial pork production feed itself is expensive, representing 75 per cent total cost of production. The energy component contributed major portion of this cost, thus making it more dietary important in terms of cost (Nyachoti *et al*., 2004).

Collin *et al.* (2001) reported that starter pigs fed with 13.6 MJ of ME/kg feed produced better energy efficiency (96.4 to 96.7 per cent of DE as ME). Goff and Noblet (2001) observed that availability of ME from DE was 96.5 and 94.8 per cent, respectively for growing pigs and adult sows fed with standard ration (14.43 and 14.71 MJ of ME/kg). In crossbred pigs fed ration with 16 per cent CP at different energy levels, better growth rate was observed in 3200 kcal of DE/kg fed group compared to 2800 and 3000 kcal of DE/kg feed (Rekha, 2001).

Urynek and Buraczewska (2003) reported a maximum nitrogen retention and apparent ileal digestibility in pigs fed rations containing 14.5 MJ of ME/kg than that of 13.5 MJ of ME/kg. King *et al.* (2004) reported that pigs fed with ration containing 351 KJ of DE/kg$W^{0.75}$ had better average daily gain than that of 506 or 566 KJ of DE/kg$W^{0.75}$ per day.

Noblet and Milgen (2004) suggested that energy value of feeds for pigs should be based on net energy (NE) content because nutrient composition of ration affects conversion of ME to NE which varies from 90 per cent for fat to 60 per cent for protein. Campbell (2005) observed significant improvement in feed efficiency in pigs as the energy level was increased from 14.5 to 16.4 MJ of DE/kg in barrows. Efficiency of utilisation of ME to NE in young pigs of 10 to 50 kg body weight was 73.8 per cent as reported by Illescu *et al*. (2006) and they required 103.4 kcal of ME/kg $W^{0.75}$ or 76.3 kcal of NE/kg $W^{0.75}$ for maintenance per day.

Lovatto *et al.* (2006) found that energy restriction at 1.55 MJ of ME per $kgW^{0.60}$ per day led to lower gain and final body weight compared to 2.60 MJ of ME per $kgW^{0.60}$ per day. Wu *et al*. (2007) reported that compared to DE and ME, the net energy system (NE) was superior in predicting the actual energy cost required for body weight gain and it was the only factor that depicted the energy available for pigs to provide better evaluation of pig performance. Cho *et al.* (2008) reported that increasing energy content of the rations to 3 times maintenance requirement resulted in higher feed intake, daily gain and feed to gain ratio in pigs compared with those fed at 1.8 times maintenance energy. Reddy (2009) reported the average ratio of DE to ME of commercial ration for growing pigs were approximately 0.96. Buragohain (2012) observed higher digestibility value for ether extract and crude fibre in pigs fed high energy (3198 kcal of DE/kg feed) than those fed low energy (2490 kcal of DE/kg feed) in the diet.

The National Research Council (NRC, 2012) recommended 3400 kcal of DE or 3265 kcal of ME per kg ration for pigs of all age groups. As per NRC (2012), ME_m (Metabolisable Energy requirement for maintenance) was estimated as 197 kcal/$W^{0.60}$ for growing-finishing pigs and 100 to 110 kcal/$W^{0.75}$ for gestating-lactating sows, respectively. ICAR (2013) recommended ME requirement of 2886, 3050, 2497 kcal/kg for pigs under age group 8 to16, 17 to 24 and 25 to 32 weeks, respectively. ICAR (2013) recommended DE requirement of 3000, 3180 and 2600 kcal/kg ration for pigs under age group 8 to 16 weeks, 17 to 24 weeks and 25 to 32 weeks, respectively.

Kil *et al*. (2013) considered DE as an accurate measurement of energy compared to ME because it did not take into account endogenous losses of energy and it was most precise and easy to determine than ME. As per the observation of Gutierrez *et al*. (2013), one of the major factor affecting DE and ME content of growing pigs was level of dietary fibre which was less digestible compared to other nutrients, providing less available energy to animal.

2.2 SOURCES OF ENERGY IN PIG RATIONS

Energy sources commonly used in pig diets include cereal grains (corn, sorghum, barley, oats, wheat) vegetable oils (corn, soya bean, rapeseed, canola), animal fats (tallow, lard, poultry fat, choice white grease), restaurant greases (spent oils and greases) and commercial blends (mixtures of vegetable oil, animal fats, restaurant grease) (NRC, 1998; Sauber, 2000; Chiba, 2004; Edwards, 2005; Pathak, 2012).

2.3 UNCONVENTIONAL FEEDS IN ANIMAL NUTRITION

Dafwang *et al*. (2001) reported that non-conventional feedstuffs could be considered as the best alternative to produce cheaper feed and ultimately lower the cost of meat and other animal products. Many of the NCFR which were designated as wastes could be utilized and converted by animals into valuable products for human benefit to alleviate the problem of existing limited feed resources (Vasta *et al*., 2008).

Several agro industrial by-products like by-products of distillery and brewing industry, by-products of sugarcane industries, by-products from fruits and vegetables and crop residues are utilized as non-conventional feed (Amaefule *et al.,* 2001; Nagalakshmi and Nasimha, 2007; Angulo *et al.,* 2012). However, the major constraints in the utilization of unconventional feeds for animal feeding were high nutritional variability, seasonal production, low digestibility, and presence of anti-nutritional factors (Al-Masri, 2005 and Shabtay *et al.,* 2008).

Kerala, as famous for ayurveda, has various ayurvedic pharmaceuticals and byproducts from these pharmaceuticals mainly comprise of residues of medicinal herbs. Sreeparvathy (2011) reported that piglets fed ration with 2.5 and 5 per cent spent brewers yeast (T2 and T3 ration) showed no difference in average daily gain and feed conversion efficiency than those fed control ration (ADG: 594.24 and 591.00 vs. 607.75g; FCE: 2.68 and 2.69 vs. 2.58 respectively). Roshma (2014) reported that kids fed with ration containing 20 per cent ksheerabala residue (T3) had similar growth rate as that of kids fed with control ration (T1) (average daily gain 73 vs. 82 g and total weight gain 5.67 vs. 6.39 kg respectively).

The feeding value of these residues for adult pigs as potential NCFR are yet to be explored. Such byproducts include ksheerabala residue, turmeric waste, spent cumin, cooked barley waste, brewery waste, dhanwantaram thailum residue, spent rosemary and spent grapes.

2.4 BARLEY

Barley is an excellent feed source for swine, especially for finishing period. Barley is intermediate to wheat and oats as an energy source for swine and it is having a feeding value of 90 per cent of maize when fed to non-ruminants because of it fibrous hull (Patience and Thacker, 1989). Thacker (1999) and Wu *et al.* (2000) opined that in swine rations barley could partially or totally replace maize. Lampe *et al.* (2006) and Opapeju *et al.* (2006) concluded that barley feeding instead of maize produced whiter and firmer pork fat due to the low concentration of carotenoids and PUFA in barley.

Noblet (2006) reported that the DE value of barley grain samples varied by 20 per cent. Lynch *et al.* (2007) concluded that incorporation of barley in the rations of starter pigs was limited due to its high fibre content, lower nutrient digestibility and net energy value. Baik and Ullrich (2008) reported that out of total global production two-thirds was used for animal feed and about 2 per cent was used for food directly. Qian *et al*. (2009) reported that hulled barley recorded lower digestible energy, crude protein and higher fiber compared to hulless barley and it lowered growth performance of pigs than those fed maize and wheat based rations.

Barley, a common feedstuff in different parts of the world ranks fifth in global grain production (USDA 2014). Kim *et al.* (2014) reported that feeding diets containing up to 60 per cent barley added at the expense of maize did not produce any detrimental effects on pig performance.

2.4.1 Chemical composition:

Bach Knudsen *et al.* (1987) observed that the chemical composition of barley varied considerably with variety, growing conditions and year. Thacker *et al.* (1988) estimated the chemical composition of hulled barley and hulless barley on dry matter basis. They reported 15.3 per cent CP, 5.8 per cent ADF, 2.4 per cent ether extract, 1.8 per cent ash and 16.5 per cent CP, 3.1 per cent ADF, 2.4 per cent ether extract and 2.1 per cent ash respectively. Bell *et al.* (1994) reported the chemical composition of hulless barley and found moisture 11.06 per cent, CP 12.36 per cent, DE 13.90 MJ/kg, crude fibre 2.02 per cent, NDF 14.09 per cent, ADF 2.36 per cent.

Joven *et al.* (2014) and Prandini *et al.* (2015) reported variations for NDF from 17.5 to 28.4 per cent, ADF from 5.8 to 8.0 per cent, CP from 11.8 to 15.1 per cent, ash from 2.8 to 3.2 per cent and starch from 52.3 to 55.9 per cent on DM basis. Rodehutscord *et al.* (2016) reported that starch levels had been found to range from 48 to 72 per cent, CP from 9 to 16 per cent, ADF from 4 to 8 per cent and NDF from 12 to 21 per cent on DM basis. Banakar (2016) estimated the chemical composition of cooked barley residue and found dry matter of 95, CP 11.82, crude fat 3.43, CF 6.28, total ash 2.14, NFE 76.33, NDF 57.39, ADF 27.19 per cent and gross energy 3629.70 Kcal/kg.

Wang *et al.* (2017) found that the DM content of the 19 barley samples averaged 88.7 per cent with a range from 86.3 to 89.8 per cent. On a DM basis, the concentrations of NDF, ADF, CP, EE, ash, starch, P, Ca and GE averaged 26.4 per cent, 6.3 per cent, 12.9 per cent, 2.8 per cent, 3 per cent, 51.5 per cent, 0.34 per cent, 0.04 per cent and 18.59 MJ/kg, respectively. The coefficients of variation for CP, EE, ash and phosphorus were greater than 10 per cent, while the coefficients of variation for NDF, ADF and calcium were above 20 per cent.

2.4.2 Effect of feeding barley in the diet of pigs

2.4.2.1 Effect on growth performance

Lawrence (1973) found a 3.5 per cent ADG improvement for pigs fed a micronized dehulled barley (MDB) based ration from 22 to 50 kg live weight, compared with a wheat based ration. Vestergaard *et al.* (1990) compared and found that the influence of extruding, roller heating, steaming, steaming under pressure or micronizing of barley on piglet performance. They reported that extruded barley was showing highest degree of starch gelatinization but on piglet growth the roller heating had beneficial effects. Chu *et al.* (1998) reported that pigs fed extruded barley grew significantly faster than coarse and finely ground barley and extrusion of barley significantly improved feed/gain of pigs.

Medel *et al.* (1999) reported improvements between 8 and 15 per cent in growth rate for the first 14 days after weaning when barley was micronized, extruded or expanded. Wu *et al*. (2000) reported that pigs fed hulless barley ration had higher ADG than those fed the maize ration during grower period (ADG: 0.671 kg to 0.714 kg). Yin *et al*. (2001) noticed that the ADG was increased by 21 and 19 per cent for the pigs at started phase fed the 50 and 100 per cent micronized dehulled barley (MDB) rations compared with maize based ration.

Daza *et al.* (2012b) reported that growth performance of pigs was not affected when barley was replaced with 100–836 g wheat/kg. Prandini *et al.* (2014) reported that the pigs fed ration with Astartis hulless barley variety and Alamo hulless barley variety weighed more than those fed the control corn based ration (Final BW: 21.25 kg and 22.74 kg vs. 21.21 kg) at the end of the study (42 days).

Prandini *et al.* (2015) reported that the pigs fed the ration with 80 per cent normal amylose hulled barley and 80 per cent low amylose hulless barley variety rations recorded higher ADG and final BW (175kg and 175 kg respectively) than those fed the control (169kg). Nasir *et al.* (2015) reported that pigs fed low quality barley ration obtained higher ADG than those fed wheat based ration (ADG: 430 g/day vs. 366 g/day) during the entire trial period of 1-21 days.

Prandini *et al.* (2016) reported that pigs fed the Alamo ration (ration with 85 per cent hulless barley) had greater final BW (171 kg) and ADG (0.84 kg) than those fed the Cometa ration (ration with 85 per cent hulled barley) (Final BW: 168; ADG: 0.82 kg) for entire trial period of 147 days. Lee *et al*. (2017) reported improved ADG in pigs fed control ration (ADG: 0.705 kg) compared with 0.5 per cent fermented whole crop barley (FWB) ration at 0 to 6 weeks.

Wu *et al*. (2000) reported no significant difference in ADG of pigs fed hulless barley ration than those fed maize during the finisher periods. Daza *et al.* (2010) reported no difference in ADG of pigs fed a control ration than those pigs fed granulated barley (ADG: 0.71 vs. 0.67 kg) during the finishing period. Kim *et al.* (2014) reported that 60 per cent barley in the rations at the expense of corn in finishing pigs resulted in acceptable pig performance during the experimental period of 8 weeks.

2.4.2.2 Feed intake and feed conversion efficiency

Daza *et al.* (2010) reported higher FCR in pigs fed granulated barley ration (FCR: 5.11) than those fed control (FCR: 4.52). Wang *et al.* (2014) reported that the pigs fed 150 g/kg water soaked barley had the highest ADG (908 g) during 4 to 8 weeks of experimental period. Clarke *et al.* (2018) observed piglets fed low quality barley ration recorded higher ADG and G: F ratio than those fed high quality barley ration.

Wu *et al*. (2000) reported no significant difference in daily feed intake of pigs fed hulless barley ration than those fed corn ration during overall trial period. Yin *et al.* (2001) found that daily feed intake and FCE were not affected by the level (25, 50 per cent) of micronized dehulled barley (MDB) in the ration from 9.9 to 37.1 kg live weight but ADFI was less (14 per cent) for the pigs fed the 75 or 100 per cent of MDB based rations without affecting F/G during second phase (37.1 to 74 kg live weight).

Nasir *et al.* (2015) reported no difference in ADFI and G: F in pigs fed high quality barley ration than those fed wheat based ration during the entire experimental period (ADFI: 564g/day vs. 606 g/day; G: F- 0.647 vs. 0.662). Zhou *et al.* (2016) reported no difference in ADFI of pigs fed wheat than those fed barley for overall period of 0 to 21 days. Upadhaya *et al.* (2017) reported that ADFI and G/F did not differ in pigs fed DB (basal ration containing 5 per cent dehulled barley) than those fed WB1 (basal ration plus 5 per cent water soaked barley) and WB2 (basal ration plus 5 per cent WB).

Weber *et al.* (2010) concluded that high fibre content of swine rations was responsible for decreased feed intake and digestibility of nutrients.

2.4.2.3 Digestibility of nutrients

Chu *et al.* (1998) observed that extrusion and enzyme supplementation were found to improve amino acids digestibility of barley in growing pigs. Thacker (1999) reported that the fecal digestibility of CP and GE in barley ration was increased by 8 and 4.4 per cent respectively by micronization. Huang *et al.* (2003) found that energy digestibilities *in vivo* were higher in hulless barley than hulled one (81.4 to 84.7 per cent vs. 76.9 to 77.6 per cent). Nasir *et al.* (2015) reported higher digestibility coefficient of DM and gross energy in finishing pigs for wheat based ration than high quality barley rations (DM: 0.817 vs. 0.752 and GE: 0.802 vs. 0.740).

Wu *et al*. (2000) reported no difference in the digestibility of energy and DM in pigs fed the hulless barley ration (88.40 and 87.64 per cent) than those fed corn (88.53 and 87.67 per cent respectively). Land´ın *et al.* (2005) reported no difference in the digestibility of protein in growing pigs fed hulled barley, barley and sorghum rations (0.671, 0.645 and 0.651 respectively). Pujol *et al.* (2007) found no differences between in vitro and in vivo apparent CP digestibilities (67 and 68.6 per cent respectively in experiment one; 66.8 and 66.4 per cent in experiment two) were found in any of the two experiments. Upadhaya *et al.* (2017) did not find any difference in the digestibility of DM and gross energy in the pigs fed different rations. Wang *et al.* (2017) did not find any difference in the digestibility of GE (80.40, 79.99 and 80.96 per cent) among the three barley samples (Australia, France and Canada variety respectively).

Wu *et al*. (2000) observed lower digestibility coefficient of nitrogen in pigs fed hulless barley than those fed corn (83.42 vs. 87.39 per cent). Zhou *et al.* (2016) reported that feeding barley based rations reduced the digestibility of dry matter, crude protein and gross energy by 2.7, 4.4 and 3.0 per cent, correspondingly.

2.5 GRAPE

In many countries, the seasonal utilization of grape pomace (GP) in animal feeding is common, because of its low cost. Schieber *et al.* (2001) reported that up to 80 per cent high polyphenol content remained in the pomaces and which made grapes important in human and animal nutrition. Baumgartel *et al.* (2007) considered grape pomace (GP) as one of the most important agricultural by-products that could contribute to addressing shortage of animal feedstuffs. Agte *et al.* (2010) found that a winemaking by-product called grape pomace (GP) used to contained high level of polyphenols, fructooligosaccharides and dietary fibers.

Gessner *et al.* (2013) reported that 1 per cent grape seeds and grape marc meal extract (GSGME) with 8.5 per cent polyphenol content increased the body weight and gain: feed ration in growing pigs. Fiesel *et al.* (2014) opined that the use of grape extracts decreased some pathogenic bacteria (*Streptococcus spp*., and *Clostridium spp*.), the expression of several pro-inflammatory intestinal genes and improved the gain to feed ratio suggesting the antimicrobial and anti-inflammatory effect of bioactive compounds from grape waste.

Evans *et al.* (2014) concluded that grape residue contained a lot of bioactive compounds such as polyphenols (anthocyanins, flavonols, phenolic acids and quercetin), polyunsaturated fatty acids especially linoleic-ω-6 fatty acid, minerals (iron, copper, zinc) fibres which had beneficial effect on human and animals. Hao *et al.* (2015) reported that feeding of grape seed procyanidins lowered diarrhoea incidence and increased immune and antioxidant response in weaned piglets. Taranu *et al.* (2017) reported that 5 per cent grape seed cake ration significantly decreased the cholesterol concentration by 9.05 per cent and increased IgA level by 49.90 per cent in plasma during finishing period.

2.5.1 Chemical composition

Bahrami *et al.* (2010) reported the chemical composition of Dried Grape Pomace (DGP) and found 89 per cent DM, 47.1 per cent NDF, 31.2 per cent ADF, 0.34 per cent total phenols, 5.4 per cent total tannins, 12.80 per cent CP, 2.05 ME (Mcal/kg). Banakar (2016) estimated the chemical composition of spent grapes and found dry matter of 96, crude protein 5.61, crude fat 2.54, crude fibre 8.53, total ash 3.1, nitrogen free extract 80.22, NDF 34.31and ADF 30.59 per cent.

Taranu *et al.* (2017) reported the chemical composition of grape pomace and found dry matter of 87.63, crude protein 10.32, ether extract 5.14, crude fibre 25.01, NDF 58.01, ADF 52.26, ash 5.75 per cent and metabolisable energy 1912 ME kcal/kg. Taranu *et al.* (2018) reported chemical composition of grape seed cake as dry matter 88.44, crude protein 10.61, ether extract 1.56 and ash 3.40 per cent.

2.5.2 Effect of feeding grapes in the diet of pigs

2.5.2.1 Effect on growth performance

Yan and Kim (2011) reported that FGP (Control plus 30 g/kg fermented grape pomace) ration increased ADG of pigs than those fed control (0.831 kg vs. 0.779 kg) during grower phase (36 to 70 day of experiment). Han *et al.* (2016) reported dietary supplementation with GSPs improved ADG of weaned piglets than those fed control group (494 vs. 467 g/day).

Kafantaris *et al.* (2018) reported ADG was increased in the piglets fed grape pomace (GP) ration by 22.79 per cent compared with control during 20 to

35 days of trial period (0.237 ± 0.01 vs. 0.193 ± 0.01 kg/day). Maupertuis *et al.* (2017) reported the proportion of total piglets born heavier at birth (> 1250 g) was higher (60 vs. 50 per cent) for sows receiving the grape pulp ration (supplemented with 10 per cent grape pulp) than those fed control. They also reported the litter weight at weaning was heavier (105.6 vs. 93 kg) for sows fed with grape pulp ration than those fed control ration.

Yan and Kim (2011) did not find any difference in ADG among the pigs fed control ration and FGP ration (Control plus 30 g/kg fermented grape pomace) during the starter phase (day 0 to 35) and overall period (105 days) (780 g vs.771 g in the starter phase and 800 g vs. 823 g in overall period respectively). Gessner *et al.* (2013) found similar results in final body weights and average daily gains among the pigs fed a ration supplemented with 1 per cent GSGME (grape seed and grape marc extract) compared to control (Final body weight : 31.9 ± 1.9 vs. 30.7 ± 2.1 kg; Daily body weight gain: 726 ± 62 vs. 681 ± 75 g respectively). Fiesel *et al.* (2014) reported similar results in pigs fed with control and ration supplemented with 1 per cent GSGME in average daily gains (497 ± 63 vs. 509 ± 74 g) and final body weights (23.7 ± 2.6 vs. 24.1 ± 2.1 kg).

Hao *et al.* (2015) did not find any differences in ADG and final body weight between piglets fed grape seed procyanidins (GSP) supplemented rations (basal ration plus 50 mg/kg GSP; 100 mg/kg GSP and 150 mg/kg GSP) and control ration during overall experimental period of day 1 to 28 (ADG: 300, 309, 287 g vs. 282 g; Final BW: 15.39, 15.65, 15.07 kg vs. 14.87 kg). They also reported supplementation with different levels of GSP (100 to 150mg/kg) decreased the diarrhea incidence in piglets significantly than the piglets fed the basal ration (6.47, 6.14, and 6.92 per cent vs. 9.82 per cent). Taranu *et al.* (2017) reported no difference in average daily weight gain of pigs fed grape seed ration (basal ration with 5 per cent grape seed cakes) than those fed control ration (1.017 kg/day for grape seed ration vs. 1.019 kg/day for control).

2.5.2.2 Feed intake and feed conversion efficiency

Fiesel *et al.* (2014) observed that pigs fed GSGME ration recorded improved gain: feed ratio by 7 per cent compared to the control (620 vs. 579 g/kg). Han *et al.* (2016) observed significant difference in average daily feed intake of weaned piglets between the GSPs supplemented group and the control group (835 ± 57 vs. 862 ± 45 g/day). They also reported improved Feed: Gain (F/G) ratio in GSPs supplemented group than the control group (1.69 ± 0.05 vs. 1.84 ± 0.05). Kafantaris *et al.* (2018) reported that inclusion of grape pomace (GP) in the ration of piglets resulted in significantly higher values of ADFI than the piglets fed control ration (0.321 ± 0.03 vs. 0.263 ± 0.02 kg feed intake/day) during 35 to 50 days of trial period.

Yan and Kim (2011) did not find any differences in ADFI and gain: feed of pigs fed with FGP ration (Control plus 30 g/kg fermented grape pomace) and control ration during starter phase of day 0 to 35 (ADFI: 2.349 kg vs. 2.433 kg; gain/feed: 0.328 vs. 0.320 respectively) and during overall period (ADFI: 2.511 vs. 2.452 kg; gain/feed: 0.328 vs. 0.326).

Gessner *et al.* (2013) did not find any difference in daily feed intake of pigs fed with 1 per cent GSGME and control ration (Daily feed intake: 1113 ± 82 vs. 1090 ± 100 g). Fiesel *et al.* (2014) did not find any difference in daily feed intake (828 ± 115 vs. 789 ± 85 g) of weaned pigs fed control ration and with 1 per cent GSGME ration. Hao *et al.* (2015) reported that pigs fed ration supplemented with GSP at 50 mg/kg, 100 mg/kg and 150 mg/kg basal diet had similar ADFI (463, 470, 454 g vs. 452 g) and F/G (1.54, 1.52, 1.59 vs. 1.61) during overall experimental period (28 days).

Taranu *et al.* (2017) found no significant difference in daily feed intake among the pigs fed grape seed ration (basal ration with 5 per cent grape seed cakes) and control ration (3.42 kg/day vs. 3.41 kg/day respectively). Kafantaris *et al.* (2018) reported no significant differences in ADFI and FCR (0.251 ± 0.05 vs. 0.218 ± 0.01kg feed intake/day; 1.091 ± 0.01 vs. 1.175 ± 0.03 respectively) during overall period between the GP supplemented and the control group.

2.5.2.3 Digestibility of nutrients

Yan and Kim (2011) reported improved digestibility of DM (79.5 vs. 71.7 per cent) and nitrogen (82.5 vs. 73.9 per cent) in the pigs fed FGP (Control plus 30 g/kg fermented grape pomace) ration than those fed control during grower phase (36-70 day of the experiment).

Fiesel *et al.* (2014) did not find any difference in digestibility of crude protein, crude fiber and NFE of pigs fed GSGME ration than those fed control (81.0 vs. 81.9 per cent; 51.4 vs. 55.1 per cent and 89.9 vs. 90.1 per cent respectively).

3. MATERIALS AND METHODS

3.1 EXPERIMENTAL PROGRAMME

A feeding trail was conducted at Centre for Pig Production and Research (CPPR), College of Veterinary and Animal Sciences, Mannuthy for a period of 63 days to study the effects of dietary incorporation of cooked barley and spent grapes as energy source in Large White Yorkshire sows.

3.2 EXPERIMENTAL ANIMALS

Fifteen Large White Yorkshire pregnant sows belonging to Centre for Pig Production and Research (CPPR), Mannuthy were used as experimental animals. The sows were selected three weeks prior to the expected date of farrowing. They were dewormed with ivermectin suspension through feed before the start of the experiment.

The sows were divided into three groups as uniformly as possible with regard to number, age and weight. There were five replicates for each treatment with one sow in each replicate.

3.3 HOUSING AND MANAGEMENT

The sows were housed replicate wise in separate pen in the same shed with facilities for feeding and watering. All the animals were housed in uniform management conditions. All sows were fed twice daily (10:00 AM in the morning and 3:00 PM in the afternoon). Restricted feeding was followed throughout the experimental period where the animals were allowed to consume as much as they could within a period of one hour and the feed leftover, if any, was collected and weighed daily and the moisture content was analysed to calculate dry matter intake. Fresh drinking water was provided *ad libitum* in all the pens throughout the experiment.

3.4 EXPERIMENTAL RATION

The animals were fed with standard lactating sow ration with 18 per cent crude protein (CP) and 3265 kcal of metabolizable energy (ME)/kg of feed (NRC, 2012).

The three dietary treatments were formulated as per NRC, 2012 as follows:

T1- Control ration (18% CP and 3265 Kcal/kg ME)

T2- Ration containing cooked barley replacing 25 per cent maize in control ration

T3- Ration containing spent grapes replacing 25 per cent maize in control ration

The ingredient composition of the lactating sow ration is given in Table 1.

3.5 COOKED BARLEY AND SPENT GRAPE

The cooked barley and spent grapes were procured from Oushadhi, Kuttanellur, Thrissur at free of cost. These ingredients were dried in sunlight, ground and mixed with the experimental ration.

3.6 FEEDING TRIAL

The experimental animals in three different dietary treatments were fed with respective lactating sow ration as per NRC (2012). The sows were fed on corresponding rations up to weaning. All rations were made isocaloric and isonitrogenous. Record of daily feed intake was maintained throughout the experiment and balance feed was collected, weighed and kept for moisture content estimation. The piglets were fed with the same ration provided to the sows. The pigs were weighed at the beginning of the trial and thereafter at fortnightly intervals. The piglets were weighed after birth and the litter weight was recorded fortnightly up to weaning.

3.7 GROWTH PATTERN AND EFFICIENCY

Daily feed intake and fortnightly body weight of individual animals in each group were recorded during the entire period of experiment and the observations were used to arrive at:

1. Average daily gain (g)
2. Average daily feed intake (kg)
3. Average feed efficiency

3.8 DIGESTIBILITY TRIAL

A digestibility trial was conducted prior to farrowing to determine the digestibility coefficient of the nutrients and availability of minerals such as calcium, phosphorus and magnesium by total collection method. Total faecal matter voided were collected for a period of three days, uncontaminated with urine and dirt and weighed. Representative sample of faeces (10 per cent) was taken daily for 3 days after thorough mixing and placed in a double lined polythene bags, labelled and kept in deep freezer (-20°C) for further analysis. The representative samples of feed offered and balance feed were also taken daily during the collection period.

3.9 ANALYSIS OF FEED AND FAECAL SAMPLE

The feed and faecal samples collected for three days from each animal during digestibility trial were pooled, mixed thoroughly and subsamples were taken for analysis. Chemical compositions of feed and faecal sample were analysed as per methods described in Association of Official Analytical Chemists (AOAC, 2012). Crude protein estimation of faecal sample was done from fresh sample and some amount was kept for wet digestion. The apparent digestibility coefficients of dry matter, crude protein, ether extract and crude fibre and availability of minerals such as calcium and phosphorus were calculated. Minerals like calcium and phosphorus in the feed samples were analysed by conventional precipitation and titration method as per AOAC (2012). Magnesium was estimated by using Atomic Absorption Spectrophotometer (PERKIN ELMER 3110, US. instrument division, Norwalk, U.S.A.).

3.10 TECHNOECONOMICS OF PRODUCTION

Cost of production per kg weight gain was calculated based on body weight gain, total feed intake on DM basis, cost of feed and supplements.

3.11 STATISTICAL ANALYSIS

Data collected on various parameters were analysed by Analysis of Variance (ANOVA) method as described by Snedecor and Cochran (1994). Means were compared by Duncan multiple range test (DMRT) using statistical package for social studies software (version 24).

Table 1. Ingredient composition of experimental ration, %

Ingredients, %	Treatments		
	T1	T2	T3
Yellow maize	71	56.25	52.25
Soya bean meal	27	24	28
Cooked barley	-	17.75	-
Spent grapes	-	-	17.75
Salt	0.5	0.5	0.5
Mineral mixture	1.5	1.5	1.5
Total	100	100	100
To the above mixture following ingredient was added			
Calcite (gm)	1.6	1.6	1.6
Cost of feed (Rs/kg)	27.42	22.05	22.46

4. RESULTS

The results of the current study are presented in the tables under different headings with suitable figures.

4.1 CHEMICAL COMPOSITION OF EXPERIMENTAL RATIONS

4.1.1 Pig ration

The percentage chemical composition of experimental pig ration on dry matter basis is presented in Table 2. The three experimental pig rations T1, T2 and T3 recorded 90.23, 90.13, and 90.32 per cent dry matter. These rations contained crude protein ranging from 18.08 to 18.37 per cent, ether extract from 1.59 to 1.74 per cent, crude fibre from 2.51 to 2.78 per cent, total ash from 4.35 to 4.60 per cent, nitrogen free extract from 72.87 to 73.23 per cent and acid insoluble ash from 0.55 to 0.57 per cent, respectively.

The calcium and phosphorus value for the three experimental pig rations ranged from 0.83 to 0.88 per cent and 0.65 to 0.68 per cent, respectively. The value of magnesium for the three experimental pig rations ranged from 0.0058 to 0.0060 per cent.

4.2 LITTER PERFORMANCE OF SOWS

4.2.1 Average litter size and weight at birth

Data regarding the litter size and weight at birth of sows given the three experimental rations T1, T2 and T3 are presented in Table 3 and graphically represented in Fig. 1. The litter size and weight at birth of piglets of the sows on average in the three groups were 11.20, 10.60, 9.60 and 1.35, 1.45, 1.46 kg, respectively.

4.2.2 Average litter size and weight at weaning

Data regarding the litter size and weight at weaning of sows given the three experimental rations T1, T2 and T3 are presented in Table 3 and graphically represented in Fig. 2. The litter size and weight at weaning of piglets of the sows on average in the three groups were 7.00, 9.00, 8.80 and 8.87, 8.25, 8.88 kg, respectively.

4.3 BODY WEIGHT, FEED INTAKE ON DRY MATTER BASIS AND FEED CONVERSION EFFICIENCY

4.3.1 Body weight

4.3.1.1 Body weight of piglets

The data on the body weight of piglets maintained on the three experimental rations T1, T2 and T3 recorded fortnightly are presented in Table 4 and graphically represented in Fig. 3. The average initial and final body weights of piglets of sow fed three experimental rations were 1.35, 1.45, 1.46 kg and 8.87, 8.25, 8.88 kg, respectively.

4.3.1.2 Body weight of sow

The data on the body weight of sows maintained on the three experimental rations T1, T2 and T3 recorded fortnightly are presented in Table 5 and graphically represented in Fig. 4. The initial and final body weights of sows on average in the three groups were 180.40, 181.00, 180.20 kg and 183.20, 180.80, 180.40 kg, respectively.

4.3.2 Feed intake on dry matter basis

4.3.2.1 Feed intake on dry matter basis of piglets

Data regarding weekly average feed intake of piglets given the three experimental rations T1, T2 and T3 on dry matter basis are presented in Table 6 and graphically represented in Fig. 5. The initial and final feed intake of piglets on average in the three groups were 0.23, 0.21, 0.20 kg and 1.03, 0.93, 1.03 kg, respectively.

4.3.2.2 Feed intake on dry matter basis of sows

Data regarding weekly average feed intake of sows given the three experimental rations T1, T2 and T3 on dry matter basis are presented in Table 7 and graphically represented in Fig. 6. The initial and final feed intake of sows on average in the three groups were 3.33, 3.57, 3.78 kg and 3.97, 4.40, 4.03 kg, respectively.

4.3.3 Average daily gain and feed conversion efficiency of piglets

Data related to average daily gain and feed conversion efficiency of piglets given three experimental rations T1, T2 and T3 are presented in Table 8 and graphically represented in Fig. 7 and 8. On an average, total weight gain of 7.52, 6.80 and 7.42 kg were recorded in the piglets fed three experimental rations (graphically depicted in Fig. 8). Average daily gain and feed conversion efficiency calculated were 179.13, 161.92 and 176.66 g and 3.44, 3.73 and 3.77, respectively in piglets fed the three rations.

4.4 DIGESTIBILITY OF NUTRIENTS

4.4.1 Chemical composition of faecal samples of pigs

Chemical composition of faecal samples of pigs maintained on three experimental rations T1, T2 and T3 are given in Table 9. The faecal samples collected from the three groups recorded a mean dry matter values of 30.34, 30.17 and 32.14 per cent, respectively. The crude protein content of faecal sample of the sows maintained on three rations varied from 18.71 to 20.39 per cent, ether extract from 4.57 to 5.22 per cent, crude fibre from 7.74 to 8.58 per cent, total ash from 17.28 to 20.62 per cent, nitrogen free extract from 45.71 to 50.20 per cent, acid insoluble ash from 4.12 to 4.81 per cent, respectively.

The faecal samples of sows fed three experimental rations recorded 2.40 to 2.53 per cent calcium, 2.02 to 2.08 per cent phosphorus, and 0.0067 to 0.0068 per cent magnesium, respectively.

4.4.2 Apparent digestibility of nutrients

Data related to apparent digestibility of nutrients of three experimental rations T1, T2 and T3 are presented on Table 10 and graphically illustrated on Fig. 9. On an average, the apparent digestibility of various nutrients in the three dietary treatments were 85.84, 85.19 and 85.93 per cent for dry matter, 85.49, 83.30 and 84.60 per cent for crude protein, 57.67, 55.56, and 59.47 per cent for ether extract, 56.35, 54.29 and 57.10 per cent for crude fibre and 90.72, 90.73 and 90.31 per cent for nitrogen free extract, respectively.

4.4.3 Availability of minerals

Availability of minerals in the three experimental rations T1, T2 and T3 are given in Table 11 and graphically depicted in Fig. 10. The estimated dietary availability of calcium and phosphorus in the three diets were 59.04, 57.60, 58.19 per cent and 58.08, 54.33, 56.26 per cent, respectively. The estimated dietary availability of magnesium in the three diets were 83.66, 83.54 and 83.66 per cent.

4.5 TECHNOECONOMICS OF PRODUCTION

Data on total feed intake on DM basis, total weight gain, cost of feed per kg body weight gain of pigs given the five experimental rations T1, T2 and T3 are presented in Table 12 and graphically depicted in Fig. 11. The cost of ingredients utilised for the study was as per the tender rate fixed by Centre for Pig Production and Research, Mannuthy for the year 2017 to 2018. Cost of feed per kg body weight gain of piglets maintained on three dietary treatments were Rs. 94.25, 82.26 and 84.69 respectively for T1, T2 and T3.

Table 2: Chemical composition* of experimental rations, %

Parameters	Treatments		
	T1	T2	T3
Dry matter	90.23	90.13	90.32
Crude protein	18.27	18.08	18.37
Ether extract	1.65	1.74	1.59
Crude fibre	2.51	2.78	2.57
Total ash	4.35	4.43	4.60
Nitrogen free extract	73.23	72.98	72.87
Acid insoluble ash	0.55	0.55	0.57
Calcium	0.83	0.88	0.85
Phosphorus	0.68	0.67	0.65
Magnesium	0.0058	0.0060	0.0058

*On dry matter basis except DM

Table 3: Litter performance of sows maintained on three dietary treatments

Parameters	Treatments[1]			P value
	T1	T2	T3	
Litter size at birth	11.20±1.24	10.60±0.68	9.60±0.81	0.50^{ns}
Litter weight at birth, kg	1.35±0.09	1.45±0.17	1.46±0.07	0.74^{ns}
Litter size at weaning	7.00±0.84	9.00±0.32	8.80±0.73	0.11^{ns}
Litter weight at weaning, kg	8.87±0.28	8.25±0.09	8.88±0.90	0.66^{ns}

[1]Mean of five values with SE

ns- Non significant (P>0.05)

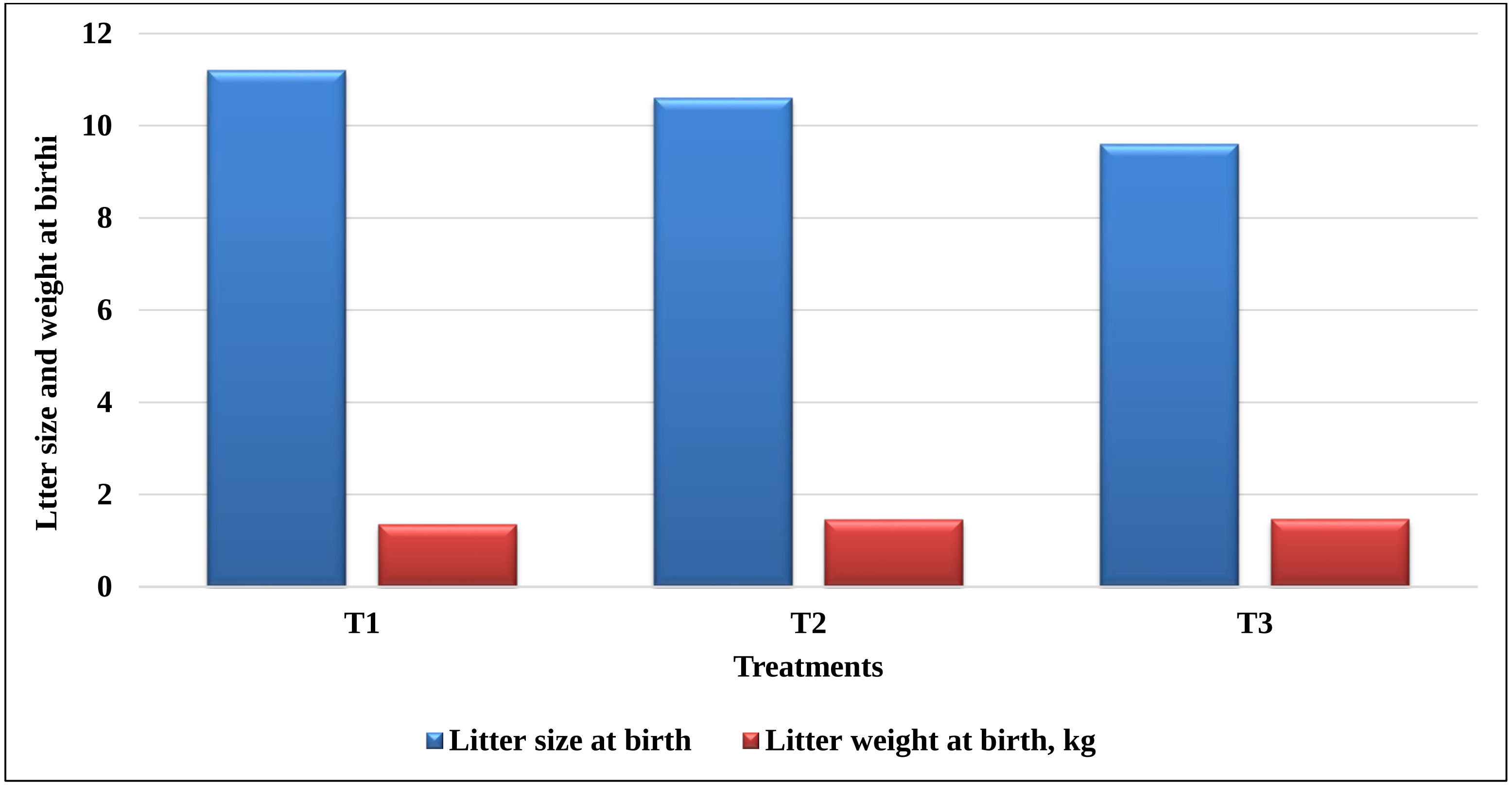

Fig. 1. Average litter size and weight at birth maintained on three dietary treatments

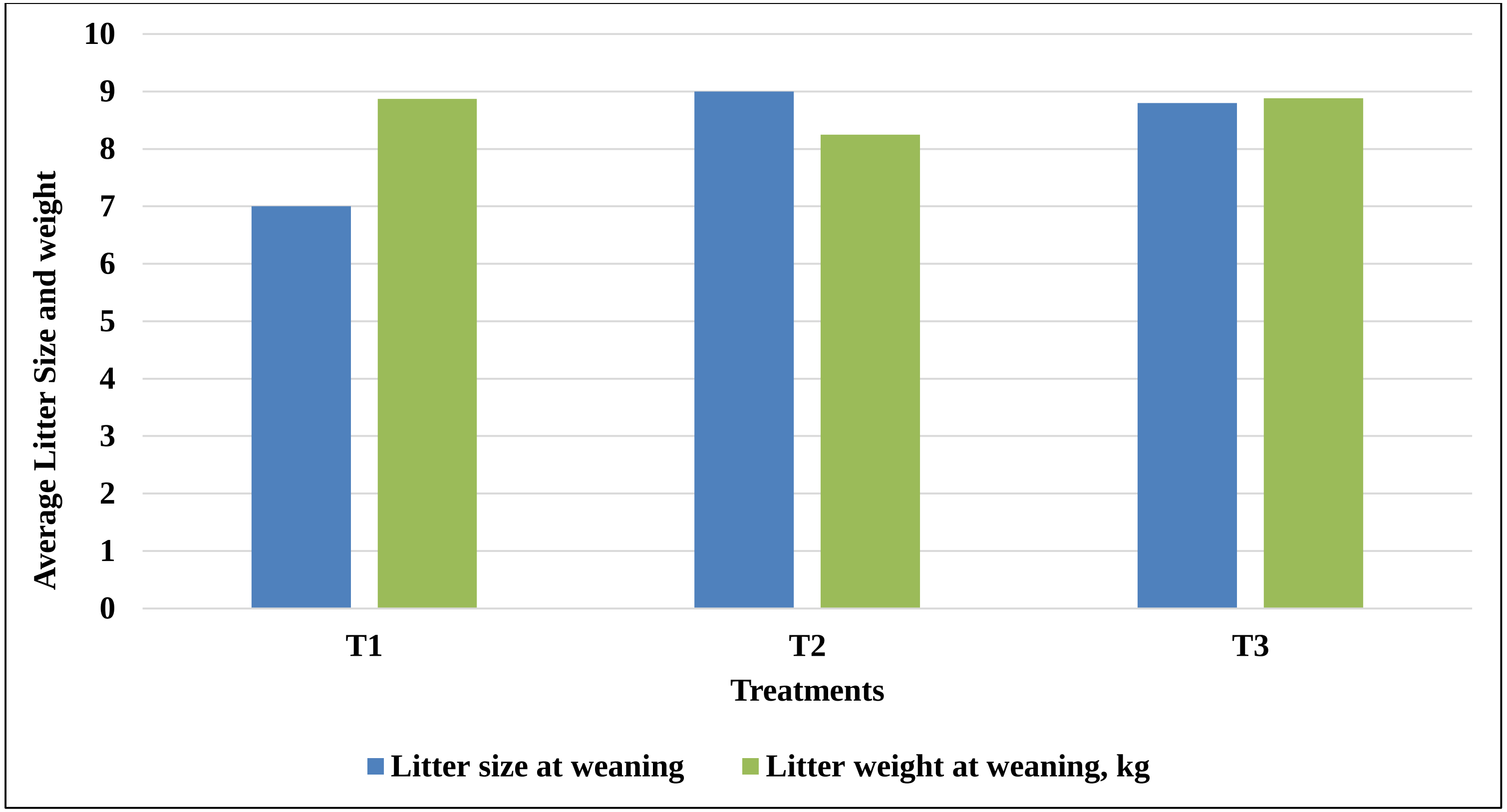

Fig.2. Average litter size and weight at weaning maintained on three dietary treatments

Table 4: Fortnightly average body weight of piglets maintained on three experimental rations, kg

Fortnight	Treatments[1]			P value
	T1	T2	T3	
0	1.35±0.09	1.45±0.17	1.46±0.07	0.74[ns]
1	2.98±0.13	3.32±0.26	3.18±0.29	0.60[ns]
2	5.56±0.13	5.46±0.08	5.73±0.65	0.89[ns]
3	8.87±0.28	8.25±0.09	8.88±0.90	0.66[ns]

[1]Mean of five values with SE

ns- Non significant (P>0.05)

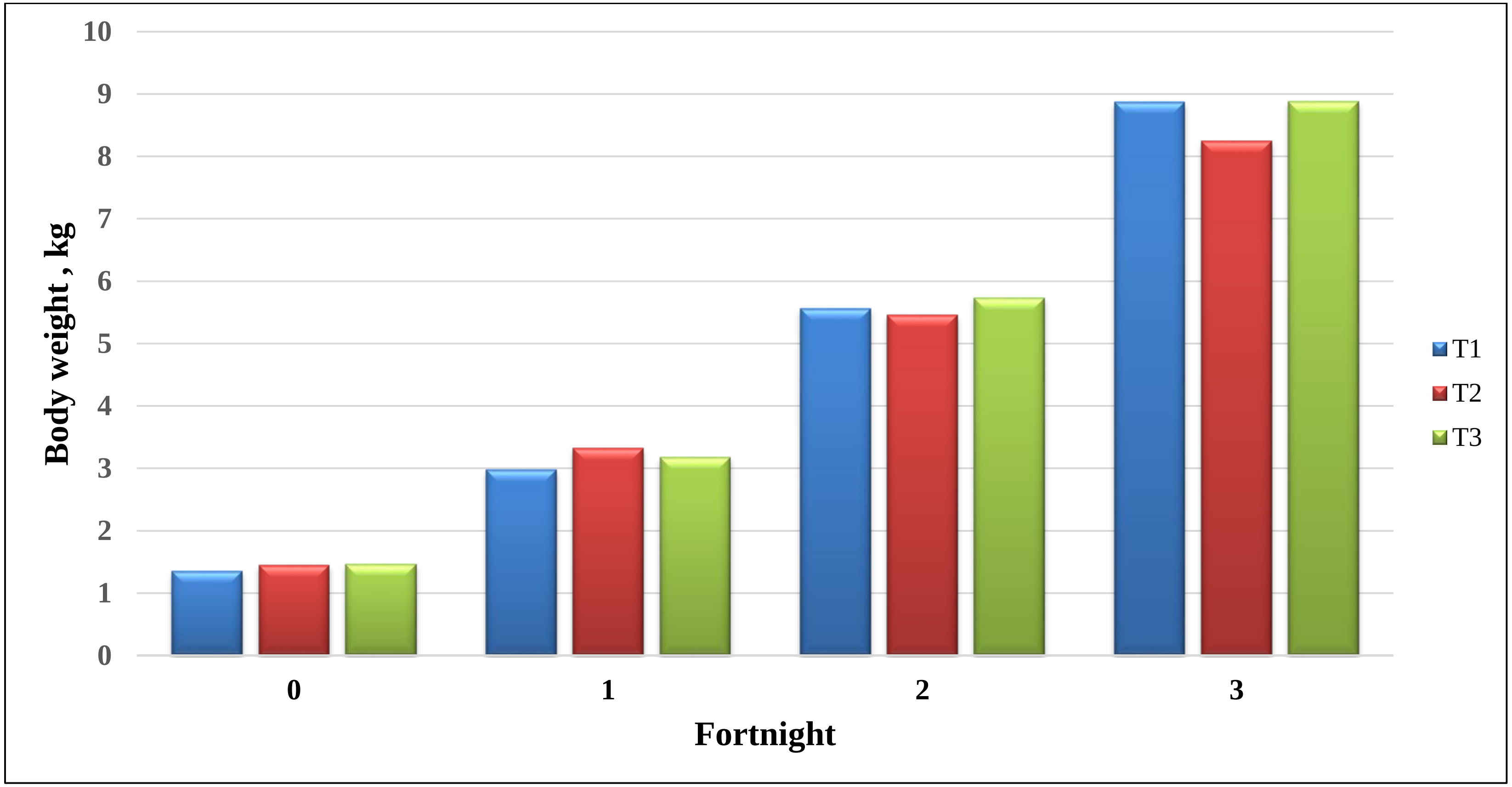

Fig. 3. Fortnightly average body weight of piglets maintained on three experimental rations, kg

Table 5: Fortnightly average body weight of sows maintained on three experimental rations, kg

Fortnight	Treatment[1]			P value
	T1	T2	T3	
0	180.40±11.06	181.00±11.45	180.20±9.77	0.99^{ns}
1	198.60±9.87	201.20±9.24	197.00±9.12	0.95^{ns}
2	195.20±13.83	193.20±9.18	199.60±5.57	0.90^{ns}
3	196.60±19.53	197.40±11.36	190.20±7.43	0.92^{ns}
4	183.20±17.70	180.80±10.93	180.40±8.43	0.98^{ns}

[1]Mean of five values with SE

ns- Non significant (P>0.05)

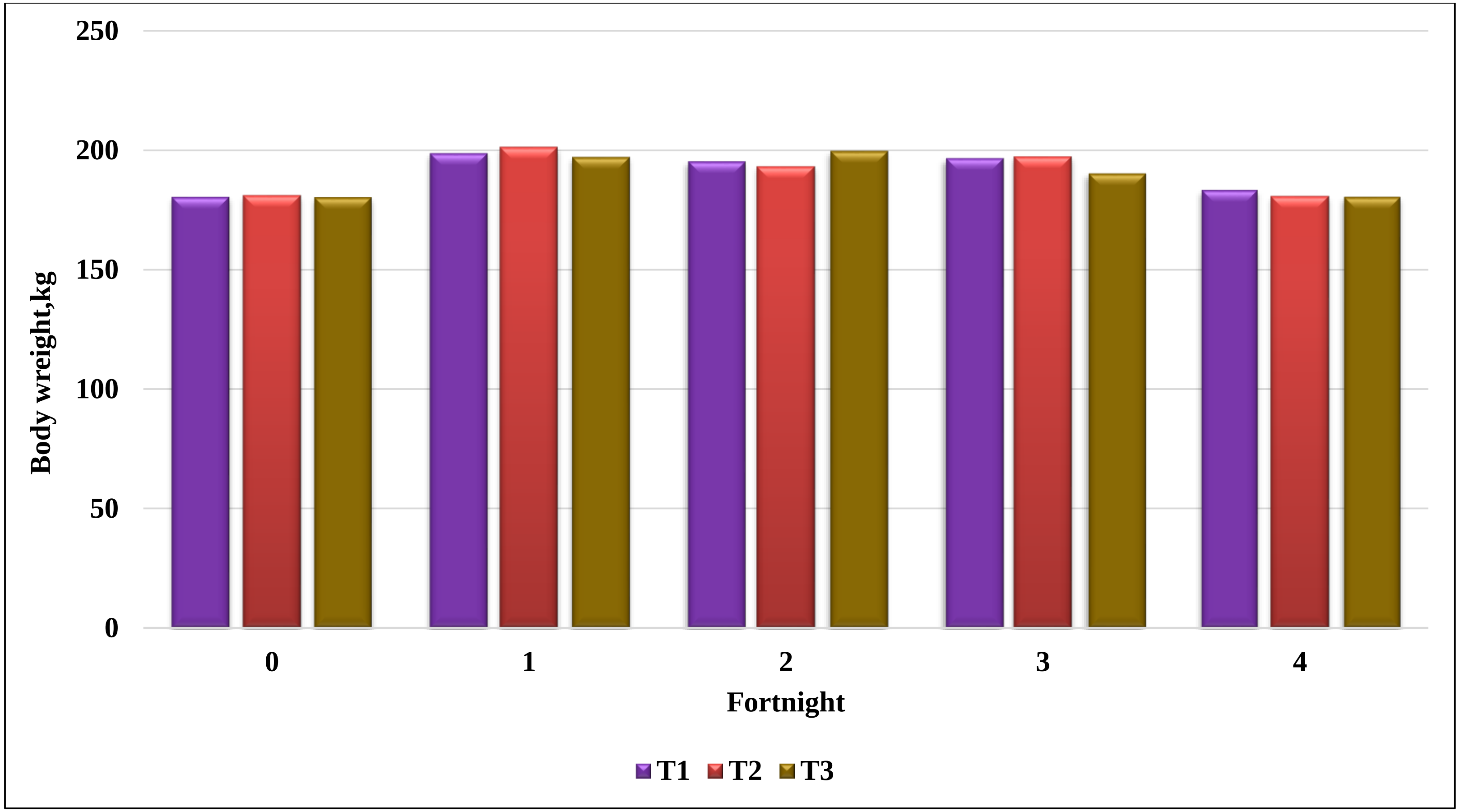

Fig. 4. Fortnightly average body weight of sows maintained on three experimental rations, kg

Table 6: Weekly average feed intake of piglets maintained on three experimental rations on dry matter basis, kg

Week	Treatments[1]			P value
	T1	T2	T3	
1	0.23±0.02	0.21±0.01	0.20±0.01	0.33[ns]
2	0.38±0.02	0.40±0.01	0.39±0.01	0.58 [ns]
3	0.50±0.04	0.57±0.01	0.57±0.01	0.09 [ns]
4	0.68±0.04	0.69±0.01	0.74±0.01	0.20 [ns]
5	0.88±0.04	0.81±0.01	0.86±0.02	0.15 [ns]
6	1.03±0.04[a]	0.93±0.02[b]	1.03±0.02[a]	0.04*

[1]Mean of five values with SE

a,b- Means with different superscripts within the same row differ significantly * ($P<0.05$)

ns- Non significant ($P>0.05$)

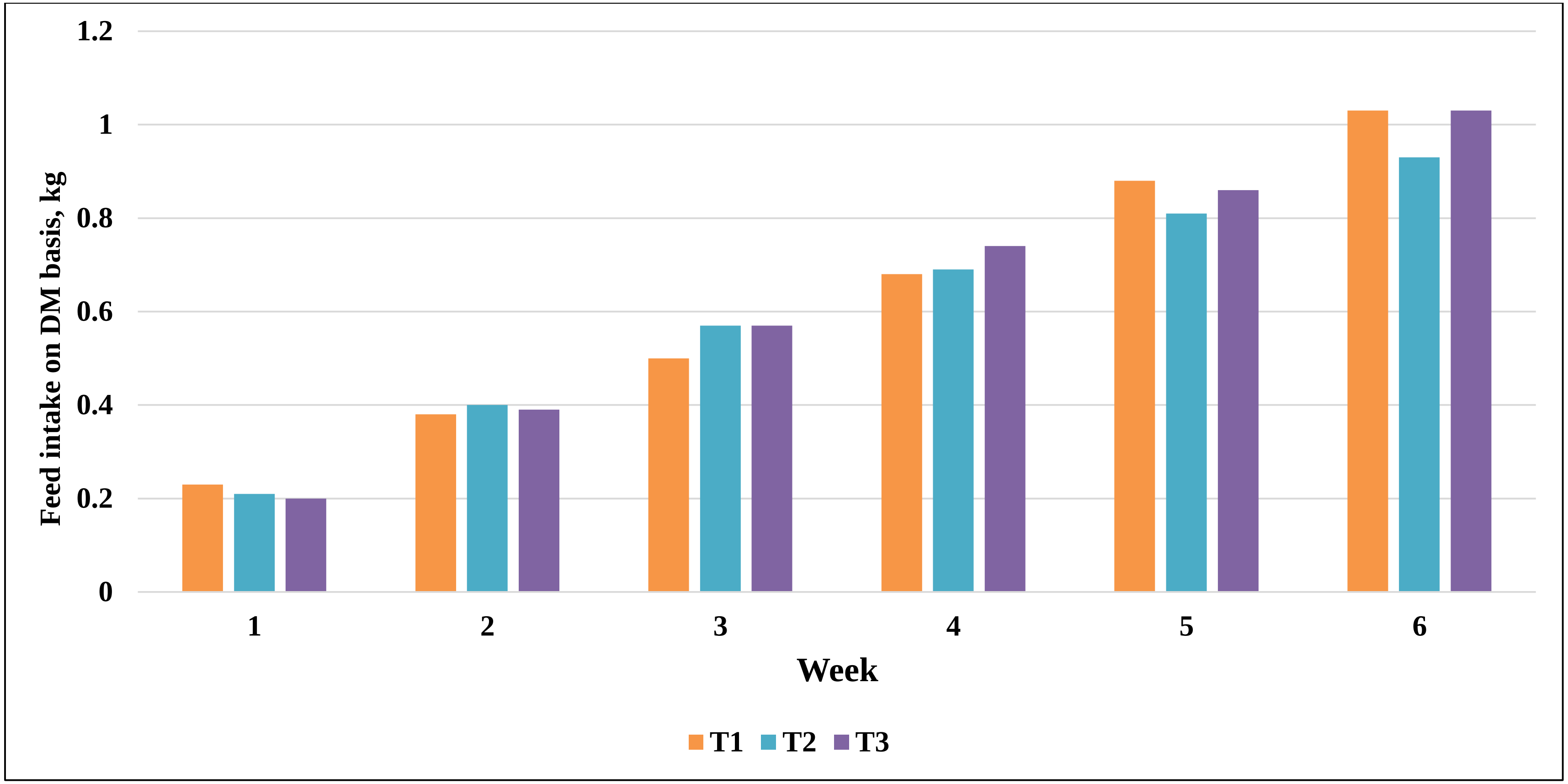

Fig. 5. Weekly average feed intake of piglets maintained on the three experimental rations on dry matter basis, kg

Table 7: Weekly average feed intake of Sows maintained on three experimental rations on dry matter basis, kg

Week	Treatments[1]			P value
	T1	T2	T3	
1	3.33±0.13	3.57±0.23	3.78±0.11	0.19 ns
2	3.65±0.13	3.50±0.18	3.73±0.15	0.58 ns
3	2.94±0.14	3.43±0.31	3.62±0.26	0.17 ns
4	2.24±0.20	2.63±0.28	2.91±0.13	0.12 ns
5	3.44±0.09	3.46±0.22	3.52±0.09	0.92 ns
6	3.45±0.14	3.70±0.24	3.38±0.29	0.60 ns
7	3.72±0.16	3.93±0.25	3.19±0.32	0.14 ns
8	3.87±0.14	4.27±0.12	3.68±0.27	0.12 ns
9	3.97±0.17	4.40±0.07	4.03±0.19	0.14 ns

[1]Mean of five values with SE

ns- Non significant (P>0.05)

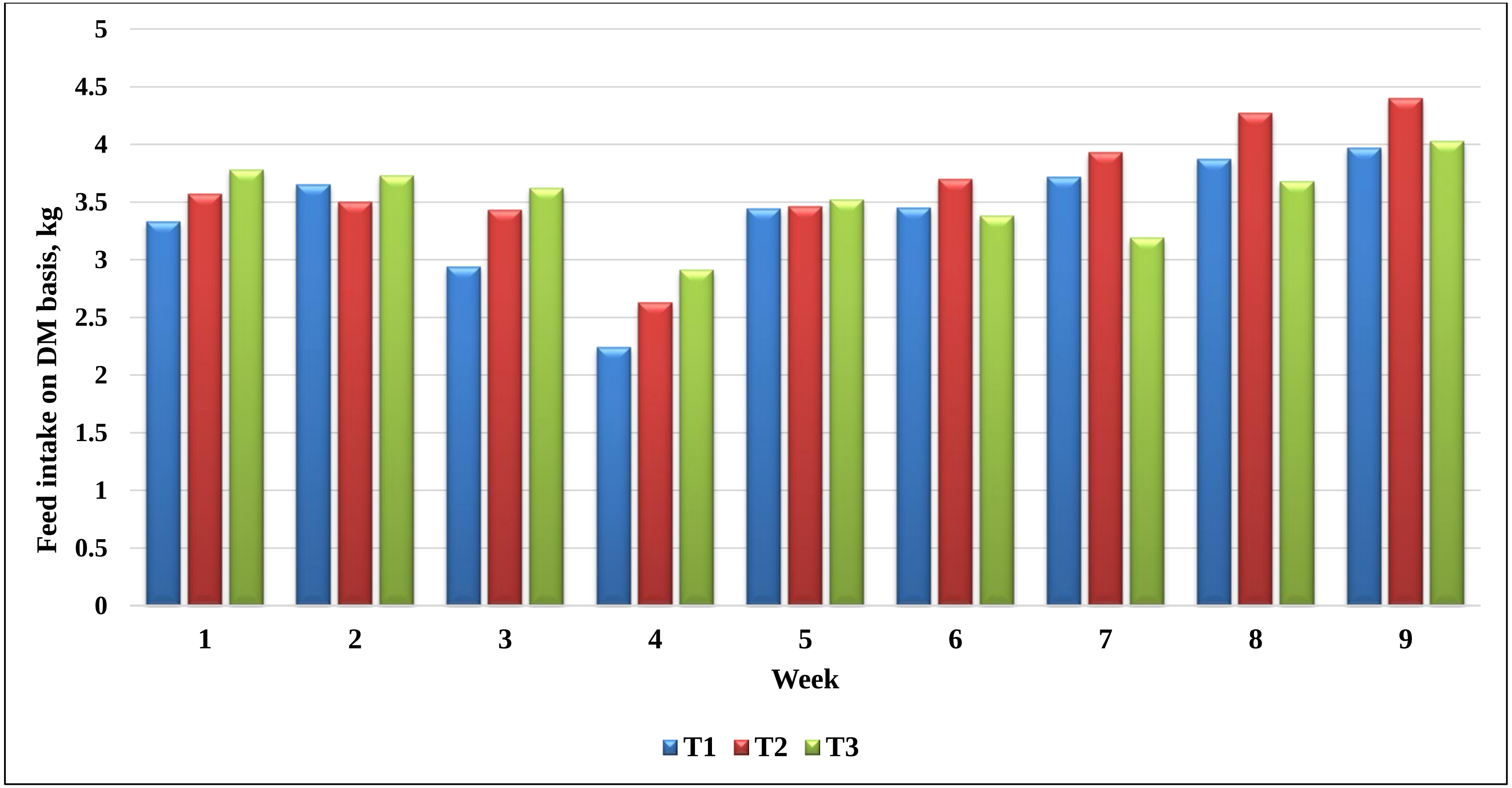

Fig. 6. Weekly average feed intake of sows maintained on the three experimental rations on dry matter basis, kg

Table 8: Average daily gain and feed conversion efficiency of piglets maintained on the three experimental rations

Parameters	Treatments[1]			P value
	T1	T2	T3	
Average initial body weight, kg	1.35±0.09	1.45±0.17	1.46±0.07	0.74^{ns}
Average final body weight, kg	8.87±0.28	8.25±0.09	8.88±0.90	0.66^{ns}
Total weight gain, kg	7.52±0.21	6.80±0.23	7.42±0.83	0.57^{ns}
Average daily weight gain, g	179.13±5.00	161.92±5.39	176.66±19.86	0.57^{ns}
Total feed intake on DM basis, kg	25.88±1.23	25.24±0.34	26.67±0.35	0.44^{ns}
Feed conversion efficiency	3.44±0.12	3.73±0.15	3.77±0.40	0.62^{ns}

[1]Mean of five values with SE

ns- Non significant (P>0.05)

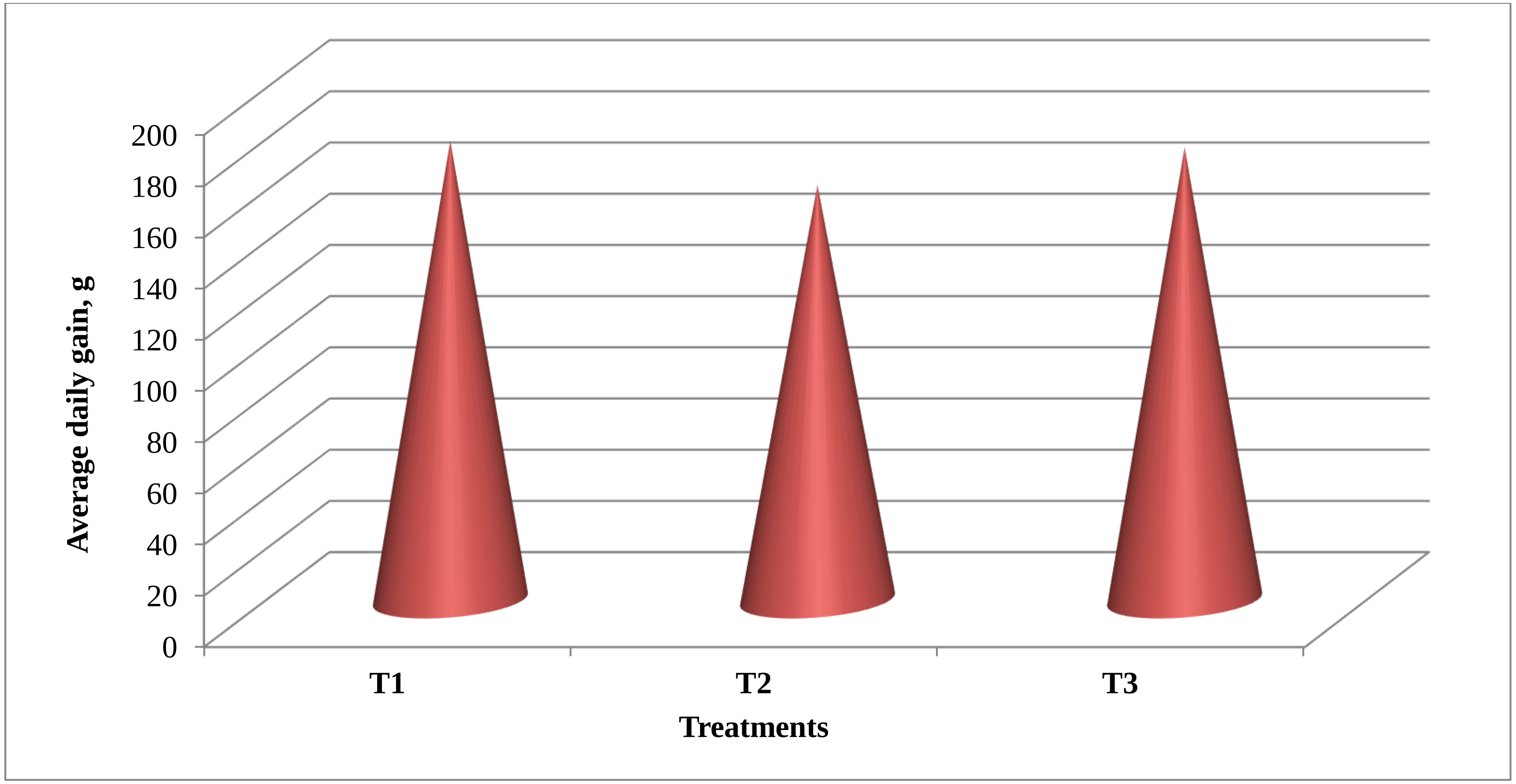

Fig. 7. Average daily gain of piglets maintained on the three experimental rations, g/day

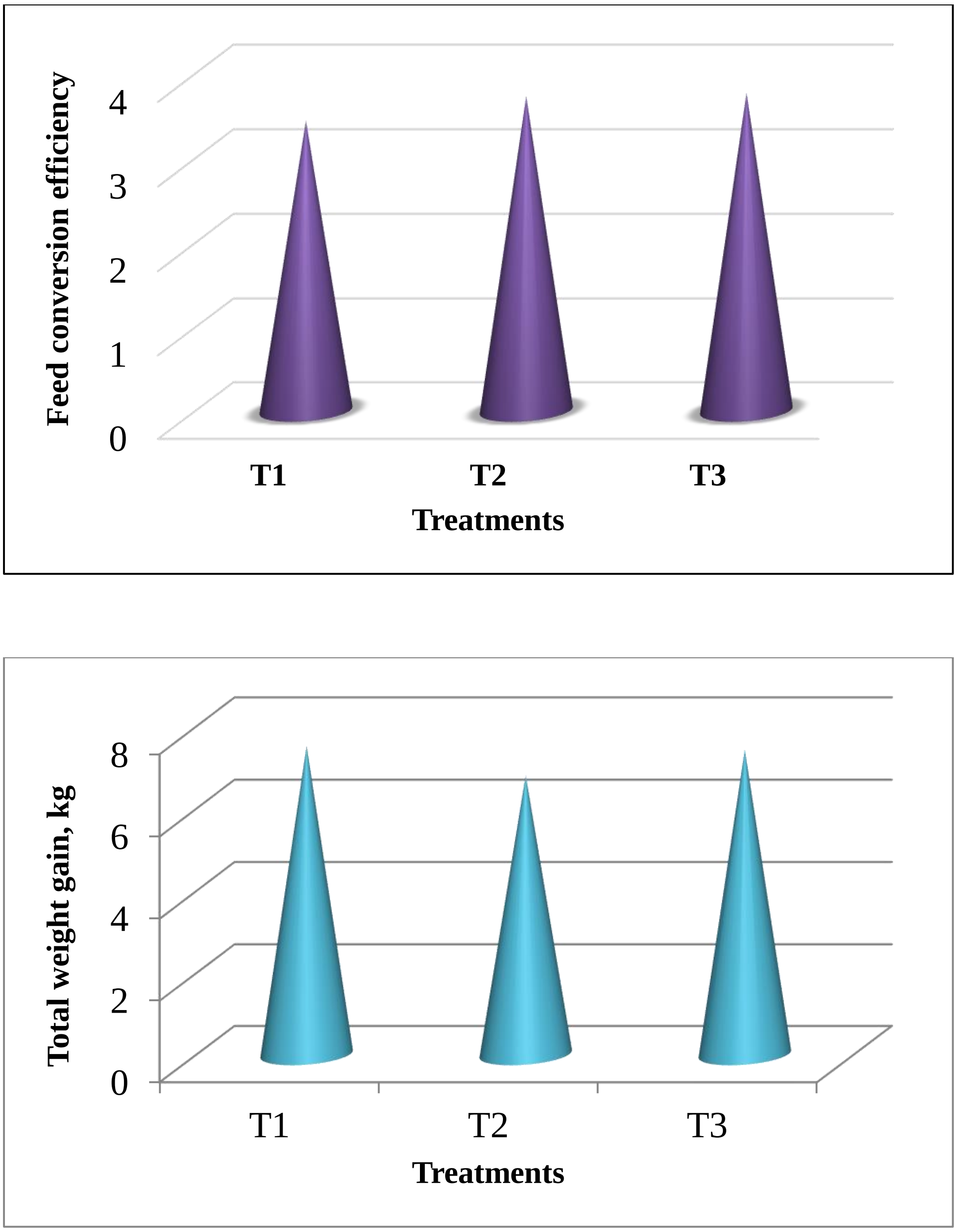

Fig. 8. Feed conversion efficiency and total weight gain (kg) of piglets maintained on the three experimental rations

Table 9: Chemical composition of faecal samples* of pigs maintained on the three experimental rations, %

Parameters	Treatments		
	T1	T2	T3
Dry matter	30.34	30.17	32.14
Crude protein	18.71	20.39	20.11
Crude fibre	7.74	8.58	7.85
Ether extract	4.92	5.22	4.57
Total ash	20.62	20.10	17.28
Acid insoluble ash	4.98	4.81	4.12
Nitrogen free extract	48.00	45.71	50.20
Calcium	2.40	2.51	2.53
Phosphorus	2.02	2.08	2.03
Magnesium	0.0068	0.0067	0.0067

*On dry matter basis except DM

Table 10: Apparent digestibility of nutrients of the three experimental rations, %

Parameters	Treatments[1]			P value
	T1	T2	T3	
Dry matter	85.84±0.01^{a}	85.19±0.04^{b}	85.93±0.06^{a}	<0.001**
Crude protein	85.49±0.06^{a}	83.30±0.09^{c}	84.60±0.07^{b}	<0.001**
Ether extract	57.67±0.16^{b}	55.56±0.33^{c}	59.47±0.22^{a}	<0.001**
Crude fibre	56.35±0.34^{a}	54.29±0.24^{b}	57.10±0.15^{a}	<0.001**
Nitrogen free extract	90.72±0.13	90.73±0.20	90.31±0.16	0.17^{ns}

[1]Mean of five values with SE

a,b,c- Means with different superscripts within the same row differ significantly
** (P<0.001)

ns- Non significant (P>0.05)

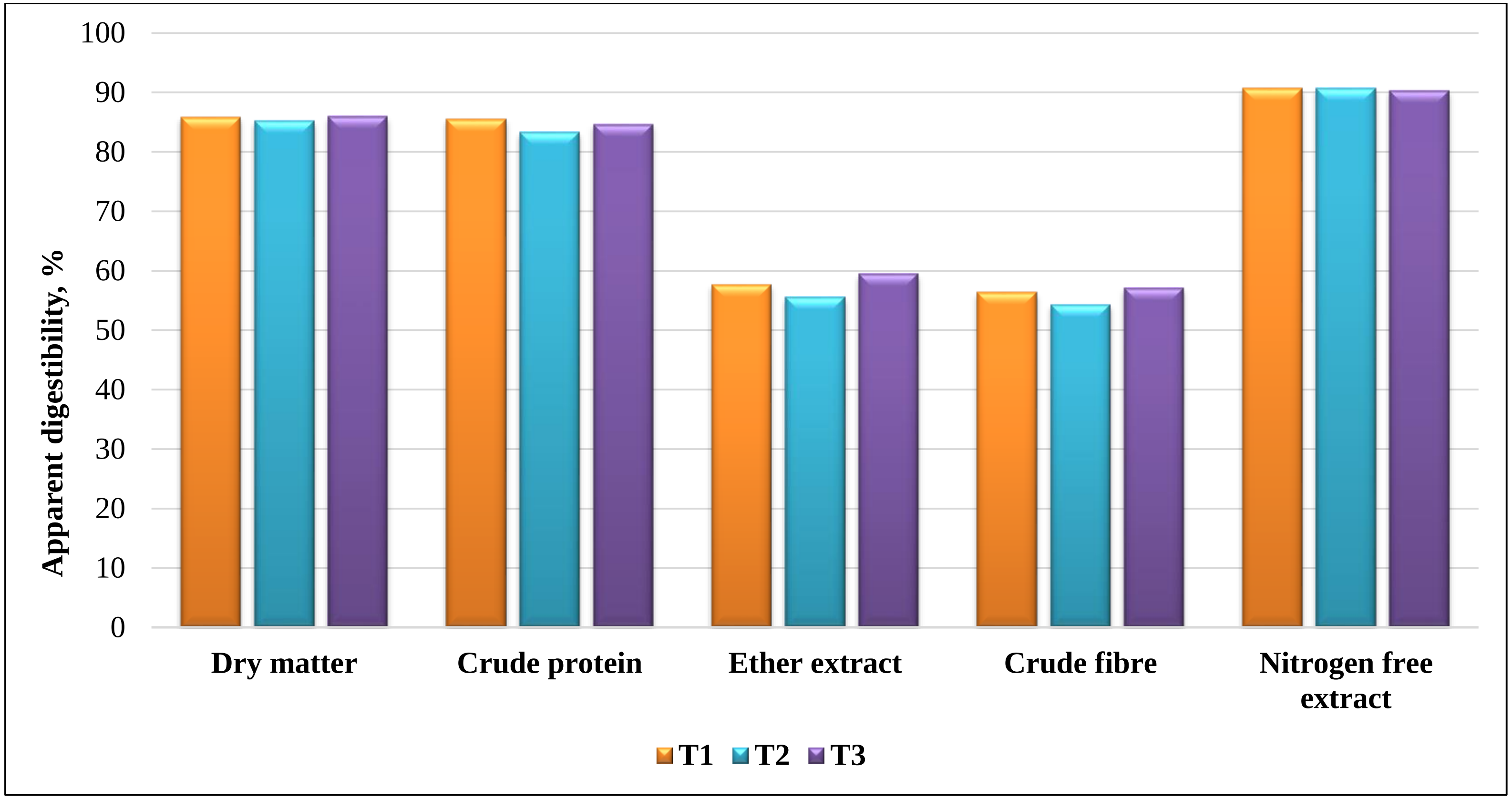

Fig. 9. Apparent digestibility of nutrients of the three experimental rations, %

Table 11: Availability of minerals of the three experimental rations, %

Parameters	Treatments[1]			P value
	T1	T2	T3	
Calcium	59.04±0.30[a]	57.60±0.23[b]	58.19±0.21[b]	<0.01**
Phosphorus	58.08±0.38[a]	54.33±0.27[c]	56.26±0.55[b]	<0.001**
Magnesium	83.66±0.04	83.54±0.04	83.66±0.09	0.26 [ns]

[1]Mean of five values with SE

a,b,c- Means with different superscripts within the same row differ significantly
** (P<0.01); (P<0.001)

ns- Non significant (P>0.05)

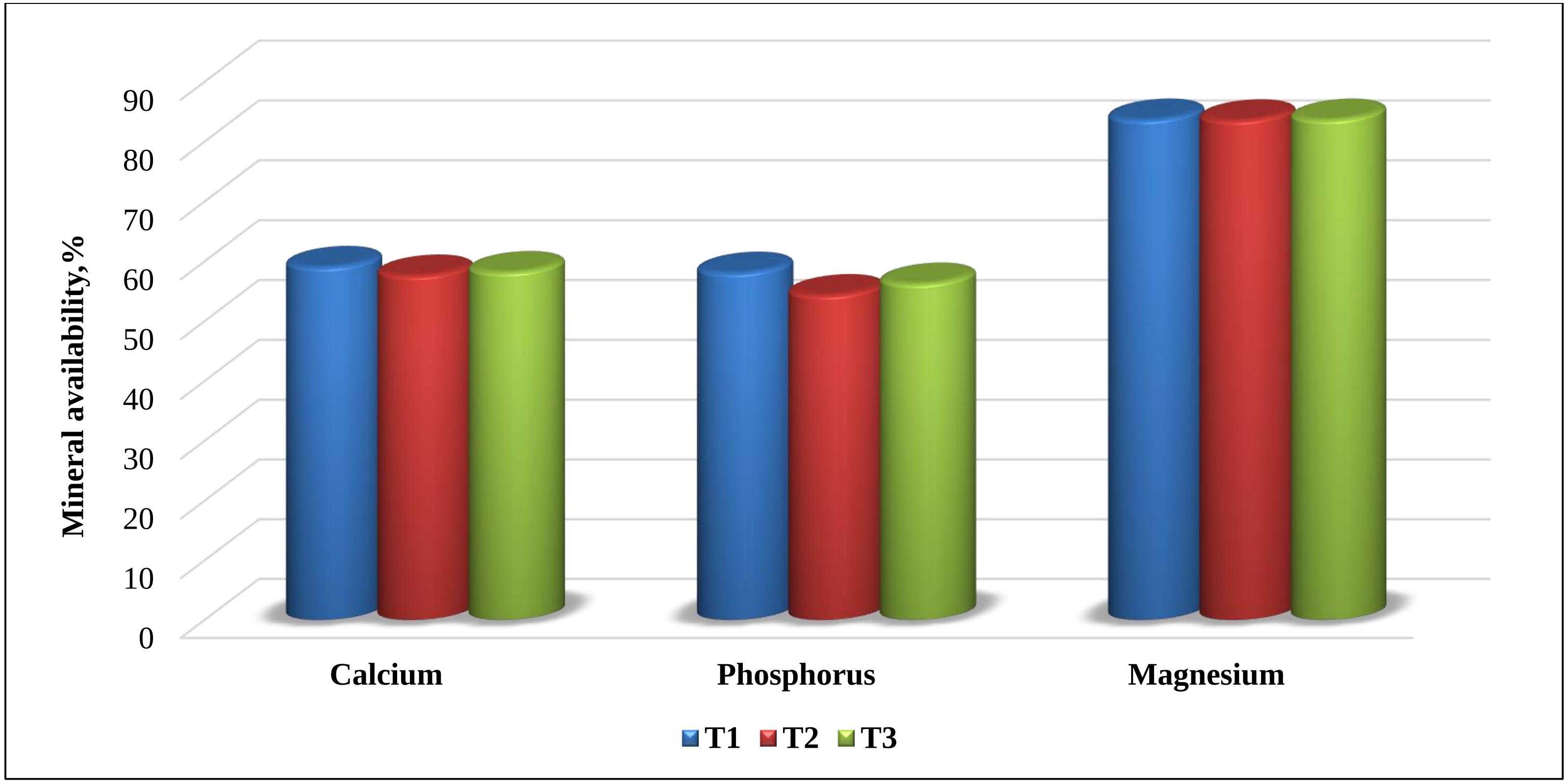

Fig. 10. Availability of minerals of the three experimental rations, %

Table 12: Cost of production of piglets maintained on three experimental rations

Parameters	Treatments[1]			P-value
	T1	T2	T3	
Total feed intake on DM basis, kg	25.88± 1.23	25.24± 0.34	26.67± 0.35	0.44^{ns}
Cost per kg feed, Rs.	27.42	22.05	22.46	-
Total feed cost, Rs.	709.53 ± 33.69^{a}	556.41 ± 7.57^{b}	598.86 ± 7.86^{b}	<0.001**
Total weight gain, kg	7.52± 0.21	6.80± 0.23	7.42± 0.83	0.57^{ns}
Cost of feed per kg weight gain, Rs.	94.25± 3.43	82.26± 3.36	84.69± 9.09	0.35^{ns}

[1]Mean of five values with SE

a,b- Means with different superscripts within the same row differ significantly ** (P<0.001)

ns- Non significant (P>0.05)

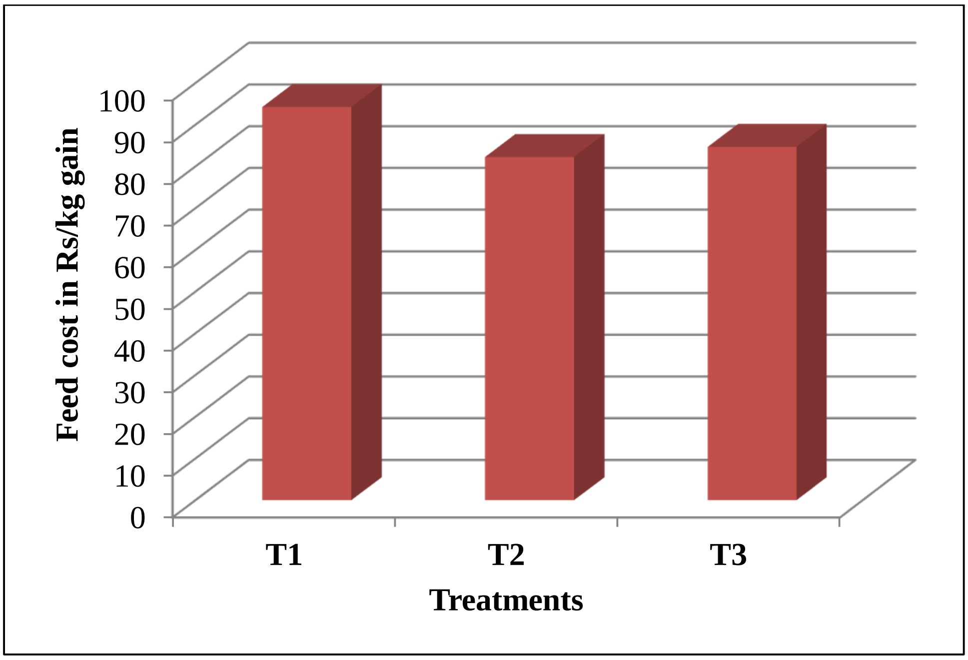

Fig. 11. Cost of production of piglets maintained on three experimental rations

5. DISCUSSION

5.1 CHEMICAL COMPOSITION OF EXPERIMENTAL RATIONS

The data related to chemical composition of experimental rations on dry matter basis are given in Table 2. The three experimental rations (T1, T2 and T3) contained dry matter ranging from 90.13 to 90.32, crude protein from 18.08 to 18.37, ether extract from 1.59 to 1.74, crude fibre from 2.51 to 2.78, total ash from 4.35 to 4.60, nitrogen free extract from 72.87 to 73.23 and acid insoluble ash from 0.55 to 0.57 per cent, respectively.

Thacker *et al.* (1988) in their work in the crossbred pigs fed ration based on hulless barley reported dry matter of 89.2, crude protein of 17.2, ether extract 2 and 4.2 per cent of total ash respectively. Prandini *et al.* (2015) observed dry matter, crude fibre and ether extract contents of 89.15, 2.51 and 1.90 per cent respectively in the ration of heavy growing – finishing pigs (80 to 120 kg) by adding 80 per cent of a normal amylose hulless barley variety named Astartis with control diet. As per ICAR feeding standards (2013), the level of DE for pigs weighing from 10 to 25 kg, 26 to 48 kg and 49 to 75 kg is 3000, 3180, 2600 kcal/kg ration respectively and that of ME is 2886, 3054, 2497 kcal/kg ration, respectively while that of crude protein in the ration is 18.4, 16.7, 15 per cent, respectively.

On an average the three experimental rations T1, T2 and T3 on dry matter basis recorded 0.83, 0.88 and 0.85 per cent of calcium, 0.68, 0.67 and 0.65 per cent of phosphorus and 0.0058, 0.0060 and 0.0058 per cent of magnesium respectively. As per NRC (2012), the requirement of calcium in growing pigs is 0.85, 0.70, 0.66, and 0.59 per cent for 5-7, 11-25, 25-50 and 50-75 kg body weight respectively, whereas the requirement of phosphorus is 0.70, 0.60, 0.56 and 0.52 per cent for 5-7, 11-25, 25-50 and 50-75 kg body weight respectively.

As per NRC (2012) the requirement level of calcium and phosphorus for gestating sows in advanced stage is 0.72 to 0.83 per cent and 0.54 to 0.62 per cent respectively, whereas in case of lactating sows the the requirement level of calcium and phosphorus is 0.60 to 0.80 per cent and 0.54 to 0.67 per cent respectively. As per ICAR (2013), requirement of calcium and phosphorus vary from 0.60 to 0.70 per cent and 0.50 to 0.60 per cent respectively for growing pigs.

5.2 LITTER PERFORMANCE OF SOWS

The average litter size and weight at birth of piglets of the sows in the three treatment groups were 11.20, 10.60, 9.60 and 1.35, 1.45, 1.46 kg, respectively. The average litter size and weight at weaning of piglets of the sows belonging to three treatment groups were 7.00, 9.00, 8.80 and 8.87, 8.25, 8.88 kg, respectively.

There was no significant difference in average litter weight at birth and average litter weight at weaning between sows belonging to three treatment groups. Maupertuis *et al.* (2017) reported that the proportion of total piglets born heavier at birth was higher for sows receiving the grape pulp ration than those fed control ration. They also reported that the litter weight at weaning was heavier (105.6 vs. 93 kg) for sows fed grape pulp ration than those fed control ration.

5.3 BODY WEIGHT, FEED INTAKE ON DRY MATTER BASIS AND FEED CONVERSION EFFICIENCY

5.3.1 Body weight

5.3.1.1 Body weight of piglets

The average fortnightly body weight of piglets maintained on the three experimental rations T1, T2 and T3 are given in Table 4 and represented graphically by Fig. 3. The average initial and final body weights of piglets belonging to sows of three treatment groups were 1.35, 1.45, 1.46 kg and 8.87, 8.25, 8.88 kg, respectively.

In the present study, the statistical analysis of data revealed that piglets belonging to sows of three treatment groups T1, T2 and T3 showed no difference in average final body weight in all weekly intervals, while Prandini *et al.* (2014)

reported that the pigs fed ration with corn and wheat bran replaced by the Astartis hulless barley variety (AS) and the Alamo hulless barley variety (AL) weighed more than those fed the control corn-based diet (Final BW: 21.25 kg and 22.74 kg vs. 21.21 kg) at the end of the study (42 days).

Present results are in agreement with Fiesel *et al.* (2014) who reported no differences in final body weights between the weaned pigs fed control ration and a ration supplemented with 1 per cent grape seed and grape marc meal extract (GSGME) and also Hao *et al.* (2015) who observed no significant differences in final body weight between the piglets fed grape seed procyanidins (GSP) supplemented rations and control ration during overall experimental period of 1 to 28 days.

5.3.1.2 Body weight of sows

The average fortnightly body weight of sows maintained on the three experimental rations T1, T2 and T3 are given in Table 5 and represented graphically in Fig. 4. The average initial and final body weight of sows belonging to three treatment groups were 180.40, 181.00, 180.20 kg and 183.20, 180.80, 180.40 kg, respectively.

In the present study, the statistical analysis of data revealed that the sows belonging to treatment groups T1, T2 and T3 showed no significant difference in average final body weight in all weekly intervals. Present results are in agreement with Daza *et al.* (2010) who observed no significant difference in growth performance between pigs fed a control ration and those fed granulated barley during the finishing period (86 to 130 kg BW).

In contrary to the results, Prandini *et al.* (2015) reported that the pigs fed the control ration with 80 per cent of a normal amylose hulled barley variety and control ration with 80 per cent of a low-amylose hulless barley variety diets had greater final BW (175kg and 175 kg respectively) than those fed the control ration (169kg).

5.3.2 Feed intake on dry matter basis

5.3.2.1 Feed intake of piglets on dry matter basis

Data on weekly average feed intake on dry matter basis of piglets maintained on three experimental rations T1, T2 and T3 are presented in Table 6 and graphically represented in Fig. 5. The total feed intake on DM basis recorded for sows of three treatment groups were 25.88, 25.24 and 26.67 kg respectively. The DM intake was similar in the dietary treatments throughout the experimental period.

Statistical analysis revealed that there was no significant difference in the dry matter intake among sows belonging to three treatment groups T1, T2 and T3 in all weekly intervals except sixth week where lower feed intake was observed for sows in T2 group than those in T1 and T3 groups. But there was no significant difference in total feed intake on DM basis for sows belonging to all treatment groups.

Present results are in agreement with Wu *et al*. (2000) who reported that pigs fed the hulless barley ration was not significantly different from that of pigs fed the corn ration, in terms of daily feed intake during the grower, finisher, and overall periods. Weber *et al.* (2010) concluded that high fibre content in swine rations had been shown to reduce feed intake which is in agreement with the present study where lower feed intake was observed in the piglets fed cooked barley ration (T2) during the sixth week of the trial period.

Yan and Kim (2011) found no significant differences in ADFI of pigs fed FGP ration (Control + 30 g/kg fermented grape pomace) and the pigs fed control ration during starter phase (day 0 to 35). Fiesel *et al.* (2014) also reported no difference in daily feed intakes between the weaned pigs fed control ration and a ration supplemented with 1 per cent grape seed and grape marc meal extract (GSGME). Later Hao *et al.* (2015) concluded that dietary supplementation with GSP at doses of 50 mg/kg, 100 mg/kg and 150 mg/kg basal ration did not exert significant effects on ADFI of piglets during overall experimental period (28 days). All these findings mentioned above are in agreement with the present study.

Nasir *et al.* (2015) reported that the average daily feed intake (ADFI) of piglets did not differ between the wheat ration and the high quality (HQ) barley ration for the entire trial (day 1–21) and Zhou *et al.* (2016) also reported the ADFI did not differ between piglets fed wheat and barley based rations for day 0–7, 8–14 and overall (day 0–21) which is in agreement with the present results.

In contrary to the result, Han *et al.* (2016) observed significant difference in ADFI of weaned piglets between the grape seed procyanidins (GSP) supplemented group than those fed control ration. Kafantaris *et al.* (2018) also reported that inclusion of grape pomace (GP) in the ration of piglets resulted in significantly higher values of ADFI than the piglets fed control ration during 35 to 50 days of trial period.

5.3.2.2 Feed intake of sows on dry matter basis

Data on weekly average feed intake on dry matter basis of sows maintained on three experimental rations T1, T2 and T3 are presented in Table 7 and graphically represented in Fig. 6. The average initial and final feed intake of sows in the three treatment groups were 3.33, 3.57, 3.78 kg and 3.97, 4.40, 4.03 kg, respectively.

Statistical analysis revealed that there was no significant difference in the dry matter intake among sows fed T1, T2 and T3 rations in all weekly intervals. Present results are in agreement with Taranu *et al.* (2017) who found no difference in daily feed intake among the fattening finishing pigs fed grape seed ration (basal ration with 5 per cent grape seed cakes) and control ration. Upadhaya *et al.* (2017) also reported no difference in ADFI among dietary treatments (DB, basal ration containing 5 per cent dehulled barley; WB1, basal ration plus 5 per cent water soaked barley; WB2, basal ration plus 5 per cent WB).

5.3.3 Average daily gain and feed conversion efficiency of piglets

Average daily gain and feed conversion efficiency of piglets maintained on the three experimental rations T1, T2 and T3 are presented in Table 8 and graphically depicted in Fig. 7 and 8. The average weight gain of the piglets was 7.52, 6.80 and 7.42 kg, respectively. The average daily gain of piglets of the three dietary treatments was 179.13, 161.92 and 176.66 g, respectively. The feed conversion efficiency of piglets belonging to three dietary treatments was 3.44, 3.73 and 3.77, respectively.

Piglets fed T1, T2 and T3 rations had no difference among them and were similar with regard to total body weight gain and average daily gain and feed conversion efficiency.

Present results are in agreement with Wu *et al*. (2000) who reported that the feed to gain ratio of pigs fed the hulless barley ration was not different from that of pigs fed the corn ration during the grower period. Yan and Kim (2011) reported no difference in ADG and gain/feed among the pigs fed control ration and FGP ration (Control plus 30 g/kg fermented grape pomace) in the starter phase (day 0 to 35). Daza *et al.* (2012a) also observed no differences for average daily gain in pigs fed granulated barley than in pigs fed control ration for the overall period. Gessner *et al.* (2013) found no difference in average daily gain among the pigs fed a ration supplemented with 1 per cent GSGME (grape seed and grape marc extract) compared to the control ration. Fiesel *et al.* (2014) reported no differences in average daily gain between the weaned pigs fed control ration and a ration supplemented with 1 per cent grape seed and grape marc meal extract (GSGME). Later Hao *et al.* (2015) observed no differences in ADG between the piglets fed grape seed procyanidins (GSP) supplemented rations (basal ration plus 50 mg/kg GSP; basal ration plus 100 mg/kg GSP; basal ration plus 150 mg/kg GSP) and control ration during overall experimental period of day 1 to 28. Nasir *et al.* (2015) reported no difference in G: F ratio between the wheat ration and the high quality (HQ) barley ration (G: F- 0.647 and 0.662) for the entire trial (day 1–21).

In contrary to the present result, Wu *et al*. (2000) reported that average daily gain (ADG) of pigs fed hulless barley diet was higher than that of pigs fed the corn ration during the grower period. Yin *et al*. (2001) noticed that the ADG was increased by 21 and 19 per cent for the pigs at started phase fed with the 50 and 100 per cent micronized dehulled barley (MDB) rations compared with maize based ration. While Daza *et al.* (2010) reported higher FCR in pigs fed granulated barley (FCR: 5.11) than those pigs consumed control ration (FCR: 4.52). Gessner *et al.* (2013) also reported that the gain: feed ratio was increased in the group fed ration containing GSGME compared to the control group. Fiesel *et al.* (2014) reported pigs fed a ration supplemented with 1 per cent grape seed and grape marc meal extract (GSGME) showed an improved gain: feed ratio by 7 per cent in comparison to those fed control ration (620 ± 53 vs. 579 ± 68 g/kg).

Later Nasir *et al.* (2015) reported that dietary inclusion of low quality barley grain to replace 650 g wheat/kg in piglet ration recorded greater ADG than piglets fed the wheat grain for the entire trial (day 1-21). Zhou *et al.* (2016) reported feeding barley (676 g/kg) increased ADG of pigs by 56, 47 and 41 g/d for day 8–14, 14–21 and overall period respectively compared with feeding wheat grain (644 g/kg). Han *et al.* (2016) reported that dietary supplementation with GSPs improved ADG and gain: feed ratio of weaned piglets when compared with those fed control ration. Kafantaris *et al.* (2018) reported increased ADG in the piglets fed grape pomace (GP) ration by 22.79 per cent compared with those fed control ration during 20 to 35 days of trial period (0.237 ± 0.01 vs. 0.193 ± 0.01 kg/day). Kafantaris *et al.* (2018) also reported that inclusion of grape pomace (GP) in the ration of piglets resulted in significantly lower values of FCR compared with those fed control ration during days 20 to 35 days of experimental period.

5.4 DIGESTIBILITY OF NUTRIENTS

5.4.1 Chemical composition of faecal samples of pigs

Data on chemical composition of faecal sample of pigs given the three experimental rations T1, T2 and T3 are presented in Table 9. The faecal sample of pigs contain dry matter ranging from 30.17 to 32.14 per cent, crude protein from 18.71 to 20.39 per cent, ether extract from 4.57 to 5.22 per cent, crude fibre from 7.74 to 8.58 per cent, total ash from 17.28 to 20.62 per cent, nitrogen free extract from 45.71 to 50.20 per cent and acid insoluble ash from 4.12 to 4.98 per cent, respectively. The faecal sample of pigs contain calcium ranging from 2.40 to 2.53 per cent, phosphorus from 2.02 to 2.08 per cent and 0.0067 to 0.0068 per cent of magnesium, respectively.

Vikash (2014) reported similar values in control group for dry matter (30.24 per cent), crude protein (18.47 per cent), ether extract (5.52 per cent), crude fibre (8.78 per cent), total ash (18.22 per cent) and nitrogen free extract (49.01 per cent) in faecal sample of crossbred pigs fed with dietary supplementation of probiotic, prebiotic and symbiotic. Arathy (2016) also reported similar values in control group for dry matter (31.84 per cent), crude fibre (7.70 per cent), total ash (18.99 per cent) and nitrogen free extract (49.50 per cent) in faecal sample of pigs fed with dietary supplementation of lecithin and carnitine.

5.4.2 Apparent digestibility of nutrients

The apparent digestibility of nutrients in the experimental rations estimated from digestibility trial in pigs belonging to three dietary treatments are presented in Table 10 and graphically depicted in Fig. 9. The percentage digestibility of nutrients for three experimental rations were 85.19 to 85.93 for dry matter, 83.30 to 85.49 for crude protein, 55.56 to 59.47 for ether extract, 54.29 to 57.10 for crude fibre, 90.31 to 90.73 for nitrogen free extract, respectively.

Similar corresponding values of nutrient digestibility were also recorded by Arathy (2016) for standard ration in pigs. Elanchezhian (2013) reported values of 85.73 per cent dry matter, 84.48 per cent crude protein, 67.60 per cent ether extract, 55.36 per cent crude fibre, 91.49 per cent NFE whereas Vikas (2014) recorded values of 82.21 per cent dry matter, 80.27 per cent crude protein, 67.91 per cent ether extract, 62.34 per cent crude fibre and 87.77 per cent NFE in standard ration for pigs.

Statistical analysis of data revealed no significant change in the percentage digestibility coefficient of nitrogen free extract among the three rations. No difference was observed in the digestibility of dry matter and crude fibre for T1 and T3 rations but lower in T2 compared to T1 and T3 rations. Crude protein and ether extract digestibility was significantly different among the treatment rations.

Present results are in agreement with Wu *et al*. (2000) who reported that hulless barley ration had a lower apparent digestion coefficient of nitrogen than ration with corn (87.39 to 83.42 per cent). Yan and Kim (2011) reported improved coefficient apparent total tract digestibility (CATTD) of dry matter (DM) in FGP (Control plus 30 g/kg fermented grape pomace) ration than the control ration (DM: 0.795 vs. 0.717) during grower phase (36-70 day of the experiment). Fiesel *et al.* (2014) concluded that apparent total tract digestibilities of crude fiber and nitrogen free extracts in the GSGME ration were not different from the control ration (51.4 vs. 55.1 per cent; 89.9 vs.90.1 per cent respectively). They also observed the apparent total tract digestibility of crude fat of experimental ration had increased in comparison to the control ration (70.0 vs. 65.0 per cent). Nasir *et al.* (2015) also reported that the apparent total tract digestibility coefficient (CATTD) of dry matter (DM) was greater for the wheat ration than for high quality barley rations (DM: 0.817 vs. 0.752) in growing finishing pigs.

In contrary to the result, Wu *et al*. (2000) reported the coefficients of dry matter of hulless barley ration (87.64 per cent) were not significantly different from those of corn ration (87.67 per cent). Upadhaya *et al.* (2017) reported no difference in dry matter and nitrogen, digestibility among dietary treatments.

5.4.3 Availability of minerals

The percentage availability of minerals in the three treatment rations T1, T2 and T3 were 59.04, 57.60, 58.19 for calcium and 58.08, 54.33, 56.26 for phosphorus respectively. The estimated dietary availability of magnesium in the three rations were 83.66, 83.54 and 83.66 per cent. The following data are illustrated in Table 11 and graphically represented in Fig. 10. Similar values of mineral availability were also reported by Arathy (2016) in piglets maintained on ration incorporated with lecithin and carnitine and that ranged from 57.67 to 61.32 per cent for calcium and 53.03 to 57.32 per cent for phosphorus respectively.

Statistical analysis of data revealed that, there was significant difference in the availability of calcium and phosphorus among the treatment rations. T1 recorded higher value compared to T2 and T3.However no significant difference was observed for magnesium availability among the treatment rations.

5.5 ECONOMICS OF PRODUCTION

Data on total feed intake, body weight gain, cost of feed and cost of feed per kg body weight gain of pigs maintained on the three dietary treatments are given in Table 12 and represented graphically in Fig. 11. The cost of ingredients used for the present study was as per the rate contract fixed for the supply of various feed ingredients to the pig farm for the year 2017-2018.

Cost of feed per kg for three experimental rations T1, T2 and T3 were Rs. 27.42, 22.05 and 22.46 respectively. Cost of feed per kg weight gain of piglets belonging to three dietary treatments was Rs. 94.25, 82.26 and 84.69 respectively. Statistical analysis of data revealed that, no significant difference was observed in the cost of feed per kg weight gain among the pigs fed treatment rations. However, the total feed cost was higher for pigs fed T1 ration than the T2 and T3.

In agreement to the results of present study, Shyama (2009) and Jisha (2012) obtained Rs. 59.15 to 63.53 and Rs. 61.45 to 65.62 as cost of feed per kg weight gain in crossbred pigs fed ration supplemented with phytase and zinc respectively. Vikas (2014) obtained similar cost of feed per kg weight gain (Rs. 79.80 to 85.66) in crossbred pigs fed ration incorporated with probiotic, prebiotic and symbiotic. Likewise, Arathy (2016) also obtained similar cost of feed per kg weight gain (Rs. 75.03 to 80.00) by supplementation of lecithin and carnitine on growth in pigs on high fat ration.

On the other hand, lower cost of feed per kg weight gain in pigs was recorded by Suresh (2003) (Rs. 31.50 to 32.82), Sakthivel (2003) (Rs. 32.25 to 35.15), Sreeparvathy (2011) (Rs. 40.71 to 45.25), Elanchezhian (2013) (Rs. 48.13 to 51.54), respectively.

An evaluation of the results obtained in the current experiment indicates that dietary incorporation of cooked barley (T2) and spent grapes (T3) as energy source partially replacing maize resulted in similar performances of sows. No differences could be observed between the treatments with respect to average final body weight, total body weight gain, average daily weight gain, body weight at fortnightly intervals of sows and piglets, feed conversion efficiency of piglets, total dry matter intake of piglets, weekly average dry matter intake of sows and cost of feed per kg body weight gain of piglets, indicating that cooked barley and spent grapes can be effectively included in sow ration partially replacing maize, the total feed cost being significantly decreased in ration containing cooked barley and spent grapes compared to control ration. So it can be concluded that dietary incorporation of cooked barley and spent grapes, partially replacing maize, in sow ration is cost effective resulting in similar litter size and litter performance as that of control ration containing maize.

6. SUMMARY

A feeding trail was conducted at Centre for Pig Production and Research (CPPR), College of Veterinary and Animal Sciences, Mannuthy for a period of 63 days to study the effects of dietary incorporation of cooked barley and spent grapes as energy source in Large White Yorkshire sows. Fifteen Large White Yorkshire pregnant sows three weeks prior to the expected date of farrowing were divided into three groups as uniformly as possible with regard to age and weight and were randomly allotted to three dietary treatments (T1, T2 and T3). There were five replicates for each treatment with one sow in each replicate. They were dewormed with ivermectin suspension through feed before the start of the experiment.

All animals were maintained under identical management conditions throughout the experimental period. The animals were fed twice daily and restricted feeding was followed by allowing them to consume as much as they can within a period of one hour and balance feed, if any, were collected and weighed after each feeding. Daily feed intake was recorded. Fresh drinking water was provided *ad libitum* in all the pens throughout the period.

All the animals were fed with standard lactating ration with 18 per cent crude protein (CP) and 3265 kcal of metabolizable energy (ME) per kg of feed (NRC, 2012). The animals were randomly allotted to three dietary treatments as follows, T1 (control ration as per NRC, 2012), T2 (Control ration plus 25 per cent maize of control ration replaced by cooked barley) and T3 (Control ration plus 25 per cent maize of control ration replaced by spent grapes). Cooked barley and spent grapes were procured from Oushadhi, Kuttanellur, Thrissur at free of cost and were sundried and were added to the corresponding rations.

The sows were weighed at the beginning of the experiment and subsequently at fortnightly intervals. The piglets were weighed after birth and the litter weight was recorded fortnightly up to weaning. A digestibility trial was conducted prior to farrowing to determine the digestibility of the nutrients and

availability of minerals such as calcium, phosphorus and magnesium by total collection method. Chemical compositions of feed and faecal sample were analysed as per methods described in Association of Official Analytical Chemists (AOAC, 2012). Finally, the economics of production per kg body weight gain was calculated.

The average initial and final body weights of piglets of sow fed three experimental rations were 1.35, 1.45, 1.46 kg and 8.87, 8.25, 8.88 kg, respectively. The initial and final body weights of sows on average in the three groups were 180.40, 181.00, 180.20 kg and 183.20, 180.80, 180.40 kg, respectively. On an average, total weight gain of 7.52, 6.80 and 7.42 kg were recorded in the piglets fed three experimental rations during overall period. The animals of treatment groups T1, T2 and T3 showed no significant difference (P>0.05) in average final body weight and total weight gain during the overall experimental period.

The average daily gain and feed conversion efficiency (overall period) were recorded as 179.13, 161.92 and 176.66 g and 3.44, 3.73 and 3.77, respectively in piglets fed the three rations and no differences (P>0.05) observed among them with regard to their average daily gain and feed conversion efficiency. The initial and final feed intake of piglets on average in the three groups were 0.23, 0.21, 0.20 kg and 1.03, 0.93, 1.03 kg, respectively. The initial and final feed intake of sows on average in the three groups were 3.33, 3.57, 3.78 kg and 3.97, 4.40, 4.03 kg, respectively and there was no significant difference in dry matter intake among the three dietary treatment groups in all weekly intervals.

On average the percentage digestibility of nutrients in the three experimental rations T1, T2 and T3 were 85.84, 85.19 and 85.93 per cent for dry matter, 85.49, 83.30 and 84.60 per cent for crude protein, 57.67, 55.56, and 59.47 per cent for ether extract, 56.35, 54.29 and 57.10 per cent for crude fibre and 90.72, 90.73 and 90.31 per cent for nitrogen free extract, respectively. There was no significant change in the percentage digestibility coefficient of nitrogen free extract among three dietary rations. No difference was observed in the digestibility of dry matter and crude fibre for T1 and T3 ration but was lower in T2. Crude protein and ether extract digestibility was significantly different among the three rations. The percentage availability of minerals in the three rations T1, T2 and T3 were 59.04, 57.60, 58.19 for calcium and 58.08, 54.33, 56.26 for phosphorus. The estimated dietary availability of magnesium in the three rations were 83.66, 83.54 and 83.66 per cent. There was significant difference in the availability of calcium and phosphorus among the treatment rations. However no significant difference was observed for magnesium availability among the treatment rations.

Cost of feed per kg body weight gain of piglets retained on three dietary treatments were Rs. 94.25, 82.26 and 84.69 respectively and the values were statistically similar ($P>0.05$).

No differences could be observed between the treatments with respect to average final body weight, total body weight gain, average daily weight gain, body weight at fortnightly intervals of sows and piglets, feed conversion efficiency of piglets, total dry matter intake of piglets, weekly average dry matter intake of sows and cost of feed per kg body weight gain of piglets. No significant difference was observed in the digestibility of NFE among the three dietary rations. Crude protein and ether extract digestibility was significantly different among the three rations, indicating that cooked barley and spent grapes can be effectively included in sow ration partially replacing maize, the total feed cost being significantly decreased in ration containing cooked barley and spent grapes compared to control ration.

So it can be concluded that dietary incorporation of cooked barley and spent grapes, partially replacing maize, in sow ration is cost effective resulting in similar litter size and litter performance as that of control ration containing maize.

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DIETARY INCORPORATION OF COOKED BARLEY AND SPENT GRAPES AS ENERGY SOURCE IN LARGE WHITE YORKSHIRE SOWS

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ABSTRACT OF THESIS

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ABSTRACT

An experiment was carried out for a period of 63 days in Large White Yorkshire pregnant sows belonging to Centre for Pig Production and Research, Mannuthy to assess the effect of dietary incorporation of cooked barley and spent grapes as energy source. Fifteen Large White Yorkshire sows with an average body weight of 180.53 kg, three weeks prior to the estimated date of farrowing were divided into three groups of five each and randomly allotted to three dietary treatments, T1 (18 per cent CP and 3265 kcal/kg ME as per NRC, 2012), T2 (Ration containing cooked barley replacing 25 per cent maize in control ration), T3 (Ration containing spent grapes replacing 25 per cent maize in control ration), using completely randomized design. All the diets were made isocaloric and isonitrogenous. Data on daily dry matter intake, litter performance, body weight at fortnightly intervals of sows and piglets, total body weight gain, average daily gain, feed conversion efficiency of piglets, chemical composition of feed and faeces, digestibility of nutrients, mineral availability were used for evaluation of work. Cost of feed per kg body weight gain of piglets was also estimated.

Average daily gain and total weight gain were 179.13 g, 161.92 g, 176.66 g and 7.52 kg, 6.80 kg, 7.42 kg, respectively for piglets fed T1, T2 and T3 ration and the values were similar. Average final body weight and total dry matter intake of piglets was 8.87, 8.25, 8.88 kg and 25.88, 25.24, 26.67 kg, respectively for T1, T2 and T3. The results of the study indicated that the piglets under dietary treatments T1, T2 and T3 showed similar growth performance with regards to average final body weight, total body weight gain, average daily weight gain and total dry matter intake during overall period. Feed conversion efficiency for piglets fed T1, T2 and T3 was 3.44, 3.73 and 3.77, respectively. Piglets showed no significant difference in feed conversion efficiency among the dietary treatments.

The per cent digestibility of nutrients was 85.84, 85.19 and 85.93 for DM , 85.49, 83.30 and 84.60 for CP, 56.35, 54.29 and 57.10 for CF, 57.67, 55.56 and 59.47 for EE and 90.72, 90.73 and 90.31 for NFE, respectively for rations T1 , T2

and T3. Dietary treatments T1 and T3 showed higher apparent digestibility of dry matter, crude protein, ether extract and crude fibre than T2 ration. The per cent availability of calcium and phosphorus was 59.04, 57.60, 58.19 and 58.08, 54.33, 56.26 respectively for rations T1, T2 and T3. Higher mineral availability was observed in rations T1 and T3 than the T2.

But no differences were observed among animals of dietary groups on body weight, feed intake, litter size and weight at birth, litter size and weight at weaning of piglets and apparent digestibility of nitrogen free extract and availability of magnesium of sows. Cost of feed per kg body weight gain of piglets retained on three dietary treatments were Rs. 94.25, 82.26 and 84.69 respectively. In economic point of view, there was no significant difference among the dietary treatments in terms of cost of feed per kg weight gain. But cost of feed per kg weight gain was lower in animals fed T2 and T3 than the control (T1), though not significant statistically. Hence it can concluded that cooked barley and spent grapes can be included effectively in sow ration without affecting litter performance and litter growth, replacing the energy source maize with a lesser cost of feed per kg body weight gain though not significant.

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