DECLARATION

I hereby declare that this thesis entitled **"Effect of dietary incorporation of ayurvedic pharmaceutic gritham residues on growth performance of Malabari kids"** is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that the thesis, entitled **"Effect of dietary incorporation of ayurvedic pharmaceutic gritham residues on growth performance of Malabari kids"** is a record of research work done by **Mahesh Kajagar** (17-MVP-15) under my guidance and supervision and that 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 **Mahesh Kajagar (17-MVP-15)** a candidate for the degree of Master of Veterinary Science in Animal Nutrition, agree that the thesis entitled **"Effect of dietary incorporation of ayurvedic pharmaceutic gritham residues on growth performance of Malabari kids"** may be submitted by **Mahesh Kajagar (17-MVP-15),** in partial fulfilment of the requirement for the degree.

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EXTERNAL EXAMINER

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1. INTRODUCTION

Goat rearing is an integral part of Indian rural economy, particularly in the arid, semi-arid and mountainous regions of the country (Kumar, 2007). Goat rearing has been one of the most remunerative livestock enterprises. In India goats are reared mainly for meat. Goat meat known as chevon, has huge domestic demand as evinced by the fact that in India 95 per cent of goat meat is consumed locally (Devi *et al*., 2014).

Chevon has heavy human consumer demand due to its high nutritional value. It contains 20.60 to 22.30 per cent protein and 0.60 to 2.60 per cent fat (Devendra, 1988). Goat meat, which contains high amount of polyunsaturated fatty acids and low amounts of saturated fatty acids reduces the risk of coronary heart disease. Chevon is also good source of conjugated linoleic acid (CLA), a fatty acid which helps to prevent cancer and other inflammatory conditions. Goat meat is rich in iron and is hence good for pregnant women, wherein it reduces the risk of anaemia in both the mother and the baby.

Goat, otherwise known as ʻpoor manʾs cowʼ has established itself as a sustainable livestock venture (MacHugh and Bradley 2001). The prospects of goat rearing in Kerala a principally consumerist state, having a non-vegetarian population of nearly 99 per cent, is immense. Chevon fetches a price of Rs. 600 to Rs. 650 per kg, in the Kerala market. At present there is a huge gap between the demand and supply of good quality chevon in Kerala, which needs to be exploited.

Malabari, the native goat breed of Kerala is well suited for being reared for meat purpose. The birth weight of Malabari kids is 2 to 3 kg. It attains a body weight of 8 to 10 kg at the weaning age of three months. Such kids, if selected and reared under intensive system for a period of three months, will attain a body weight of 18 to 20 kg at the market age of six months.

Scarcity of feed resources and increase in feed cost are the major constraints in animal production today. Economic goat rearing, like any other livestock enterprise, can be achieved only by the incorporation of cheaper and locally available agro-industrial byproducts, popularly referred to as nonconventional feed resources

(NCFR), to the extent possible, in place of costly conventional feed ingredients like cereal grains and oilcakes.

Kerala, a state renowned for its ayurvedic tradition has various ayurvedic pharmaceuticals. Byproducts from these pharmaceuticals mainly include waste products of medicinal herbs which are rich in fibre. Ruminants can effectively utilise this fibre as energy source without competing for human feed resources. Though various agro industrial byproducts and crop residues are being used in animal feeds to reduce feed cost, the potential of byproducts from ayurvedic pharmaceuticals has not been explored widely. Hence the present investigation is envisaged with the following objectives:

1. Study the effect of dietary incorporation of four ayurvedic pharmaceutic gritham residues, *viz*., indukanta gritham, tiktaka gritham, brahmi gritham and saraswata gritham by *in vitro* technique.
2. Assess the effect of the best ayurvedic pharmaceutic gritham residue based on i*n vitro* study on growth performance and nutrient utilisation of Malabari kids.

2. REVIEW OF LITERATURE

2.1 NON CONVENTIONAL FEEDS IN ANIMAL NUTRITION

The use of non-conventional feed resources (NCFR) in livestock feeding should be explored to the maximum to get optimum benefit in the feeding of ruminants (Salem *et al*., 2004). Vasta *et al*. (2009) reported that most of the NCFR which were categorised as wastes can be efficiently utilised by animals and by converting them into useful products fit for human use, reducing the problem of limited feed availability. Amata (2014) observed that shortage of feed ingredients in feeding of ruminants, necessitated research for exploring the possibilities of solving the problem.

Agro-industrial byproducts, fruit and vegetable wastes can used for feeding of ruminants (Bakshi *et al*., 2016). Agricultural residues are leftover materials in the field after the harvesting of crops (Prashanthkumar *et al*., 2018).

The major constraints of NCFR in animal feeding are variable chemical composition, problems associated with collection, storage, dehydration and detoxification processes, low digestibility and seasonal production (Al-Masri 2005; Weinberg *et al*., 2008). Singh (2018) observed that there was an urgent need for feed processing techniques that are economic and practicable.

2.2. USE OF AYURVEDIC HERBS, PHARMACEUTICAL BYPRODUCTS, AND RESIDUES IN ANIMAL FEEDING

Verma *et al*. (1996) reported that male growing goats fed on water washed neem seed cake (WWNSC) supplemented rations at 15 and 25 per cent level had similar slaughter body weight as compared to those fed on an unsupplemented control containing mustard cake alone, as protein source. Kudke *et al*. (1999) reported that calves fed on green fodder supplemented with or without powdered neem (*Azadirachta indica*) leaves at 0, 5 and 10 g per day for 12 weeks had a significantly higher growth rate than those fed on the unsupplemented control.

Uegaki *et al*. (2001) observed that in farm animals, the beneficial effects of addition of residues of medicinal herbs are as a result of improved feed intake,

increased secretion of digestive enzymes, decreased digestive disturbances, improved feed efficiency, digestive stimulation, inhibition of methane production, improved productive performance, better reproductive parameters, immune-stimulation, anti-bacterial, anthelminthic, coccidiostatic, antiviral and antioxidative activity. An *et al.* (2007) used red pepper seed oil meal as an unconventional plant protein source in chick feed at 5 and 10 per cent level and observed similar growth rate and significant reduction in serum cholesterol when compared to those fed on unsupplemented control ration.

Sharma (2011) performed an investigation to evaluate the utilisation of herbs, Shatavari (*Asparagus racemosus*) and Bhringraj *(Eclipta alba*) as feed additive in goats by incorporation at levels of 1, 2, 3, 4 and 5 per cent and reported that goats fed on diets with 3 per cent level of incorporation had a significantly higher dry matter intake (DMI), body weight gain and nutrient utilisation than those fed on the other levels as well as the unsupplemented control group. Mir and Kumar (2012) reported that incorporation of raw fenugreek seeds (*Trigonella foenun-graecum)* at the rate of 3 per cent in the diet of goats had similar DMI as compared to those fed on the unsupplemented control group.

Malabari kids fed on kid starter with 20 per cent Ksheerabala residue had a significantly higher growth rate than those fed on kid starter with 10 per cent Ksheerabala residue and a kid starter without Ksheerabala residue (Roshma, 2014). Tufarelli *et al*. (2013) observed that diets supplemented with different levels of partly destined exhausted olive cake (PDEOC) in lamb ration at the rate of 10 and 20 per cent level had a significantly higher body weight and similar feed intake as compared to the unsupplemented control group. Seethal *et al*. (2016) reported that Ksheerabala residue could be incorporated up to 40 per cent level in the rations of crossbred calves with no adverse effect on nutrient digestibility and DMI. Ukanwoko *et al.* (2016) observed that inclusion of *Gmelina arborea* leaves at 10 and 20 per cent levels in the diet of West African dwarf bucks resulted in a significantly higher feed intake, growth rate and feed conversion ratio compared to those fed on control diet.

2.3. CHEMICAL COMPOSITION OF SOME MEDICINAL HERBS, SEEDS AND AYURVEDIC RESIDUES

2.3.1. Dry matter (DM)

Al-Jassir (1992) observed that the DM content of *Nigella sativa* seeds was 95.36 per cent. Verma *et al*. (1996) reported that DM content of WWNSC was 88.2 per cent. Ayssiwede *et al*. (2011) reported that the DM content of *Leuceana leucocephala, Cassia tora, Moringa oleifera, Adansonia digitata,* and *Sesbania rostrata* leaf meal were 92.40, 92. 20, 92.30, 91.10 and 91.60 per cent, respectively. El-bushra (2012) noted that the DM content of fenugreek seeds was 92.85 percent. DM content of Ksheerabala residue was 92.55 per cent (Roshma 2014). Tufarelli *et al*. (2014) observed that the DM content of PDEOC was 92.05. Seethal *et al*. (2018) reported that DM per cent of 'Dhanwantharam' thailam residue was 96.40 per cent.

2.3.2. Crude protein (CP)

The CP content of Shatavari root ranged from 4.60 to 6.10 per cent (Mishra *et al*., 2005). Mokoboki *et al*. (2005) reported that the CP content of *Vachellia karroo* leaf meal was 10.80 per cent. Hosoda *et al*. (2006) observed that the CP content of peppermint, clove and lemon grass extract were 24.30, 8.10 and 10.60 per cent, respectively. Devasena *et al*. (2010) reported that fenugreek (*Trigonella foenugraecum*) seed residue from ayurvedic pharmaceutical industry contained 29.20 per cent CP. Ansari *et al*. (2012) reported that *Azadirachta indica* dried leaf meal contained 20.52 per cent CP. Obeidat *et al*. (2011) reported that sesame hull contained 25.80 per cent CP on DM basis. Roshma (2014) reported that Ksheerabala residue contained 29.52 per cent CP. Tufarelli *et al*. (2013) reported that PDEOC contained 10.21 per cent CP. El-Far *et al*. (2014) reported that seeds of *Nigella sativa* seeds and *Zingiber officinale* contained 28.94 and 7.65 per cent CP, respectively. Seethal *et al*. (2018) reported that the CP content of 'Dhanwantharam' thailam residue was 9.29 per cent.

2.3.3. Ether extract (EE)

Al- Jassir (1992) observed that *Nigella sativa* seeds contained 38.2 per cent of EE. Devasena *et al*. (2010) reported that fenugreek (*Trigonella foenugraecum*) seed residue from ayurvedic pharmaceutical industry contained 3.00 per cent EE. Ayssiwede *et al*. (2011) reported that EE content of *Leuceana leucocephala, Cassia tora, Moringa oleifera, Adansonia digitata* and *Sesbania rostrata* leaf meal were 6.80, 3.80, 9.80, and 14.40 per cent, respectively. Ansari *et al*. (2012) reported that *Azadirachta indica* dried leaf meal contained 7.00 per cent EE. El-bushra (2012) reported that fenugreek seeds contained 9.49 per cent of EE. Mahmoud and Bendary (2014) reported that *Nigella sativa* and sesame seed meal contained 12.72 and 15.45 per cent EE, respectively. Tufarelli *et al*. (2013) observed that the EE content of PDEOC was 1.20 per cent. Seethal *et al*. (2016) reported that Ksheerabala residue contained 13.26 per cent EE. Bhakshi *et al*. (2017) reported that pumpkin waste and pumpkin oil meal contained 4.00 and 1.30 per cent EE, respectively. Seethal *et al*. (2018) reported that the EE content of 'Dhanwantharam' thailam residue was 26.16 per cent.

2.3.4. Crude fibre (CF)

Verma *et al*. (1996) reported that CF content of WWNSC was 12.20 per cent. Al-Jassir. (1992) observed that the CF content of *Nigella sativa* seed was 7.94 percent. Red pepper seed oil meal contained 27.70 per cent of CF. (An *et al*., 2007). Devasena *et al*. (2010) reported that fenugreek (*Trigonella foenugraecum*) seed residue from ayurvedic pharmaceutical industry contained 15.70 per cent CF. Ayssiwede *et al*. (2011) reported that the CF content of *Leuceana leucocephala, Cassia tora, Moringa oleifera, Adansonia digitata,* and *Sesbania rostrata* leaf meal were 14.20, 16.80, 11.70, 14.40 and 16.10 per cent, respectively. El-bushra (2012) reported that the CF content of fenugreek seed was 33.03 percent. Seethal *et al*. (2016) reported that Ksheerabala residue contained 6.39 per cent CF. Mahmoud and Bendary (2014) reported that *Nigella sativa* meal and sesame seed meal contained 10.96 and 9.00 per cent CF, respectively. Seethal *et al*. (2018) reported that CF content of 'Dhanwantharam' thailam residue was 18.37 per cent.

2.3.5. Neutral detergent fibre (NDF)

Smith *et al*. (2005) reported that the NDF content of *Dichrostachys cinerea* and *Acacia nilotica* fruits were 236.00 and 441.00 g per kg DM, respectively. Karabulut *et al*. (2007) reported that the NDF content of *Citrus grandis, Citrus aurantium* and *Citrus oranges* leaves were 355.40, 295.80 and 219.40 g per kg DM, respectively. Devasena *et al*. (2010) reported that fenugreek (*Trigonella foenugraecum*) seed residue from ayurvedic pharmaceutical industry contained 53.20 per cent of NDF. Moyo *et al*. (2011) reported that *Moringa oleifera* leaves contained 11.40 of NDF. Bhat *et al*. (2018) reported that *Artemisia Absinthium* (Titween) contained 52.10 per cent NDF on DM basis. Seethal *et al*. (2016) reported that Ksheerabala residue contained 33.34 per cent of NDF. Seethal *et al*. (2018) found that 'Dhanwantharam' thailam residue contained 59.01 per cent NDF.

2.3.6 Acid detergent fibre (ADF)

Smith *et al*. (2005) reported that the ADF content of *Dichrostachys cinerea* and *Acacia nilotica* fruit were 178.00 and 269.00 g per kg DM, respectively. Karabulut *et al*. (2007) observed that the ADF content of *Citrus grandis, Citrus aurantium* and *Citrus oranges* leaves were 278.80, 253.70 and 240.60 g per kg DM, respectively. Devasena *et al*. (2010) reported that fenugreek (*Trigonella foenugraecum*) seed residue from ayurvedic pharmaceutical industry contained 29.50 per cent ADF. Moyo *et al*. (2011) reported that *Moringa oleifera* leaves contained 8.49 per cent ADF. Seethal *et al*. (2016) reported that Ksheerabala residue contained 14.21 per cent ADF. Bhat *et al*. (2017) observed that *Artemisia Absinthium* (Titween) contained 47.50 per cent ADF on DM basis. Seethal *et al*. (2018) reported that 'Dhanwantharam' thailam residue contained 41.06 per cent ADF.

2.3.7. Nitrogen free extract (NFE)

Al-Jassir (1992) reported that *Nigella sativa* seeds contained 31.94 per cent NFE. Verma *et al*. (1996) reported an NFE level of 34.10 per cent for WWNSC.

Abbas (2010) observed that the NFE content of fenugreek, parsley and sweet basil seeds were 54.36, 42.64 and 61.88 per cent, respectively. Devasena *et al*. (2010) reported that fenugreek (*Trigonella foenugraecum*) seed residue from ayurvedic pharmaceutical industry contained 48.40 per cent of NFE. The NFE content of fenugreek seed was 33.82 per cent as observed by El-bushra (2012). The NFE content of sea buck thorn cake was 53.00 per cent (Hasanuzzaman, 2013). Seethal *et al*. (2016) reported that Ksheerabala residue contained 42.41 per cent of NFE. Seethal *et al*. (2018) reported that the NFE content of 'Dhanwantharam' thailam residue was 40.07 per cent.

2.3.8. Total ash

Al-Jassir (1992) found that the total ash content of *Nigella sativa* seed was 4.37 per cent. Devasena *et al*. (2010) reported that fenugreek (*Trigonella foenugraecum*) seed residue from ayurvedic pharmaceutical industry contained 3.70 per cent total ash. Abbas (2010) found that the total ash content of fenugreek, parsley and sweet basil seeds were 3.68, 8.94 and 9.51 per cent, respectively. El-bushra (2012) found that the total ash content of fenugreek seeds was 7.15 percent. Roshma (2014) reported that the total ash content of Ksheerabala residue was 8.42 per cent. Tufarelli *et al*. (2013) observed that PDEOC contained 9.73 per cent total ash. Mahmoud and Bendary (2014) reported that *Nigella sativa* and sesame seed meal contained 8.45 and 10.2 per cent total ash, respectively. Seethal *et al*. (2018) reported that total ash content of 'Dhanwantharam' thailam residue was 6.11 per cent.

2**.4. EFFECT OF MEDICINAL HERBS, SEEDS AND RESIDUES**

2.4.1. Growth

Bampidis *et al*. (2005) observed that the growth rate of lambs fed on garlic bulb at levels of 0, 3 and 6 percent were similar. Belewu *et al*. (2007) conducted a study by incorporating Tigernut (*Cyperus esculentus*) leaf meal at 10 and 20 per

cent level as replacement for wheat offal in the rations of Western African dwarf goats and reported that goats fed on both 10 and 20 per cent Tigernut meal supplemented diets had a significantly higher weight gain**.** Obeidat *et al.* (2011) reported that the final body weight of Black goat kids fed on seame hull at 10 and 20 per cent level were similar to those fed on unsupplemented control diet.

Sharma (2011) performed an investigation to evaluate the utilisation of herbs, Shatavari (*Asparagus racemosus*) and Bhringraj *(Eclipta alba*) as feed additive in goats by incorporation at levels of 1, 2, 3, 4 and 5 per cent and reported that goats fed on diets with 3 per cent level of incorporation had a significantly higher body weight gain than those fed on the other levels as well as the unsupplemented control. Mir and kumar (2012) observed that the body weight of male non-descript goats fed on fenugreek seed (*Trigonella foenum-graecum*) at the rate of 3 per cent level in the diet had similar growth rate as compared to those fed on unsupplemented control diet.

Zanouny *et al*. (2012) reported that sheep fed on rations supplemented with *Nigella sativa* seeds at the rate of 100 mg and 200 mg per kg body weight per day had a significantly higher weight gain than those fed on the unsupplemented control. Tufarelli *et al*. (2013) observed that incorporation of PDEOC in the diet of *Gentile di Puglia* breed lambs at the rate of 10 and 20 per cent, significantly lowered the growth rate as compared to the control group. Sultana *et al*. (2015) reported that feeding of Moringa (*Moringa Oleifera*) foliage in Black Bengal goats at the rate of 25, 50, 75 and 100 per cent of total ration showed a significantly higher growth rate compared to the control group. Ukanwoko *et al.* (2016) observed that inclusion of *Gmelina arborea* leaves at 10 and 20 per cent levels in the diet of West African dwarf bucks resulted in a significantly higher growth rate compared to those fed on control diet.

Nath *et al*. (2017) conducted a study by supplementing *Carica papaya*, *Artocarpus heterophyllus* and *Terminalia bellirica* leaf mixture at 1:1:1 ratio in concentrate mixture of goat at the rate of 5 and 10 per cent level and reported that goats fed on the mixture at 10 per cent level had a significantly higher growth rate

compared to those fed on 5 per cent leaf mixture and un supplemented control group. Odhaib *et al*. (2018) reported that dietary supplementation of *Rosmarinus officinalis* leaves alone at 1 per cent level in the concentrate mixture of male Dorper lambs resulted in a significantly higher growth rate than those fed on a concentrate mixture without additive as well as concentrate mixture containing *N. sativa* alone and *N. sativa* seeds plus *Rosmarinus officinalis* leaves at 1 per cent level.

2.4.2. Feed intake

Bampidis *et al*. (2005) reported that the feed intake of lambs fed on garlic bulb at 0, 3 and 5 per cent levels, were similar. Rani *et al*. (2006) reported that the DMI of buffalo calves supplemented with two herbs, *viz*., bringraj (*Eclipta alba*) and kutki (*Kutaki picorrhiza*) at the rate of 0.4 per cent DMI, were similar. Belewu *et al.* (2007) observed that Western African dwarf goats fed on diets incorporated with Tigernut (*Cyperus esculentus)* leaf meal at 10 and 20 per cent level as replacement for wheat offal had a significantly higher feed intake than the unsupplemented control.

Obeidat *et al*. (2011) reported that the feed intake of Black goat kids fed on sesame hull at 10 and 20 per cent level were similar to those fed on an unsupplemented control diet.

Sharma (2011) observed that goats fed on diets incorporated with 3 per cent level of herbs, *viz*., Shatavari (*Asparagus racemosus*) and Bhringraj *(Eclipta alba*) had a significantly higher DMI than those fed on the unsupplemented control diet as well as those fed on diets with 1, 2 and 4 per cent level of incorporation.

Hasanuzzaman (2013) found that calves fed on sea buck thorn (SBT) cake at 50 percent level (2.93 kg) had a similar feed intake as that of control group (2.99 kg) but at 75 per cent level, the feed intake was significantly lowered (2.19 kg), in an experiment conducted to replace the CP of GNC with SBT.

Tufarelli *et al*. (2013) observed that incorporation of PDEOC in the diet of *Gentile di Puglia* lambs at 10 and 20 per cent level had a similar feed intake. Roshma (2014) reported that there was no significant difference in DMI of Malabari kids fed on diets containing Ksheerabala residue at the rate 10 and 20 per cent level

as compared to an unsupplemented control. Babeker and Abdalbagi (2015) reported that Sudan Nubian goats fed on *Moringa oleifera* leaves at 20 per cent of the total ration had a significantly higher feed intake than those fed on 50 per cent level and an unsupplemented control ration. Ukanwoko *et al.* (2016) observed that inclusion of *Gmelina arborea* leaves at 10 and 20 per cent levels in the diet of West African dwarf bucks resulted in significantly higher feed intake, compared to those fed on control diet.

Seethal *et al*. (2016) reported that dietary incorporation of Ksheerabala residue in the ration of weaned crossbred calves of one month of age at 0 and 40 per cent level, resulted in similar average daily DMI. Odhaib *et al*. (2018) reported that dietary supplementation of *Rosmarinus officinalis* leaves alone at 1 per cent level in the concentrate mixture of male Dorper lambs had a significantly higher feed intake than those fed on a concentrate mixture without additive as well as concentrate mixture containing *N. sativa* alone and *N. sativa* seeds plus *Rosmarinus officinalis* leaves at 1 per cent level.

2.4.3. Feed conversion efficiency (FCE)

Verma *et al*. (1996) reported that the FCE of goats fed on rations containing 15 and 25 per cent WWNSC, were similar. Belewu *et al*. (2007) reported that Western African dwarf goats fed on 10 and 20 per cent Tigernut meal supplemented diets as replacement for wheat offal had a significantly higher FCE than those fed on an unsupplemented control. Obeidat *et al.* (2011) reported that the FCE of Black goat kids fed on sesame hull at the rate of 10 and 20 level were similar among themselves as well as an unsupplemented control.

Hasanuzzaman (2013) reported that the FCE of calves fed on CP of sea buck thorn cake at 50 and 75 per cent levels as replacement for CP of ground nut cake in the ration, were similar. Zanouny *et al*. (2012) reported that the FCE of sheep fed on rations supplemented with *Nigella sativa* seeds at the rate of 0, 100 and 200 mg per kg body weight per day were similar. Malabari kids fed on kid starter with 20 per cent Ksheerabala residue had a significantly higher FCE than those fed on kid

starter with 10 per cent Ksheerabala residue and kid starter without Ksheerabala residue (Roshma, 2014).

Babeker and Bdalbagi (2015) reported that Sudan Nubian goats fed on *Moringa oleifera* leaves at 20 per cent of the total ration had a significantly higher FCE than those fed on 50 per cent *Moringa oleifera* leaves and an unsupplemented control ration. Ukanwoko *et al.* (2016) observed that inclusion of *Gmelina arborea* leaves at 10 and 20 per cent levels in the diet of West African dwarf bucks resulted in a significantly higher feed conversion ratio compared to those fed on the control diet. Nath *et al*. (2017) observed that the FCE of goats supplemented with the leaf mixture containing *Carica papaya*, *Artocarpus heterophyllus* and *Terminalia bellirica* at 1:1:1 ratio in concentrate mixture at rate 0, 5 and 10 per cent level in the diet, were similar.

2.4.4. Digestibility coefficient of nutrients

Verma *et al*. (1996) observed that the digestibility coefficient of all nutrients except CF were similar in the ration containing WWNSC at 15 and 25 per cent levels as well as on the control ration. These workers also observed that digestible coefficient CF was significantly higher in treatment groups, the values being 53.40 and 58.20 per cent, for the 15 and 25 per cent WWNSC fed groups, respectively, compared to the control, where the value was 46.30 per cent. Rani *et al*. (2006) reported that the digestibility coefficients of nutrients *viz*., DM, CP, NDF and ADF of buffalo calves fed on a ration supplemented with bringraj (*Eclipta alba*) and kutki (*Kutaki picorrhiza*) herbs at the rate of 0.40 per cent of DMI, were similar.

Belewu *et al.* (2007) observed that Western African dwarf goats fed on Tigernut (*Cyperus esculentus)* leaf meal as replacement for wheat offal in the ration at 10 and 20 per cent level had a significantly higher digestibility coefficients of nutrients for CP, CF, EE and ADF than the unsupplemented control. They also observed that the EE digestibility was significantly higher in the control and 20 per cent level than the 10 per cent level. Obeidat *et al*. (2011) reported that the digestibility coefficients of nutrients of Black goats fed on sesame hull at 10 and 20

per cent level were similar to those fed on an unsupplemented control diet. Sharma (2011) observed that incorporation of the herbs, *viz*., Shatavari (*Asparagus racemosus*) and Bhringraj *(Eclipta alba*) as feed additive in goats by incorporation at a level of 3 per cent of ration had a significantly higher digestibility coefficient of nutrients than those fed on the other levels (1, 2, 4 and 5 per cent) as well as the unsupplemented control diet.

Mir and Kumar (2012) found that the digestibility of DM, EE, CP, CF, NDF and ADF was significantly higher in goats fed on 3 per cent fenugreek seeds (*Trigonella foenum-graecum*) as compared to the unsupplemented control group. Tufarelli *et al*. (2013) observed that inclusion of PDSEOC at 0, 10 and 15 per cent levels in the diet of lambs resulted in similar values for digestibility coefficients of nutrients of CP and EE. These researchers also found that the DM digestibility was significantly lower for both diets containing PDSEOC as compared to the unsupplemented control.

Zanouny *et al*. (2012) reported that sheep supplemented with *Nigella sativa* seeds at the rate of 100 and 200 mg per kg body weight per day had significantly higher values for digestibility coefficients of DM, CP, EE, CF and NFE as compared to the unsupplemented control group. Roshma (2014) reported that Malabari kids fed on Ksheerabala residue at the rate of 0, 10 and 20 per cent in kid starter had similar digestibility coefficients of nutrients. Seethal *et al*. (2016) reported that dietary incorporation of Ksheerabala residue in weaned crossbred calves of one month of age at the rate of 0 and 40 per cent in the calf starter, resulted in similar digestibility coefficient of nutrients compared to the unsupplemented control group, except for CP and EE, which were significantly higher in the treatment groups than the unsupplemented control group.

2.4.5. Haemato-biochemical parameters

Verma *et al*. (1996) reported that male growing goats fed WWNSC supplemented rations at 15 and 25 per cent level had haemoglobin levels as compared to those fed on an unsupplemented control containing mustard cake alone

as protein source. Habeeb and El-Tarabany (2012) reported that Zaraibi goat kids, fed on a ration supplemented with *Nigella sativa* seed (T1) and Curcumin (T2) at the rate of 2 g per day had a significantly higher haemoglobin level compared to the unsupplemented control (T3), the values being 12.90, 12.50 and 11.56 g per 100 ml for T1, T2 and T3, respectively. Chaturvedi *et al*. (2013) found that the haemoglobin levels of Barbari goat kids fed on 0.50 per cent of herbal additive mixture of Tulsi (*Ocimum sanctum*), Haldi (*Curcuma longa*), Amla (*Emblica officinalis*) and Arni (*Clerodendrum phlomidis*) in the ratio of 1:1:1:1 were similar at both 21st and 170th day.

Roshma (2014) reported that haemoglobin level of Malabari kids fed on kid starters incorporated with Ksheerabala residue at the rate of 0 (T1), 10 (T2) and 20 (T3) per cent level were similar, the values being 11.88, 12.00 and 11.94 g per 100 ml for kids in groups T1, T2 and T3, respectively. Babeker and Abdalbagi (2015) reported that Sudan Nubian goats fed on *Moringa oleifera* leaves at 20 and 50 per cent of the total ration had a significantly higher haemoglobin level compared to an unsupplemented control ration. El-halim *et al*. (2014) reported that the haemoglobin values in sheep fed on diet containing black cumin (*Nigella sativa*) seed oil at the rate of 47 mg per kg of concentrate were similar to those fed on an unsupplemented control.

Thakur *et al*. (2015) reported that the haemoglobin levels of goat kids fed on solvent extracted karanj seed cake at 8.09 and 16.18 per cent level in the concentrate mixture as replacement for 25 and 50 per cent of ground nut cake and a control ration were similar. Seethal *et al*. (2018) observed that crossbred calves fed on diets incorporated with 'Dhanwantharam' thailam residue at the rate of 20 (T2) and 30 (T3) per cent of the ration had a significantly higher haemoglobin level compared to the unsupplemented control group (T1), the values being 10.43, 11.42 and 11.52 g per 100 ml for kids fed on the rations T1, T2 and T3, respectively.

2.4.6. Serum biochemical parameters

Habeeb and El-Tarabany (2012) reported that Zaraibi goat kids, fed on a ration supplemented with *Nigella sativa* seed (T1) and Curcumin (T2) at the rate

of 2.00 g per day had a significant higher total protein level compared to the control un supplementedgroup. These workers also reported that the levels of liver enzyme like ALT and AST were similar in all the groups.

Roshma (2014) observed that total protein, cholesterol and triglycerides of Malabari kids fed on diets incorporated with Ksheerabala residue at the rate of 0, 10 and 20 per cent in the ration were similar. Al-Sherwany (2015) reported that the value of total protein, cholesterol, Triglyceride and liver enzymes aspartate aminotransferase (AST) and alanine transaminase (ALT) in the serum of Hamdani ewes fed on crushed fenugreek seed at the rate of 0.60 and 1.20 g per kg live body weight were similar among themselves also to an unsupplemented control basal diet. Babeker and Abdalbagi (2015) reported that Sudan Nubian goats fed on *Moringa oleifera* leaves at 20 per cent of the total ration had a significantly higher serum total protein compared to those fed on 50 per cent *Moringa oleifera* leaves and an unsupplemented control ration. Seethal *et al*. (2018) reported that the serum total protein, total cholesterol, ALT, and AST of the crossbred calves fed on diets incorporated with 'Dhanwantharam' thailam residue at the rate of 20 and 30 per cent of the ration and an unsupplemented control group, were similar.

2.4.7. *In vitro* gas production technique

Akinfemi *et al*. (2009) conducted an experiment by *in vitro* gas production technique **(**IVGPT) with agricultural wastes like cassava peels, maize cobs, orange pulps, guinea corn threshed tops and yam peels using rumen liquor of West African Dwarf female goats and found that the metabolisable energy (ME) and organic matter digestibility (OMD) values were 8.51, 6.63, 9.41, 7.56, 10.31 MJ per kg DM and 60.73, 48.32, 66.08 5.20, 72.10 per cent, respectively. Negesse *et al*. (2009) performed IVGPT on cactus (*Opuntia ficus-indica*) by using the rumen liquor of rumen-cannulated, Holstein Friesian cows and reported ME and DOM values 7.50 MJ per kg DM and 650 g per kg DM, respectively.

Anugna *et al.* (2018) performed IVGPT to evaluate four different ayurvedic pharmaceutic residues, viz., panchagavya gritham kottamchukkadi thailam,

dhanvantharam kashayam and vilvadi lehyam and reported that the values of ME, DOM and *in vitro* IVDN (as a per cent of N) were 4.49, 4.64, 5.07, 2.39 MJ per kg DM; 48.13, 51.10, 62.30, 28.67 per cent and 19.51, 19.39, 27.53, 26.62 per cent, respectively. Raseel (2018) performed IVGPT to evaluate four energy rich un conventional feeds, *viz.*, pine apple waste, cashew apple waste, banana stem waste and jackfruit waste and reported that the values of ME, DOM and IVDN as a per cent of total N were 9.66, 8.20, 5.47, 7.52 MJ per kg DM; 67.65, 50.81, 54.91, 57.88 per cent and 45.61, 44. 40, 50.18, 45.75 per cent, respectively.

2.4.8. Economics

Ghosh *et al*. (2010) reported that crossbred dairy calves fed on garlic extract supplemented ration at 200 mg per kg body weight had a significantly lower feed cost per kg gain (Rs. 161.61) compared to those fed on an un supplemented control group (Rs. 231.01). Obeidat and Gharaybeh (2011) reported that Black goat kids fed on sesame hull at the rate of 10 and 20 per cent, had a significantly lower cost per kg gain ($ 3.37) compared to those fed on an unsupplemented control ($ 4.01).

Roshma (2014) reported that Malabari kids fed on kid starter with 20 per cent Ksheerabala residue had a lower cost per kg gain compared to those fed on 10 per cent residue and the unsupplemented control, the values being Rs. 91.97, 115.92 and 80.85 per kg gain for the control, 10 and 20 per cent supplemented groups, respectively

3. MATERIALS AND METHODS

This research was conducted in Malabari goat kids to study the effect of dietary incorporation of ayurvedic pharmaceutic gritham residues on growth performance. The study was carried out in Goat Farm, Instructional Livestock Farm Complex (ILFC), College of Veterinary and Animal Sciences, Pookode. The materials used and the methodology adopted during the conduct of research work are discussed in this chapter.

3.1. COLLECTION OF STUDY MATERIAL

The residues obtained from the manufacture of four ayurvedic pharmaceutic grithams such as indukanta gritham, tiktaka gritham, brahmi gritham and saraswatha gritham were procured from the Vaidyarathnam P. S. Varier's Arya Vaidya Shala, Kottakkal.

3.2. *IN VITRO* STUDY

Four ayurvedic pharmaceutic grithams, *viz.,* indukanta gritham, tiktaka gritham, brahmi gritham and saraswatha gritham were tested *in vitro* by the *in vitro* gas production technique (IVGPT) to estimate the metabolisable energy (ME), digestible organic matter (DOM) and *in vitro* degradable nitrogen (IVDN) content in the feeds.

3.2.1. *In vitro* gas production - Calculation of ME, DOM and IVDN

The prediction equation for the calculation of ME and DOM from gas production data are given below:

ME (KJ/kg DM) = 1.24+0.146 x gas (ml/200 mg DM) + 0.007 x CP* + 0.0224 x EE*

DOM (%) = 14.88+0.889 x gas (ml/200 mg DM) + 0.45 x CP*+0.65 x TA*

*CP (crude protein content in %), EE (ether extract in %) and TA (total ash in %)

$$IVDN^{**} = \frac{A-(A-B)\ C-(\text{ammonia nitrogen of blank})}{(C-D)} \Big/ \text{Total nitrogen of feeding stuff incubated}$$

**A = mg of ammonia nitrogen after 24 h incubation, with no carbohydrate added; B = mg NH_3-N after 24 h incubation with carbohydrate added; C = ml gas production in 24 h, with no carbohydrate added; D = ml of gas production in 24 h, with carbohydrate added (Raab *et al*. 1983 and Menke and Steingass, 1988)

3.2.2. SCORING SYSTEM

A four point scoring system as depicted in Table 1 was devised for ranking the unconventional feeds tested in the *in vitro* study. Based on the values obtained for each of the above three parameters¸ individual scores were assigned for each of the four unconventional feeds tested and the feed ingredient having the highest aggregate score was selected as the best feed.

3.3. SELECTION AND GROUPING OF GOAT KIDS

Fifteen healthy Malabari kids of three months of age were selected from Goat Farm, ILFC, Pookode. They were divided into three groups of five animals in each, on the basis of their body weight, age and sex, following completely randomised design. These animals were maintained for two weeks on a standard diet which consisted of kid starter and green grass, before the start of the actual experiment.

3.4. HOUSING AND MANAGEMENT

The kids were housed in well ventilated sheds having facilities for individual feeding and watering. Strict management and hygienic practices were adopted throughout the experimental period. All the kids were dewormed before the start of experiment and subsequently at regular intervals. Clean drinking water was provided *ad libitum*.

3.5. FORMULATION OF KID STARTER

The kids in the three experimental groups were fed with a kid starter containing 24 per cent crude protein and 70 per cent TDN for the entire feeding period of 90 days.

The three experimental kid starter were formulated as per BIS (2012)

T_1 – kid starter (control)

T_2 - kid starter containing 10 per cent of gritham residue selected from *in vitro* study

T_3- kid starter containing 20 per cent of gritham residue selected from *in vitro* study

3.6. EXPERIMENTAL RATION

The experimental rations were prepared at Feed Mixing Plant, ILFC. Pookode. The ingredient composition of experimental kid starters of T1, T2 and T3 are presented in Table 2. Kids were maintained under uniform management conditions and were fed on isonitrogenous and isocaloric rations (ICAR, 2013). They were maintained on their respective feeding regimen for a period of three months.

3.7. FEEDING TRIAL.

Data on daily feed and fodder intake and fortnightly body weight were recorded during the course of the experiment.

3.7.1. Dry matter intake

Weighed quantity of calf starter and fresh green grass were given daily in the forenoon and afternoon, respectively to the kids throughout the experimental period. Individual data on quantity of kid starter and green grass offered daily were recorded. Left over portion of the kid starter and green grass were weighed daily and its moisture content was analysed to calculate the dry matter intake. Daily dry matter intake from calf starter and green grass with respect to each kid was calculated and the total dry matter intake was estimated. The concentrate allowance and green grass offered were increased based on intake and body weight taking into

consideration the increased nutrient requirement that commensurate with the growth increment.

3.7.2. Body weight

Body weight of kids were recorded on fortnightly basis using the electronic weighing balance at ILFC, Pookode. Body weight was recorded in the morning, before feeding and watering.

3.7.3. Feed efficiency

Based on the data on feed intake and body weight, the feed efficiency was calculated.

3.8. PROXIMATE ANALYSIS

Samples of ayurvedic residue, kid starter and dung were analysed for proximate principles as per the methods of Association of Official Analytical Chemists (AOAC, 2016). Samples of feed and dung were analysed for neutral detergent fibre (NDF) and acid detergent fibre (ADF) as per the methods of Van Soest *et al.* (1991). The calcium and phosphorus content of the feed was determined by standard procedure (AOAC, 2016).

3.9. BLOOD AND SERUM ANALYSIS

Blood samples were collected at the beginning and end of the experiment to estimate haemoglobin (cyanomethemoglobin method), plasma protein (direct Biuret method), triglycerides (peroxidase coupled method), total cholesterol (CHOD-PAP method), AST and ALT (IFCC method) using standard kits supplied by Agappe Diagnostics, Maharashtra, India. All the hematological parameters listed above were determined using the Auto analyser (Merck, Microlab 300).

3.10. DIGESTIBILITY TRIAL

A digestibility trial of five days duration was conducted at the twelfth week of the experiment. The feeding schedule was same in digestibility trial period as the week prior to it. Weighed amount of feed was offered at regular intervals and

residue was collected on 24 hour basis. Each animal in separate pen was assigned a bucket for collection of dung voided by it. Dung voided by each animal was collected immediately and was stored in respective buckets. Amount of feed offered, balance feed and amount of dung voided by each animal was recorded.

The total dung voided by individual kids during the period of 24 hours was collected and weighed at a fixed time (9.00 A.M), regularly. A proportionate sample of dung from each animal was taken after thorough mixing and stored at a temperature of -20°C in double lined polythene bags. The samples of five days were pooled together and the pooled samples were analysed for proximate principles. From the data on feed intake, dung output and nutrient composition of feed and dung, digestibility coefficient of various nutrients were calculated for each animal.

3.11. ECONOMICS

From the data gathered on various parameters, the cost of feed per kilogram of weight gain was worked out.

3.12. STATISTICAL ANALYSIS

All the data generated in the above experiments was statistically analysed as per Snedecor and Cochran (1994) by analysis of variance (ANOVA) technique, using statistical package for social sciences (SPSS) version 21.0.

Table 1: Score sheet for ranking the unconventional feeds of *in vitro* study

Parameter tested *in vitro*	Unit (on DM basis)	Range of value	Score
ME	MJ/kg DM	<4	0
		4-5	+
		5-6	++
		6-7	+++
		7-8	++++
		8-9	+++++
		>9	++++++
DOM	%	<40%	0
		40-50	+
		50-60	++
		60-70	+++
		70-80	++++
		80-90	+++++
		>90%	++++++
IVDN as % of total N	%	<40%	0
		40-50	++++
		50-60	+++++
		60-70	++++++
		70-80	+++
		80-90	++
		>90%	+

Table.2. Ingredient composition of kid starter* (%)

Ingredients	T1 (Control – without selected gritham residue) kg	T2 (Treatment – with selected gritham residue 10%) kg	T3 (Treatment – with selected gritham residue 20%) kg
Maize	37	10	1
Soyabean meal	38	35	33
Deoiled rice bran	22	42	43
Calcite	2	2	2
Salt	1	1	1
Gritham residue	0	10	20
Total	100	100	100

***** To every 100 kg of kid starter, 100g of Vitamin AD_3E supplement (containing 10,00,000 IU of Vitamin A, 2,00,000 IU of Vitamin D_3 and 1,00,000 IU of Vitamin E), 50g of trace mineral mixture (KERAMIN FORTE) and 50g of toxin binder (CURATOX) were added.

4. RESULTS

The results obtained in the present study are given under the following headings:

Photographs of the four ayurvedic pharmaceutic gritham residues and *in vitro* gas production in glass syringes are presented in Plates 1 and 2, respectively.

4.1. *IN VITRO* STUDY

The results of *in vitro* study of four ayurvedic pharmaceutic gritham residues are presented in Table 4. The scores obtained are given in Table 5 and represented in Figure 1.

4.2. CHEMICAL COMPOSITION

Chemical composition of the four ayurvedic pharmaceutic gritham residues and three experimental rations are given in the Tables 3 and 6, respectively. The CP content of three experimental rations T1, T2 and T3 were 23.50, 22.96 and 22.92 per cent, respectively. The CP of green grass used for feeding of kid along with kid starter was 9.43 per cent on dry matter basis.

4.3. DRY MATTER INTAKE (DMI)

Average fortnightly daily DMI (kg) of experimental kids maintained on the three different dietary treatments are shown in Table 7 and graphically represented in Figure 2. The fortnightly average DMI per 100 kg body weight and DMI per kg metabolic body weight both in kg, are presented in Tables 8 and 9, respectively.

4.4. BODY WEIGHT

The data on fortnightly body weight (kg) of experimental kids maintained on the three different rations are given in Table 10 and graphically represented in Figure 3. Fortnightly weight gain (kg) of experimental kids are given in Table 11 and graphical represented in Figure 4.

4.5. AVERAGE DAILY GAIN (ADG)

Consolidated data on initial and final body weight, total weight gain, all in kg and ADG (g) of experimental kids maintained under the three different dietary treatments are given in Table 12. The initial body weight of the experimental animals in the groups, T1, T2 and T3 were 11.10, 11.18 and 11.16 kg, respectively. ADG of kids maintained on the three different rations, T1, T2 and T3 were 56.44, 64.66 and 54.88 g per day, respectively.

4.6. FEED CONVERSION EFFICIENCY (FCE)

The mean cumulative FCE (kg feed per kg body weight gain) is presented in Table 13 and graphically represented in Figure 6. The cumulative FCE of kids maintained on the three different experimental feeds was 5.08, 4.48 and 5.13 for kids maintained on rations T1, T2 and T3, respectively.

4.7. DIGESTIBILITY COEFFICIENT OF NUTRIENTS

The chemical composition of the dung of experimental kids collected during the digestion trail are given Table 14. The digestibility coefficient of nutrients *viz.*, dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen free extract (NFE), neutral detergent fibre (NDF), acid detergent fibre (ADF) of kids fed on the experimental rations are given in Table 15 and graphically represented in Figure 7.

4.8. HAEMATO-BIOCHEMICAL PARAMETERS

The summarised data of the values of blood and serum parameters such as haemoglobin, total protein, aspartate aminotransferase (AST), alanine transaminase (ALT), total cholesterol and total triglycerides of experimental kids maintained on the experimental rations, estimated at the beginning and end of the feeding trail are given in Table 16 and graphical representation of the same at the beginning and end of the experiment are given in Figures 8, 9, 10, 11, 12 and 13 respectively.

4.9. TECHNO-ECOMNOMICS

Techno-economics of production of the present study are presented in Table 17 and graphically represented in Figure 14. Cost per kg body weight gain of experimental kids fed on rations, T1, T2 and T3 were Rs.172.22, 141.88 and 149.91, respectively.

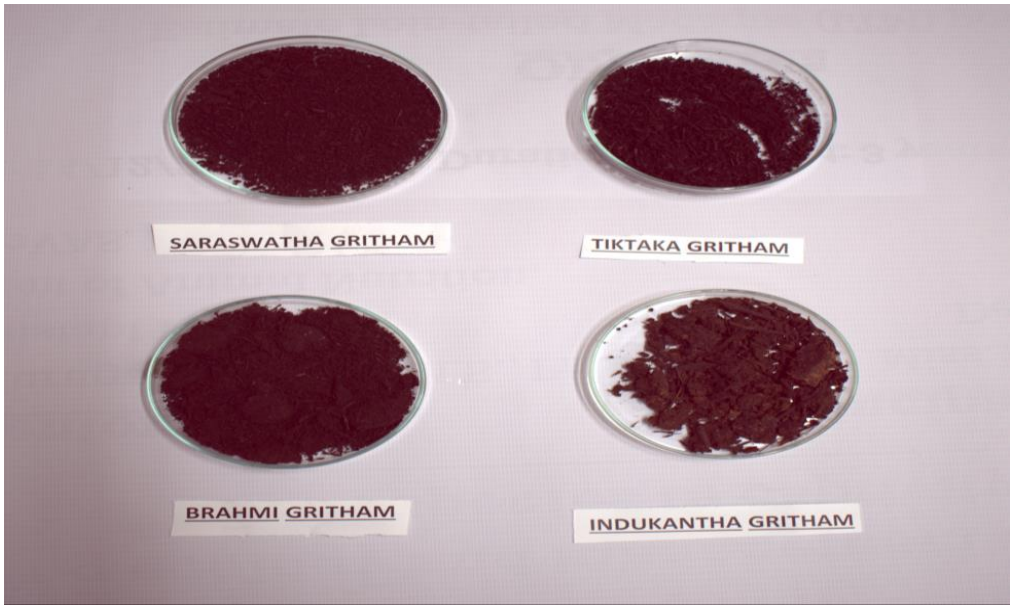

Plate 1. Photograph of four ayurvedic pharmaceutic gritham residues tested *in vitro*

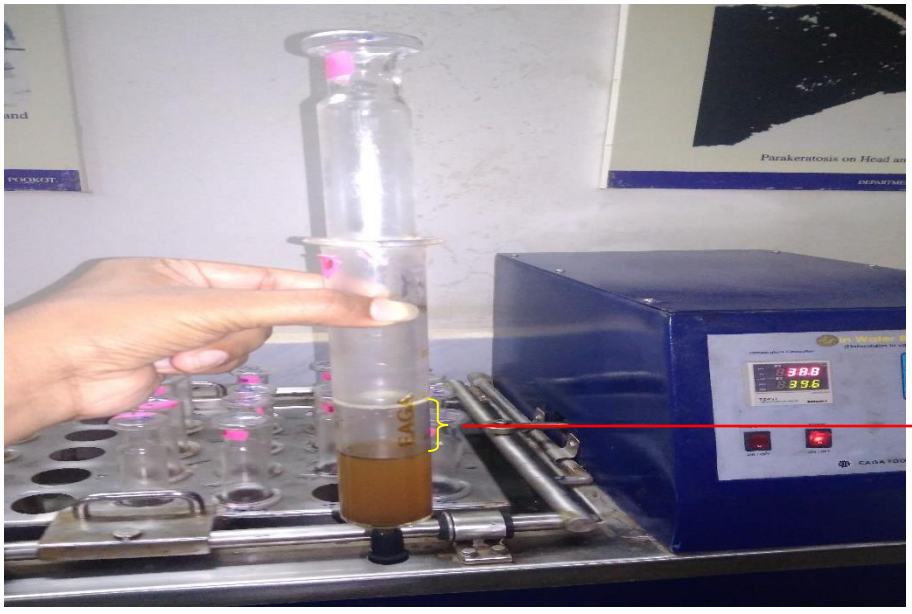

Plate 2. Photograph of glass syringe with gas produced in IVGPT

Table 3. Chemical composition of ayurvedic pharmaceutic gritham residues

Parameter	Nutritive value (%, on DM basis)			
	Saraswatha gritham residue	Tiktaka gritham residue	Brahmi gritham residue	Indukantha gritham residue
DM	86.90	90.00	90.00	86.00
CP	21.87	17.50	14.50	21.50
CF	15.71	23.42	15.39	19.58
EE	13.50	20.50	20.00	7.22
Total ash	10.90	7.23	11.37	14.14
NFE	38.02	31.35	38.74	37.56
Acid insoluble ash	0.56	0.74	0.68	0.35
NDF	30.50	34.30	34.12	35.95
ADF	20.40	19.89	20.15	18.9
Hemicellulose	10.10	14.41	13.97	17.05
Ca	1.58	1.66	1.58	1.66
P	1.00	1.20	2.10	1.90

Table 4. *In vitro* characteristics of four ayurvedic pharmaceutic gritham residues

Parameters	Saraswatha gritham residue	Tiktaka gritham residue	Brahmi gritham residue	Indukantha gritham residue
ME (MJ/kg DM)	5.60	5.61	5.77	5.34
DOM (%)	55.72	57.24	51.93	58.29
IVDN as % of total N	24.04	32.36	41.45	16.40

Table 5. Score card after assigning grade to each parameter

Residue	ME (MJ/kg DM)	DOM (%)	IVDN (as % of total N)	Total
Saraswatha gritham	2	2	0	4
Tiktaka gritham	2	2	0	4
Brahmi gritham	2	2	1	5
Indukantha gritham	2	2	0	4

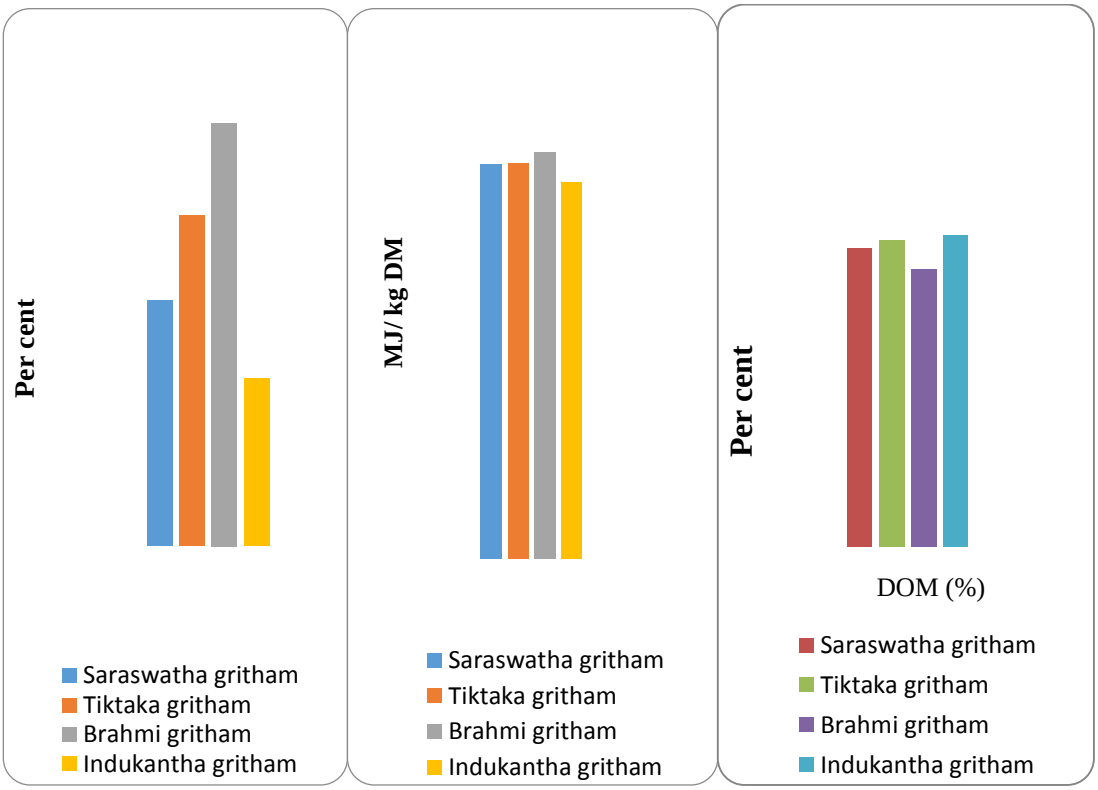

Fig. 1. *In vitro* characteristics of ayurvedic pharmaceutic gritham residues

Table 6. Chemical composition of kid starter and green grass fed to experimental kids*, (%, on DM basis)

Parameter	Dietary treatments			Grass
	T1	T2	T3	
DM	89.04 ± 0.03	89.04 ± 0.04	89.11 ± 0.06	23.00 ± 0.58
CP	23.50 ± 0.05	22.96 ± 0.06	22.92 ± 0.03	9.46 ± 0.17
CF	9.20 ± 0.05	10.16 ± 0.03	13.25 ± 0.02	37.36 ± 0.34
EE	4.22 ± 0.06	4.52 ± 0.02	9.57 ± 0.03	1.88 ± 0.09
Total ash	10.33 ± 0.06	13.62 ± 0.02	9.59 ± 0.01	10.20 ± 0.06
NFE	52.66 ± 0.08	48.74 ± 0.04	44.67 ± 0.05	41.10 ± 0.29
Acid insoluble ash	0.90 ± 0.15	1.46 ± 0.06	1.73 ± 0.02	2.45 ± 0.04
NDF	28.92 ± 0.03	33.56 ± 0.22	33.61 ± 0.01	48.63 ± 0.59
ADF	15.93 ± 0.08	17.66 ± 0.18	18.23 ± 0.003	38.1 ± 0.33
Hemicellulose	12.99 ± 0.09	15.90 ± 0.40	15.38 ± 0.02	10.53 ± 0.86
Ca	1.50 ± 0.06	0.99 ± 0.06	1.37 ± 0.35	0.48 ± 0.03
P	1.00 ± 0.11	1.30 ± 0.05	1.33 ± 0.03	0.36 ± 0.02

* Average of five values with SE

Table 7. Fortnightly average daily dry matter intake* of kids maintained on the three experimental rations, kg

Fortnight	Dietary treatments			F - value	p - value
	T1	T2	T3		
1	0.37 ± 0.04	0.39 ± 0.03	0.40 ± 0.04	0.11^{ns}	0.89
2	0.43 ± 0.05	0.46 ± 0.03	0.47 ± 0.04	0.23^{ns}	0.79
3	0.48 ± 0.05	0.52 ± 0.03	0.52 ± 0.04	0.23^{ns}	0.79
4	0.55 ± 0.05	0.59 ± 0.03	0.59 ± 0.04	0.23^{ns}	0.79
5	0.61 ± 0.05	0.65 ± 0.03	0.66 ± 0.04	0.33^{ns}	0.72
6	0.68 ± 0.05	0.74 ± 0.03	0.76 ± 0.04	0.79^{ns}	0.47

* - Average of five values with SE

ns- Non significant

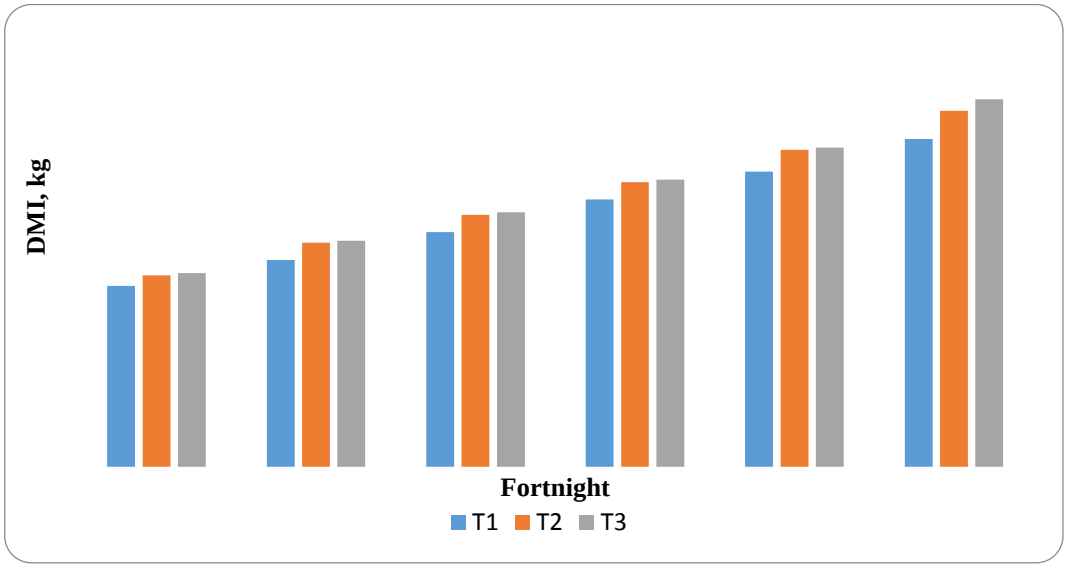

Fig 2. Fortnightly average daily dry matter intake of kids maintained on the three experimental rations, kg

Table 8. Fortnightly average daily dry matter intake* per 100 kg body weight of kids maintained on the three experimental rations, kg

* Average of five values with SE

Fortnight	Dietary treatments			F - value	p - value
	T1	T2	T3		
1	3.69 ± 0.38	3.81 ± 0.37	3.73 ± 0.17	0.05 ^{ns}	0.95
2	3.90 ± 0.37	4.16 ± 0.42	4.13 ± 0.20	0.16 ^{ns}	0.85
3	4.26 ± 0.47	4.36 ± 0.41	4.45 ± 0.25	0.06 ^{ns}	0.94
4	4.63 ± 0.53	4.60 ± 0.43	4.70 ± 0.28	0.01 ^{ns}	0.98
5	4.83 ± 0.54	4.80 ± 0.50	4.98±0.34	0.04 ^{ns}	0.95
6	4.98 ± 0.56	5.03 ± 0.50	5.36 ± 0.37	0.19^{ns}	0.83

ns- Non significant

Table 9. Fortnightly average daily dry matter intake* per kg metabolic body weight of kids maintained on the three experimental rations, kg

*- Average of five values with SE

Fortnight	Dietary treatments			F - value	p - value
	T1	T2	T3		
1	0.06 ± 0.003	0.06 ± 0.004	0.06 ± 0.002	0.25^{ns}	0.77
2	0.07 ± 0.003	0.07 ± 0.004	0.07 ± 0.002	0.80^{ns}	0.46
3	0.07 ± 0.005	0.08 ± 0.004	0.08 ± 0.003	0.40^{ns}	0.67
4	0.08 ± 0.006	0.08 ± 0.005	0.08 ± 0.003	0.13^{ns}	0.87
5	0.09 ± 0.005	0.09 ± 0.005	0.09 ± 0.004	0.25^{ns}	0.78
6	0.09 ± 0.006	0.09 ±0.006	0.10 ± 0.004	0.66^{ns}	0.53

ns- Non significant

Table 10. Fortnightly average body weight[1] of kids maintained on the three experimental rations, kg

Fortnight	Dietary treatments			F - value	p - value
	T1	T2	T3		
0	11.10 ± 0.23	11.18 ± 1.99	11.16 ± 1.62	2.18^{ns}	0.15
1	11.76±2.24	11.98 ± 2.00	11.68 ± 1.62	2.19^{ns}	0.15
2	12.40 ± 2.30^{ab}	12.78 ± 2.02^{a}	12.20 ± 1.61^{b}	4.77 *	0.03
3	13.02 ± 2.33	13.60 ± 2.02	13.04 ± 1.66	3.93 ^{ns}	0.05
4	13.74 ± 2.41	14.46 ± 2.02	13.78 ± 1.78	1.62^{ns}	0.24
5	14.80 ± 2.52	15.58 ± 2.17	14.72±1.88	1.81 ^{ns}	0.21
6	16.18 ± 2.66	16.86 ± 2.29	16.10 ± 1.95	1.86 ^{ns}	0.20

1 – Average of five values

ns- Non significant

* - Significant at 5 per cent level

a, b and ab - Means with different superscripts within the same row differ significantly

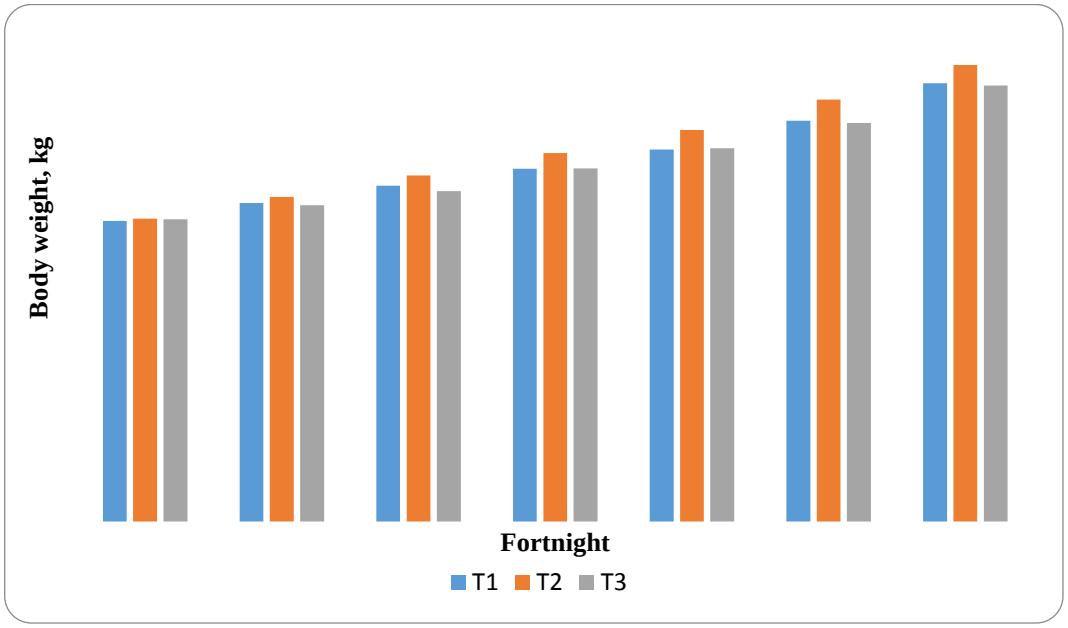

Fig.3. Fortnightly average body weight of kids maintained on the three experimental rations, kg

Table 11. Fortnightly average body weight gain[1] of kids maintained on the three experimental rations, kg

Fortnight	Dietary treatments			F - value	p - value
	T1	T2	T3		
1	0.66 ± 0.06^{ab}	0.80 ± 0.14^{a}	0.38 ± 0.06^{b}	4.93^{*}	0.02
2	0.64 ± 0.06	0.72 ± 0.03	0.57 ± 0.05	1.86^{ns}	0.19
3	0.62 ± 0.08	0.90 ± 0.14	0.94 ± 0.14	1.82^{ns}	0.20
4	0.72 ± 0.17	0.96 ± 0.16	0.80 ± 0.13	0.61^{ns}	0.55
5	1.06 ± 0.16	1.06 ± 0.20	1.04 ± 0.29	0.002^{ns}	0.99
6	1.38 ± 0.14	1.38 ± 0.17	1.20 ± 0.20	0.35^{ns}	0.70

1- Average of five values with SE

ns- Non significant

* - Significant at 5 per cent level

a, b - Means with different superscripts within the same row differ significantly

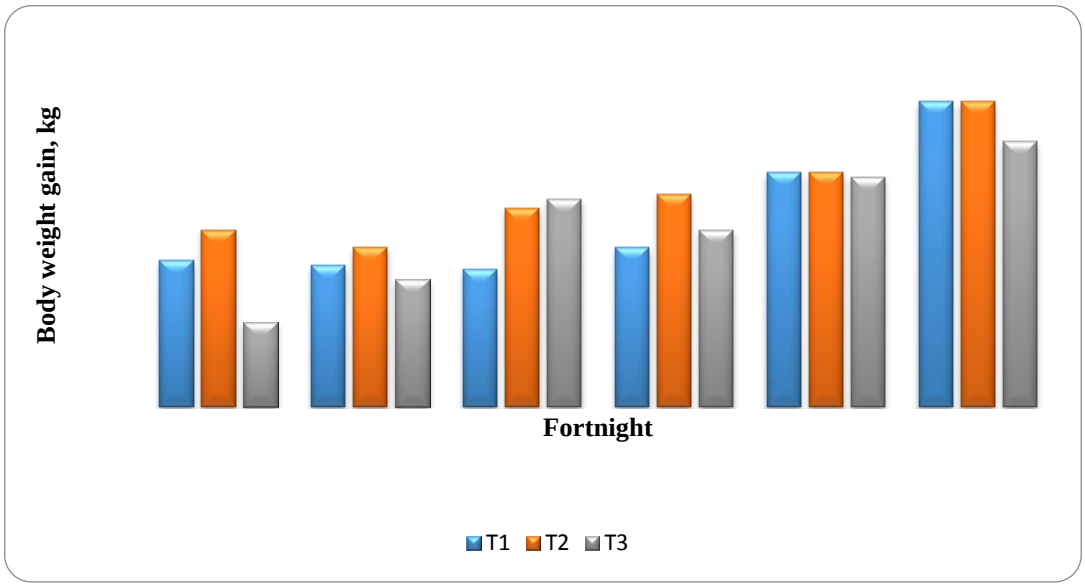

Fig 4. Fortnightly body weight gain of kids maintained on the three experimental rations, kg

Table 12. Summarised data on body weight, total gain and average daily gain of experimental kids* maintained on the three experimental rations

Parameter	T1	T2	T3	F - value	p – value
Initial body weight (kg)	11.10 ± 0.23	11.18 ±1.99	11.16 ± 1.62	2.18^{ns}	0.15
Final body weight (kg)	16.18±2.66	16.86±2.29	16.10 ± 1.95	0.35^{ns}	0.70
Total gain (kg)	5.08 ± 0.51	5.82 ± 0.52	4.94 ± 0.34	1.01^{ns}	0.39
Average daily gain (g)	56.44 ± 5.69	64.66 ± 5.87	54.88 ± 3.87	1.01^{ns}	0.39

*- Mean values with SE

ns- Non significant

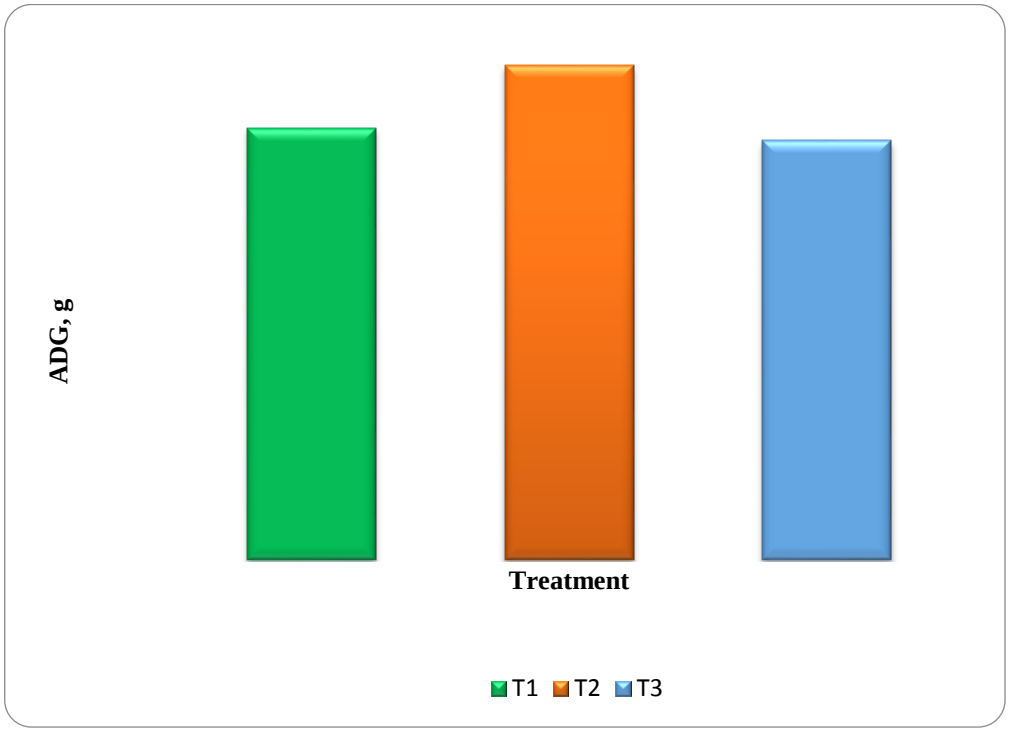

Fig 5. Average daily gain (ADG) of experimental kids maintained on the three experimental rations, g

Table 13. Cumulative feed conversion efficiency* of kids maintained on the three experimental rations

*- Average of five values with SE

Parameter	T1	T2	T3	F - value	p - value
Total dry matter intake (kg/ animal)	23.49 ± 2.09	25.63 ± 2.22	25.49 ± 2.22	0.001 ^{ns}	0.99
Average daily dry matter intake (kg/ animal)	0.25± 0.36	0.28 ± 0.24	0.28 ± 0.28	0.19 ^{ns}	0.82
Total body weight gain (kg)	5.08 ± 0.51	5.82 ± 0.52	4.94 ± 0.34	1.01 ^{ns}	0.39
Feed conversion efficiency	4.62± 0.27	4.48 ± 0.43	5.13 ± 0.25	1.18^{ns}	0.33

ns- Non significant

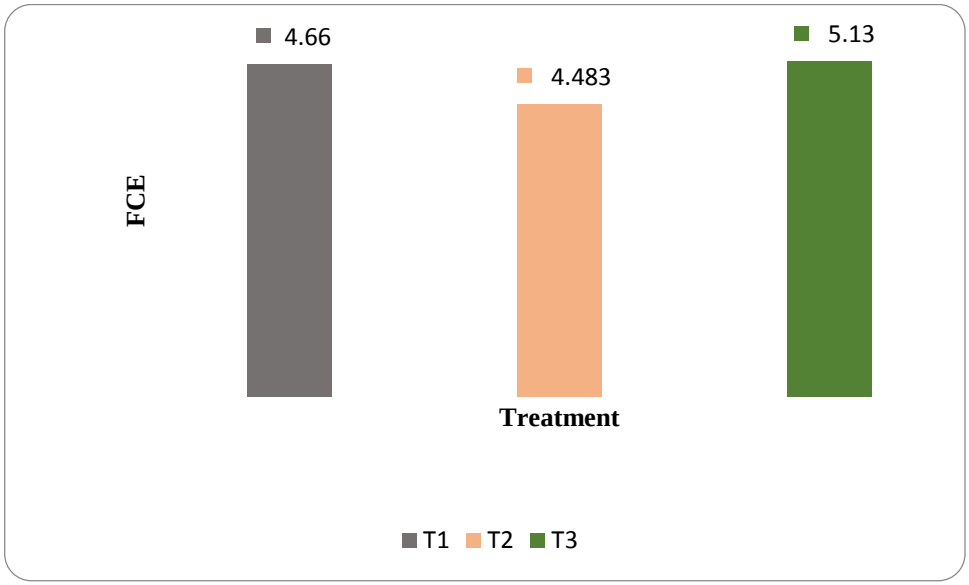

Fig 6. Cumulative feed conversion efficiency (FCE) of experimental kids maintained on the three experimental rations

Table 14. Chemical composition of dung* of experimental kids collected during the digestion trail (%, on DM basis)

Parameter	T1	T2	T3
Moisture	38.85±0.50	38.34±0.53	39.20±0.74
DM	61.15±0.50	61.66±0.53	60.80±0.74
CP	15.80±0.21	15.44±0.40	15.22±0.47
CF	22.00±0.46	24.10±0.54	23.30±0.71
EE	3.16±0.12	3.14±0.13	3.24±0.12
Total ash	16.72±0.57	18.14±0.46	17.64±0.89
NFE	42.32±0.78	39.18±0.55	40.60±1.30
Acid insoluble ash	8.00±0.48	8.79±0.43	7.93±0.31
NDF	56.28±0.94	55.74±0.40	58.54±0.97
ADF	30.74±0.94	30.96±1.11	29.96±0.23
Hemicellulose	25.54±0.44	24.78±1.41	28.58±0.93
Ca	2.23±0.12	1.99±0.09	2.27±0.18
P	1.80±0.27	1.82±0.08	2.20±0.10

*- Average of five values with SE

Table 15. Digestibility coefficient of nutrients[1] of kids fed on the three experimental rations, %

Parameter	Dietary treatments			F - value	p - value
	T1	T2	T3		
DM	70.20 ±1.08	70.91±0.79	67.31±1.64	2.42^{ns}	0.13
CP	72.27±1.48	73.06±0.77	69.32±2.31	1.43 ^{ns}	0.27
CF	67.87±1.49	68.53±1.11	67.48±2.23	0.10 ^{ns}	0.90
EE	70.58±2.32^{b}	72.78±0.95^{ab}	77.47±1.04^{a}	5.00*	0.02
NFE	73.49±1.13^{a}	74.75±1.07^{a}	69.16±0.98^{b}	6.44*	0.01
NDF	58.82±2.70	61.51±1.89	58.91±2.36	0.42 ^{ns}	0.66
ADF	52.15±2.63	56.94±1.32	50.36±3.10	1.89 ^{ns}	0.19

1 -Average of five values with SE

* - Significant at 5 per cent level

a, b and ab - Means with different superscripts within the same row differ significantly

ns – Non significant

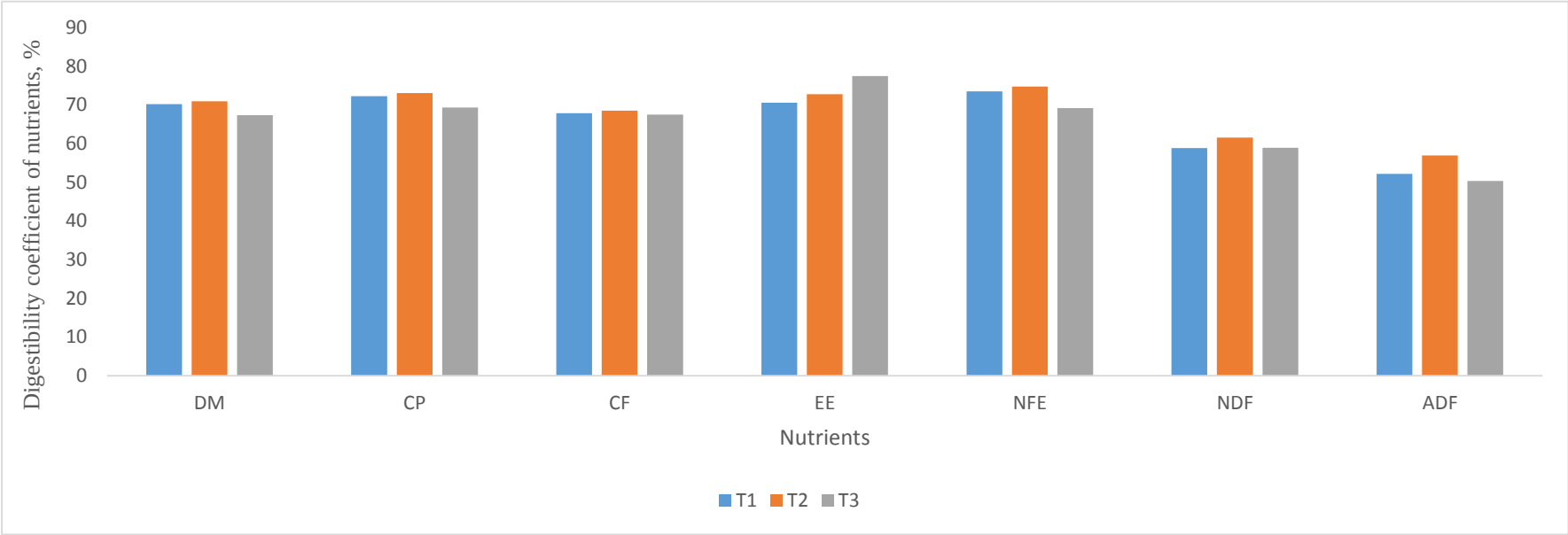

Fig.7. Digestibility coefficient of nutrients of kids fed on the three experimental rations, %

Table 16. Haemato-biochemical parameters[1] of kids maintained on the three experimental rations, at beginning and end of the experiment

1- Average of five values with SE

Treatment	Haemoglobin, g/dl		Total protein, g/dl		AST, IU/l		ALT, IU/l		Cholesterol, mg/dl		Triglycerides, mg/dl	
	1st day	90th day	1st day	90th day	1st day	90th day	1st day	90th day	1st day	90th day	1st day	90th day
1	10.18±0.46	9.88±0.45	9.05±1.75	6.57±0.20	78.61±8.08	83.65±10.46	12.33±3.44	21.34±4.67	95.60±8.17	58.20±7.99	24.20±1.90	26.60±6.18
2	9.48±0.75	9.12±0.39	7.48±1.94	6.44±0.61	68.92±5.18	76.78±5.92	9.06±3.43	19.17±0.76	74.40±1.74	94.60±16.94	31.25±5.04	28.00±5.01
3	10.56±0.84	9.48±0.41	9.06±0.69	6.56±0.44	86.70±3.94	73.87±10.52	10.19±4.97	16.22±1.17	83.00±5.80	100.60±9.13	21.60±1.20	30.60±5.24
F value	0.59 ns	0.81 ns	0.33 ns	0.14 ns	2.20 ns	0.29 ns	0.85 ns	0.83 ns	3.29 ns	3.63 ns	2.42 ns	0.13 ns
p value	0.56	0.46	0.72	0.86	0.15	0.74	0.45	0.45	0.07	0.05	0.13	0.87

ns - Non significant

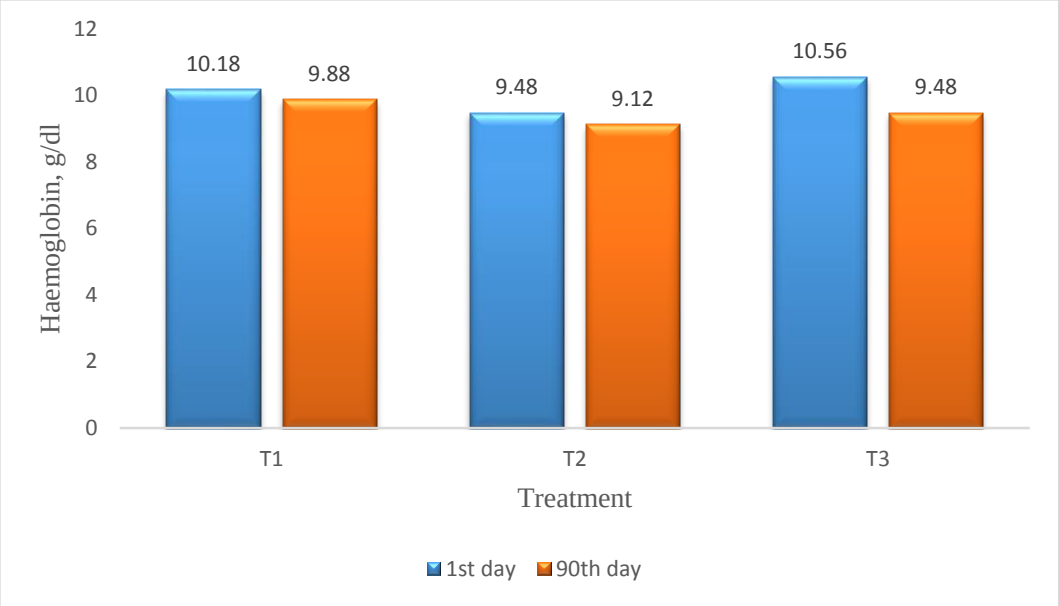

Fig 8. Haemoglobin concentration of kids maintained on the three experimental ration, g/dl

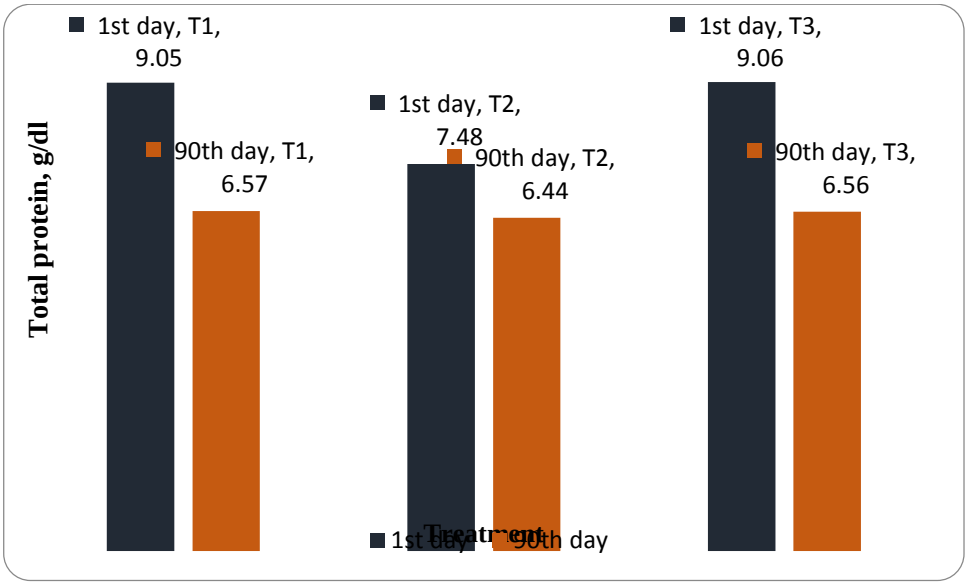

Fig 9. Serum total protein concentration of kids maintained on the three experimental rations, g/dl

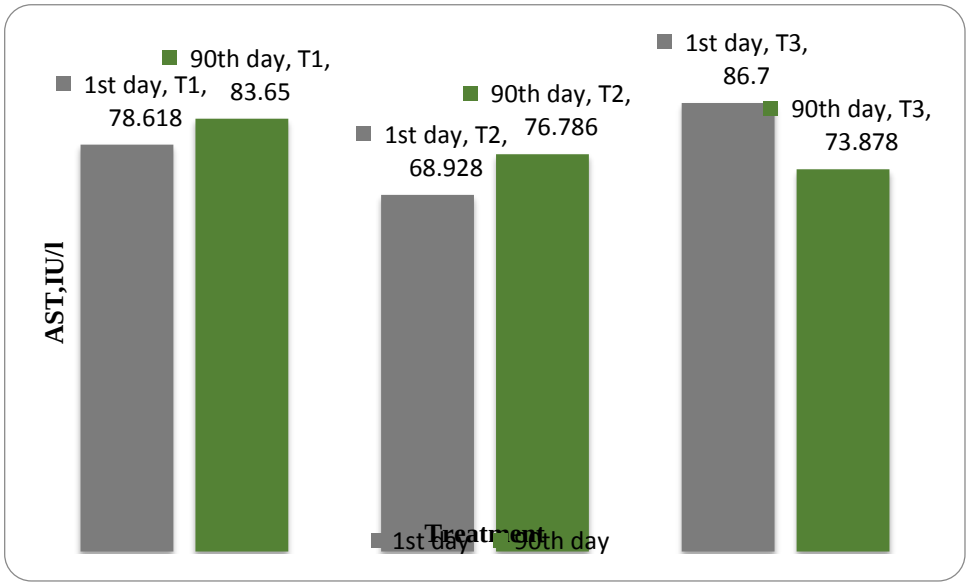

Fig.10. AST concentration of kids maintained on three experimental diet, UL/l

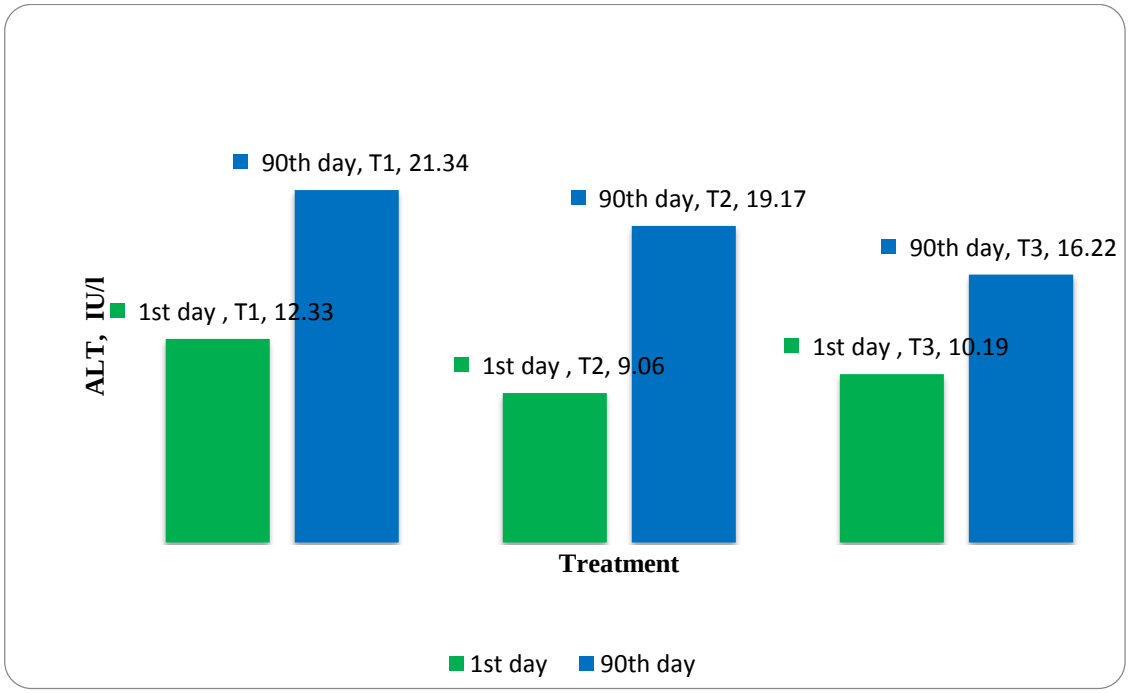

Fig 11. ALT concentration of kids maintained on the three experimental ration, IU/l

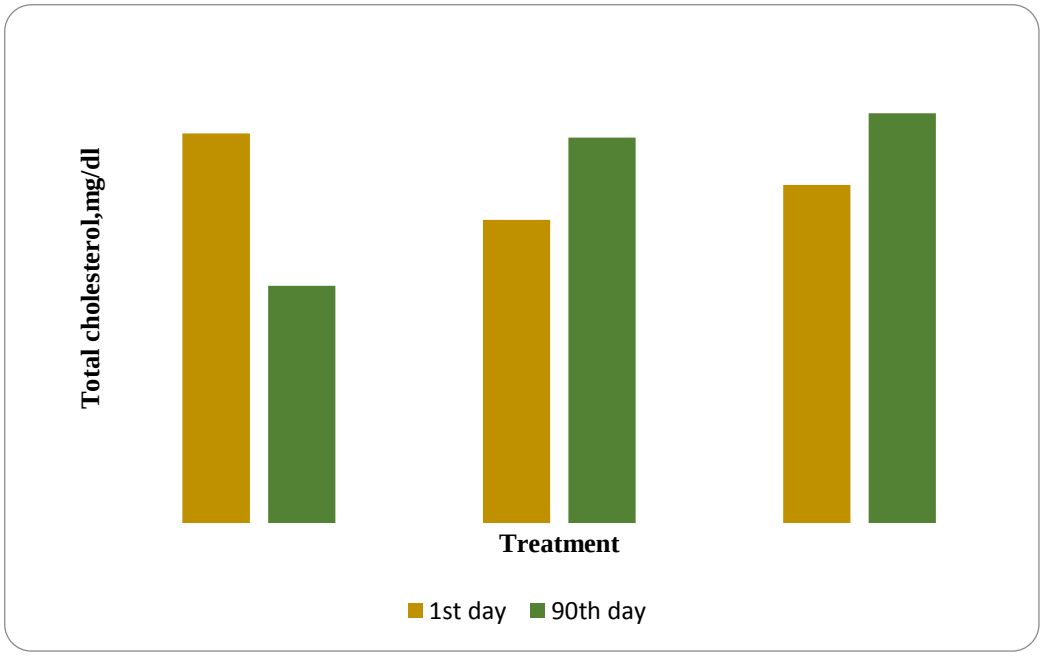

Fig 12. Total cholesterol concentration of kids maintained on three experimental diet, mg/dl

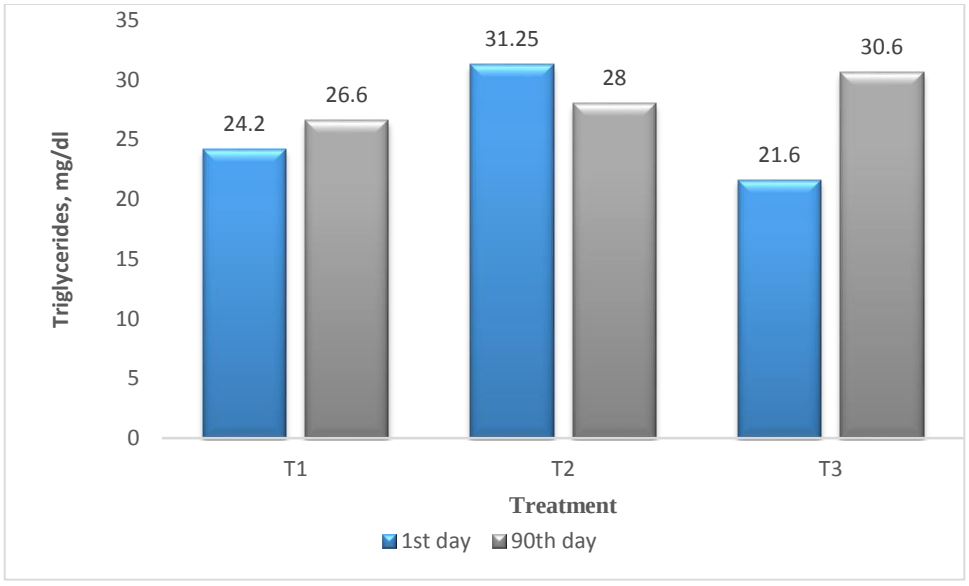

Fig 13. Total triglycerides, concentration of kids maintained on the three experimental diet, mg/d

Table 17. Economics of production of kids maintained on the three experimental rations

Parameter	T1	T2	T3
Total kid starter intake kg	132.00	144.00	143.25
Kid starter intake (kg/ kid)	26.40	28.80	28.65
Cost of kid starter/ kg (Rs.)	30.00	25.62	22.78
Total cost of kid starter/kid (Rs.)	792.00	737.00	652.00
Total grass intake (kg)	118.45	125.58	125.58
Grass intake (kg/ kid)	23.69	25.11	25.11
Cost of grass/ kg (Rs.)	3.50	3.50	3.50
Total cost of grass/ kid (Rs.)	82.91	87.90	87.90
Total cost of feed (Rs./ kid)	874.91	825.79	740.58
Total weight gain (kg/ kid)	5.08	5.82	4.94
Cost per kg gain (Rs.)	172.22	141.55	149.91

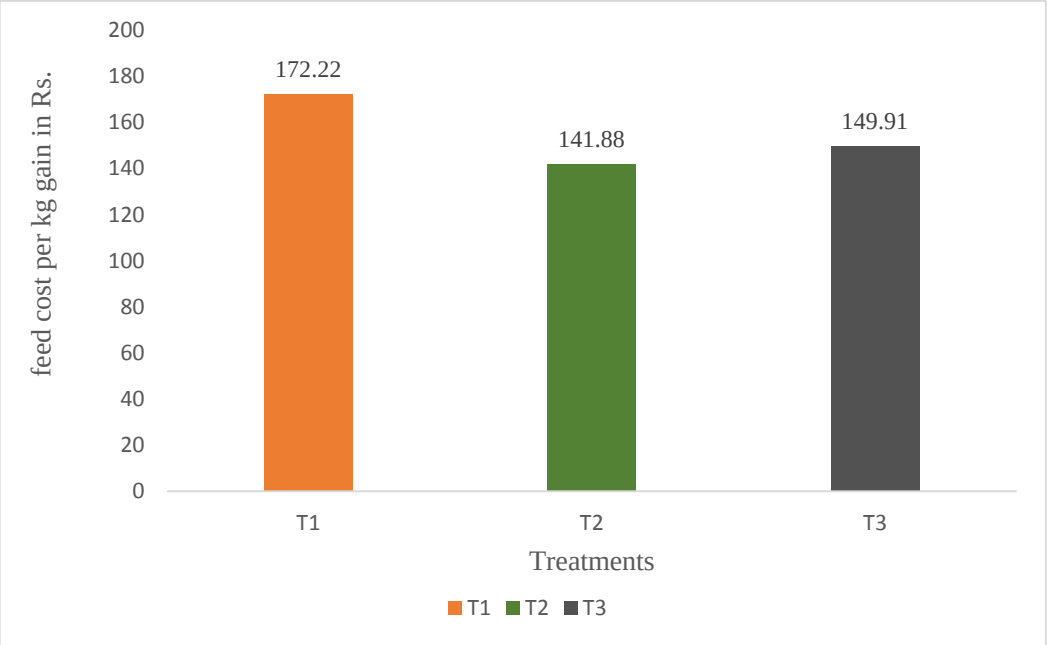

Fig 14. Cost per kg gain of kids maintained on the three experimental rations.

5. DISCUSSION

5.1. *In vitro* study

Four ayurvedic pharmaceutic gritham residues, *viz*., indukanta gritham, tiktaka gritham, brahmi gritham and saraswata gritham were tested *in vitro* by *in vitro* gas production technique (IVGPT) to estimate metabolisable energy (ME), digestible organic matter (DOM) and *in vitro* degradable nitrogen (IVDN), the values being 5.60, 5.61, 5.77, 5.34 MJ/kg DM; 55.72, 57.24, 51.93, 58.29 per cent and 24.04, 32.30, 41.45, 16.40 per cent, respectively and were ranked on the basis of a six point scoring system. Brahmi gritham residue which obtained the highest aggregate score was selected as the best ayurvedic pharmaceutic gritham residue which was used for further *in vivo* study. These results are comparable with Anugna *et al.* (2018) who observed that the values of ME, DOM and IVDN as a per cent of N of ayurvedic pharmaceutic residues, such as panchagavya gritham kottamchukkadi thailam, dhanvantharam kashayam and vilvadi lehyam were 4.49, 4.64, 5.07, 2.39 MJ per kg DM; 48.13, 51.10, 62.30, 28.67 per cent and 19.51, 19.39, 27.53, 26.62 per cent, respectively.

5.2. *In vivo* study

5.2.1. Chemical composition

The chemical composition of brahmi gritham residue presented in Table 3 revealed that it contained 90.00, 14.50, 15.39, 20.00, 38.74, 11.37, 0.68, 34.12, 20.15, 13.97, 1.58 and 2.10 per cent of DM, CP, CF, EE, NFE, total ash, acid insoluble ash, NDF, ADF, hemicellulose, Ca and P, respectively.

Chemical composition of kid starter fed to experimental kids given in Table 6 indicated that the experimental kid starters, T1, T2 and T3 containing brahmi gritham residue at 0, 10 and 20 per cent level, respectively, had 89.04, 89.04, 89.11 per cent for DM; 23.50, 22.96, 22.92 per cent CP; 9.20, 10.16 13.25 per cent CF; 4.22, 4.52, 9.57 per cent EE; 52.66, 48.71, 44.65 per cent NFE; 10.33, 13.62, 9.59 per cent total ash; 28.92, 33.56, 33.61 per cent NDF; 15.93, 17.66 18.23 per cent ADF; 1.50, 0.99, 1.37 per cent Ca and 1.00, 1.30, 1.33 per cent P, respectively. The chemical composition of kid starter observed in the experiment was comparable to

those of Roshma (2014) who formulated kid starter rations of similar composition, the values being in the range of 92.19 to 91.73 per cent for DM, 23.74 to 24.51 per cent for CP, 4.95 to 6.04 per cent for CF, 4.95 to 6.04 per cent for EE, 81.65 to 84.04 per cent for NFE, 9.72 to 10.41 per cent for total ash, 22.34 to 25.84 per cent for NDF, 6.61 to 9.84 per cent for ADF, 1.03 to 1.18 per cent for Ca and 0.65 to 0.86 per cent for P, in studies conducted in Malabari kids.

Nutritional value of grass used in the experiment contained 23.00 per cent DM, 9.46 per cent CP, 37.36 per cent CF, 1.88 per cent EE, 41.50 per cent NFE 10.20 per cent total ash, 2.45 per cent acid insoluble ash, 48.63 per cent NDF, 38.10 per cent ADF, 0.48 per cent Ca and 0.36 per cent P. The chemical composition of grass used in the study was similar in composition with those used by Roshma (2014) in Malabari kids and Fahmida (2018), Seethal (2018) in calves.

5.2.2. Dry matter intake (DMI)

5.2.2.1. DMI per day

The fortnightly average daily DMI (kg) of kids fed on rations T1, T2 and T3 given in Table 7 and graphically presented in Figure 2 reveal that the values ranged from were 0.37 to 0.40 kg, 0.43 to 0.47 kg, 0.48 to 0.52 kg, 0.55 to 0.59 kg, 0.61 to 0.66 kg and 0.68 to 0.76 kg, respectively, in the first to the sixth fortnights. Statistical analysis of the data showed that the values between groups were similar ($P>0.05$).

These results are in agreement with those of Roshma (2014) who reported that the DMI of Malabari kids fed on Ksheerabala residue at 0, 10 and 20 per cent level in kid starter were similar and Polizel *et al.* (2016) who reported that the DMI of goats fed on 50 per cent of citrus pulp and soybean hull as replacement of corn in their diet ranged from 0.65 to 0.80 kg per day and were similar. The findings of Seethal (2018) who reported that DMI of calves fed on 20 and 30 per cent of 'Dhanwantharam' thailam residue in calf starter, were similar, are also in agreement with those of the present study.

The present results are however, contradictory to the findings of Ukanwoko *et al.* (2016) who observed that inclusion of *Gmelina arborea* leaves at 10 and 20

per cent levels in the diet of West African dwarf bucks resulted in a significantly higher DMI, compared to those fed on an unsupplemented control diet.

5.2.2.2. DMI per 100 kg body weight

The fortnightly average daily DMI per 100 kg body weight of kids fed on rations T1, T2 and T3, given in Table 8 reveal that the values ranged from 3.69 to 3.73 kg, 3.90 to 4.13 kg, 4.26 to 4.45 kg, 4.63 to 4.70 kg, 4.83 to 4.98 kg and 4.98 to 5.36 kg, respectively, in the first to sixth fortnights and the total average DMI of kids in the experiment was 4.38 kg, 4.46 kg and 456 gin T1, T2 and T3, respectively. On statistical analysis it was found that the values were similar ($P>0.05$) and comparable to those of Roshma (2014) who observed that the DMI per 100 kg body weight of Malabari kids fed on 0, 10 and 20 per cent Ksheerabala residue, were similar, the values being in the range of 3.75 to 3.87 kg.

The results of present study are contradictory, but the values are higher than those of Chanjula *et al*. (2011) who observed significantly higher DMI per 100 kg bodyweight in crossbred goats fed on rations incorporated with 20 and 30 per cent of rubber seed and palm kernel cake compared to the unsupplemented control ration, with the values being in the range of 2.01 to 2.41 per cent.

5.2.2.3. DMI per kg metabolic body weight

The fortnightly average daily DMI per kg metabolic body weight of kids fed on rations T1, T2 and T3, given in Table 9, reveal that the values ranged from 0.06 to 0.06 kg, 0.07 to 0.07 kg, 0.07 to 0.08 kg, 0.08 to 0.08 kg, 0.09 to 0.09 kg and 0.09 to 0.10 kg, respectively, in the first to the sixth fortnights. Statistical analysis revealed that the values were similar ($P>0.05$) and comparable to those of Roshma (2014) who reported that Malabari kids fed on Ksheerabala residue at 10 and 20 per cent in kid starter had a similar DMI per kg metabolic bodyweight and the values ranged from 0.04 to 0.07 kg.

The results of the present study showed that dietary inclusion of brahmi gritham residue at 10 and 20 per cent level in kid starter did not significantly affect the average daily DMI of experimental Malabari kids.

5.2.3. Growth

The initial body weight of kids in groups T1, T2 and T3 were 11.10 11.18 and 11.16 kg, respectively. The final body weight of kids fed on rations T1, T2 and T3 were 16.18, 16.86 and 16.10 kg, respectively. The total weight gain and average daily gain (ADG) of kids fed on rations T1, T2 and T3 were 5.08, 5.82, 4.94 kg and 56.44, 64.66, 54.88 g per day, respectively. These data are presented in Table 12 and graphically represented in Figures 5. Statistical analysis of the data showed that the initial and final body weight of the experimental kids were similar (P>0.05) among themselves, except in the second fortnight where kids of group T2 had significantly higher (P>0.01) body weight than those of T3, with T1 being similar to both T2 and T3 (P>0.05).

5.2.3.1. Final body weight

The results of final body weight of the present study are in agreement with those of Obeidat *et al*. (2011) who reported that the final body weight of Black goat kids fed on sesame hull at 10 and 20 per cent level were similar to those fed on an unsupplemented control diet, the values being in the range of 24.60 to 27.80 kg and Thakur *et al*. (2015) who observed that the body weight of goats fed on diet containing 25 and 50 per cent detoxified karanj seed cake (*Pongamia glabra vent*) were similar with values being in the range of 14.04 to 14.05 kg, both at six months of age.

The present results are contradictory to the findings of Obeidat *et al.* (2009) who reported that the final body weight was significantly higher (P<0.05) in Awassi lambs fed on rations containing 8 per cent sesame meal compared to those fed on 16 per cent sesame meal and an unsupplemented control, the values being 31.00, 33.50 and 30.60 kg at four months of age, for the control, 8 and 16 per cent sesame meal supplemented groups, respectively.

5.2.3.2. Total weight gain and average daily gain (ADG)

The total weight gain values of the present study are comparable to those of Roshma (2014) who observed values ranging from 4.23 to 6.37 kg in Malabari kids fed on kid starters containing Ksheerabala residue at 10 and 20 per cent level, as compared to those fed on and an unsupplemented control. The ADG values are

comparable to the control ration of Roshma (2014) but lower than the Ksheerabala supplemented groups, with the ADG values being 54, 73 and 82 g for the control, 10 and 20 per cent Ksheerabala supplemented groups, respectively.

The ADG values of the present study are higher than the results of Nath *et al*. (2017) who reported that goats fed on *Carica papaya*, *Artocarpus heterophyllus* and *Terminalia bellirica* leaf mixture at 1:1:1 ratio in concentrate mixture at the rate of 5 and 10 per cent level and unsupplemented control, had similar ADG, the values being 27.50, 24.80 and 31.75 g per day, respectively.

Similarity in ADG values between treatments, as observed in this study, is in agreement with the findings of Nath *et al.* (2017), in goats.

The findings of the present study are however contradictory to those of Roshma (2014) who reported that the total weight gain and ADG was significantly higher in Malabari kids fed on kid starters containing Ksheerabala residue at 10 and 20 per cent level as compared to those fed on an unsupplemented control.

5.2.4. Feed conversion efficiency (FCE)

The average values of FCE of kids fed on rations T1, T2 and T3, were 4.62, 4.48 and 5.13, respectively, as given in Table 13 and graphically represented in Figure 6. Statistical analysis of the data showed that the FCE was similar ($P>0.05$). These values are comparable and in agreement to those observed by Nath *et al.* (2017) who reported that goats fed on medicinal leaves at 5 and 10 per cent level in their diets had similar FCE, with the values being in the range of 4.43 to 5.69.

The FCE of the present investigation are in agreement with the results, but the values are lower and better than those of Odhaib *et al.* (2018) who reported that the FCE of Dorper lambs fed on *Nigella sativa* seeds and *Rosmarinus officinalis* leaf mixture was 8.07 as against 8.83 in those fed on the unsupplemented control, with the values being similar.

The results of the present study are contradictory to those of Belewu *et al*. (2007) who reported that Western African dwarf goats fed on 10 and 20 per cent Tigernut meal supplemented diets as replacement for wheat offal had a significantly lower and poorer FCE than those fed on an unsupplemented control and Roshma (2014) who reported that the FCE of Malabari kids fed on kid starters incorporated

with Ksheerabala residue at the rate of 10 per cent level, had a significantly lower and poorer FCE than those fed on 20 per cent and an unsupplemented control, the values being 4.49, 6.19 and 4.80 for the control, 10 and 20 per cent Ksheerabala residue supplemented groups, respectively.

5.2.5. Digestibility coefficient of nutrients

The values of digestibility coefficient of nutrients of experimental kids fed on rations T1, T2 and T3 are presented in Table 15 and graphically represented in Figure 7.

5.2.5.1. Dry matter (DM)

The average values of digestibility coefficient of DM observed in this experiment were 70.20, 70.91 and 67.31 per cent for groups, T1, T2 and T3, respectively. Statistical analysis showed that there was no significant difference ($P>0.05$) in the digestibility of DM among the groups. Current results are in agreement and the values are comparable with the findings of Roshma (2014) who reported that the digestibility coefficient of DM of Malabari kids fed on kid starter without and with 10 and 20 per cent Ksheerabala residue, were similar, the values being 77.34, 76.43 and 75.28 per cent, respectively.

The values of the present investigation are higher than the values of Sharma (2011) who observed DM digestibility values ranging from was 58.52 to 64.91 per cent in goats fed on diets supplemented with Shatavari (*Asparagus racemosus*) and Bhringraj (*Eclipta alba*) herbs, as well as an unsupplemented control.

The DM digestibility values obtained in the present experiment are lower than those of Bueno *et al.* (2002) who reported DM digestibility values ranging from 71.90 to 74.60 per cent in goats fed on rations containing dehydrated citrus pulp at the rate of 33, 66 and 100 per cent in their diet, as well as an unsupplemented control diet.

The findings of the present study are contradictory to those of Oni *et al*. (2010) who observed significantly lower ($P<0.05$) DM digestibility in West African Dwarf goats fed on diets containing 20, 40 and 50 per cent dried cassava leaves than those fed on an unsupplemented control.

5.2.5.2. Crude protein (CP)

The average values of digestibility coefficient of CP of kids fed on rations T1, T2 and T3 were 72.27, 73.06 and 69.32 per cent, respectively. Statistical analysis showed that the values were similar (P>0.05).

These results are in agreement and comparable to those of Chanjula *et al.* (2011) who reported that the digestibility coefficient of CP of goats fed on diets containing 20 and 30 per cent of rubber seed and palm kernel cake as well as unsupplemented control, were similar, the values being in the range of 71.05 to 74.17 per cent. The present results are in agreement, but the values are lower than those of Roshma (2014) who reported that Malabari kids fed on Ksheerabala residue at the rate of 0, 10 and 20 per cent level in kid starter had a similar digestibility coefficient for CP, where the values ranged from 79.66 to 81.97 per cent.

The CP digestibility of present study are contradictory and the values are lower than those of Seethal *et al.* (2016) who observed that the digestibility coefficient of CP was significantly lower (P<0.01) in calves fed on a ration containing 40 per cent Ksheerabala residue compared to an unsupplemented control, the values being 81.06 and 82.34 per cent, respectively.

5.2.5.3. Crude fibre (CF)

The digestibility coefficient of CF of kids fed on rations T1, T2 and T3 were 67.87, 68.53 and 67.48 per cent, respectively and statistical analysis of the data showed that the values are similar (P>0.05) between treatments.

These results are in agreement and the values are comparable to those of Roshma (2014) who observed that the digestibility coefficient of CF in Malabari kids fed on kid starters, without and with Ksheerabala residue at the rate of 10 and 20 per cent level, were similar, the values being 64.47, 64.29 and 61.21 per cent, respectively.

The digestibility coefficient of CF observed in the present experiment are in agreement and the values are higher than those observed by Seethal *et al* (2016) in

calves fed on rations incorporated with Ksheerabala residue at 0 and 40 per cent level, the values being in the 54.63 and 54.97 per cent, respectively.

The findings of Meel *et al.* (2015) who observed that Rathi calves fed on diets containing 3 per cent herbal additive had a significantly higher ($P<0.01$) digestibility coefficient of CF compared to the unsupplemented control, are contradictory to the results of the present investigation.

5.2.5.4. Ether extract (EE)

The average values of digestibility coefficient of EE of kids fed on rations T1, T2 and T3 were 70.58, 72.78 and 77.47 per cent, respectively and statistical analysis of the data showed significantly higher ($P<0.05$) EE digestibility in T3 than T1, with T2 being similar ($P>0.05$) to both T1 and T3. These results are in accordance with but the values are lower comparable to those of Seethal (2016) who observed that significantly higher ($P<0.05$) digestibility coefficient of EE in calves fed on diets containing 40 per cent Ksheerabala residue as compared to those fed on unsupplemented control, the values being 85.61 and 86.41 per cent, respectively.

The findings of the current study are contradictory and the values are lower than the control and higher than the experimental group of Pal *et al.* (2010) who observed that the digestibility coefficient of EE of goats fed on the unsupplemented control ration was higher ($P<0.05$), compared to those fed on the diet supplemented with isonitrogenous leaf meal mixture, the values being 79.14 and 63.05 per cent for the control and experimental group, respectively. Roshma (2014) reported that the digestibility coefficient of EE of Malabari kids fed on diets containing Ksheerabala residue in kid starter at the rate of 0, 10 and 20 percent level, respectively, were similar and the values ranged from 81.33 to 84.65 per cent, which are higher and in contrast to the results of the present study.

5.2.5.5. Nitrogen free extract (NFE)

The average value of digestibility coefficient of NFE of kids were 73.49, 74.75 and 69.16 per cent in groups, T1, T2 and T3, respectively. Statistical analysis of the data showed that kids fed on T1 and T2 had a significantly higher ($P<0.05$) digestibility coefficient of NFE than T3, with T1 and T2 being similar ($P>0.05$).

The present results are in agreement and the values are higher than the results of Mahmoud and Bendary (2014) who observed that the digestibility coefficient of NFE of calves fed on 1.20 per cent wheat straw in concentrate mixture were significantly higher (P<0.05) than those fed on the unsupplemented control, the values being 50.92 and 66.15 per cent for the control and treatment groups, respectively.

Roshma (2014) reported that there was no significant difference (P>0.05) in the digestibility of coefficient of NFE in Malabari kids fed on rations containing Ksheerabala residue at the rate of 0, 10 and 20 percent level, the value being 84.04, 82.58 and 81.65 per cent, respectively, which are contradictory to the results of the present study and her values are higher than the present investigation. The findings of Seethal *et al* (2016) who observed that the average values of digestibility coefficient of NFE of calves fed on rations supplemented with Ksheerabala residue at the rate of 40 per cent level and an unsupplemented control were similar, the values being 83.16 and 83.63 per cent, respectively, are also higher and contradictory to those of the present study.

5.2.5.6. Neutral detergent fibre (NDF)

The average values of digestibility coefficient of NDF of kids fed on rations T1, T2 and T3 were 58.82, 61.51 and 58.91 per cent, respectively and statistical analysis of the data showed that the values were similar (P>0.05)**.**

The present results are in agreement and the values are higher than those of Dhuria *et al.* (2007) who observed that the digestibility coefficient of NDF in sheep fed on diets containing mustard (*Brassica Campestris*) straw at the rate of 40, 50 and 60 per cent in complete feed, were similar, the values being 45.64, 46.90 and 48.63 per cent respectively. These results are in agreement and the values are comparable to those of Roshma (2014) who observed that the digestibility coefficient NDF in Malabari kids fed on rations without and with Ksheerabala residue at rate of 10 and 20 per cent, were similar, the values being 59.77, 58.20 and 57.80 per cent in the control 10 and 20 per cent Ksheerabala residue supplemented groups, respectively. The findings of Seethal *et al*. (2016) who reported that the digestibility coefficient of NDF of calves fed without and with 40

per cent Ksheerabala residue, were similar, is in accordance with the results of the present study.

The findings of the present study are contradictory to those of Oni *et al*. (2010) who observed that the digestibility coefficient of NDF of West African Dwarf goats fed on an unsupplemented control was significantly higher ($P<0.05$) compared to those fed on diets supplemented with 20, 40 and 50 per cent dried cassava leaves.

5.2.5.7. Acid detergent fibre (ADF)

The digestibility coefficient of ADF of kids fed on rations T1, T2 and T3 were 52.15, 56.94 and 50.36 per cent respectively and statistical analysis of the data showed that the values are similar ($P>0.05$) between the experimental groups. The present results are in agreement and the values are comparable with the results of Roshma (2014) who observed that the digestibility coefficient ADF of Malabari kids fed on rations containing Ksheerabala residue at the rate of 10 and 20 per cent and an unsupplemented control, were similar, the values being, 55.23, 52.78 and 55.58 per cent, respectively and Seethal *et al*. (2016) who reported that the digestibility coefficient of ADF of calves fed without and with 40 per cent Ksheerabala residue, were similar, the values being 52.78 and 55.58 per cent, respectively.

Contradictory findings to those observed in the present study were observed by Mir and Kumar (2012) who reported that the digestibility coefficient of ADF was significantly higher ($P<0.05$) in goats fed on fenugreek seeds (*Trigonella foenum-graecum*) at the rate of 3 per cent in their ration as compared to those fed on an unsupplemented control.

5.2.6. Haemato-biochemical parameters

The haemato-biochemical parameters of experimental kids such as haemoglobin, total protein, ALT, AST, total cholesterol and total triglycerides estimated at the beginning (1^{st} day) and end of the experiment (90^{th} day) are presented in Table 16 and graphically represented in Figures 8 to 13.

5.2.6.1. Haemoglobin

The average haemoglobin (Hb) levels of kids at the beginning (1st day) and at end (90th day) of the experiment were 10.18, 9.48, 10.56 g per dl and 9.88, 9.12, 9.48 g per dl, for kids in groups, T1, T2 and T3, respectively, with values being similar (P>0.05). All the values were in the normal range for kids.

The Hb values obtained in the present experiment are comparable with the values of Aruwayo *et al*. (2011) who reported Hb levels ranging from 9.32 to 10.50 g per dl in Uda Lambs fed on diets containing 0, 5, 10, 15 and 20 per cent alkali treated neem kernel cake and Jiwuba *et al.* (2017) who reported values in the range of 9.98 to 10.88 g per dl in West African Dwarf goats, fed *on Moringa oleifera* leaf meal at the rate of 0, 5, 10 and 15 per cent level in their diet.

The values of the current experiment are lower than those reported by Roshma (2014) who observed Hb values in the range of 11.88 to 12.00 g per dl in Malabari kids fed on 0, 10 and 20 per cent of Ksheerabala residue in kid starter.

These results are in agreement with and the values are comparable to those of Thakur *et al*. (2015) who observed that goat kids fed on diets containing solvent extracted and alkali processed karanj (*Pongamia glabra* vent) seed cake at the rate of 25 and 50 per cent level and unsupplemented control, were similar, the values being 10.40, 11.53, 10.83, 11.83 and 10.63 g per dl, respectively.

The present results are contradictory, but the values are comparable to those of Babeker and Abdalbagi (2015) who reported that Sudan Nubian goats fed on *Moringa oleifera* leaves at 20 and 50 per cent of the total ration had a significantly higher haemoglobin level than those fed on an unsupplemented control ration, the values being 8.32 g per dl in the unsupplemented group and 10.46 and 9.21 g per dl in the 20 and 50 per cent levels, respectively.

5.2.6.2. Total protein

The average serum total protein levels of kids at the beginning (1st day) and end of the experiment (90th day) were 9.05, 7.48, 9.06 g per dl and 6.57, 6.44, 6.56

g per dl, in the groups, T1, T2 and T3, respectively. Statistical analysis of the data revealed that there was no significant difference (P>0.05) between the groups and the values were within the normal range of kids. These values are comparable and the results are in agreement to those of Roshma (2014) who reported total protein values in the range of 6.28 to 6.33 g per dl in kids fed on rations without and with 10 and 20 per cent Ksheerabala residue.

Similarity in total protein values between treatments as obtained in the present study are in agreement with the results of Aruwayo *et al*. (2011) who observed that the total protein values of Uda Lambs fed on diets containing 0, 5, 10, 15 and 20 per cent alkali treated neem kernel cake, were similar and Saleem *et al*. (2017) who reported that the total protein values of lambs fed on prebiotic supplemented diet and an unsupplemented control, were similar.

The findings of present study are contradictory to those of Abu *et al*. (2018) who observed that the total protein values were higher (P<0.05) in Ossimi ewes fed on rations containing 3 per cent each of onion, garlic and fenugreek seeds, compared to those fed an unsupplemented control.

5.2.6.3. Serum AST and ALT

The mean serum AST and ALT values in kids of groups T1, T2 and T3 at the beginning (1^{st} day) were 78.61, 68.92, 86.70 and 12.33, 9.06, 10.19 IU/l, respectively. The AST and ALT values at the end of the experiment (90^{th} day) in kids of T1, T2 and T3 were 83.65, 76.78, 73.87 and 21.34, 19.17, 16.22 IU/l, respectively. Statistical analysis of the data showed that the values of serum AST and ALT, were similar (P>0.05) among the groups.

These values are comparable with those of Seethal (2018) who reported that the serum AST and ALT values of calves fed on rations without and with 'Dhanwantharam' thailam at rate of 20 and 30 per cent level were similar and the values ranged from 64.38 to 68.69 IU/l and 12.29 to 14.84 IU/l, respectively.

The present values are higher than those of Jiwuba *et al.* (2017) who reported that West African Dwarf goats fed on *Moringa oleifera* leaf meal in diets

at the rate of 0, 5, 10 and 15 per cent level, had AST values ranging from 24.50 to 28.50 IU/l and ALT values ranging from 16.75 to 18.25 IU/l.

Similarity in AST and ALT values between the treatments are in agreement with those of Roshma (2014) who reported that the values of serum AST and ALT of Malabari kids fed on rations containing Ksheerabala residue at rate of 10 and 20 per cent and unsupplemented control, were similar.

5.2.6.4. Total cholesterol

The average total cholesterol levels of kids in groups, T1, T2 and T3 at the beginning (1st day) and end of the experiment (90th day) were 95.60, 74.40, 83.00 and 58.20, 94.60, 100.60 mg per dl, respectively. The above data revealed that the values were similar (P>0.05) between groups.

Similarity in total cholesterol between treatments as observed in this study are in agreement with the findings of Roshma (2014) who observed that feeding of Ksheerabala residue at the rate of 0, 10 and 20 per cent level in the diets of kids showed similar total cholesterol levels, the values being 110.83, 104.03 and 108.62 mg per dl, which are higher than the results of the present study.

The values of the present study are lower than those values of Seethal (2018) who reported that the total cholesterol level of calves fed on rations without and with 'Dhanwantharam' thailam residue at the rate of 20 and 30 per cent level in the ration were 118.62, 107.93 and 118.30 mg per dl, with the values being similar, which is in accordance with the findings of the present study

5.2.6.5. Serum triglycerides

The serum triglyceride levels of kids in groups T1, T2 and T3, at the beginning of the experiment (1st day) were 24.20, 31.25 and 21.60 mg per dl, respectively. The values at the end of the study (90th day) in kids of groups T1, T2 and T3 were 26.60, 28.00 and 30.60 mg per dl. Statistical analysis found that the values were similar (P>0.05), between treatments.

Similarity in serum triglycerides between treatments as observed in this study are in agreement with the findings of Roshma (2014) who observed that feeding of Ksheerabala residue at the rate of 0, 10 and 20 per cent level in the diets of kids showed similar total cholesterol levels, the values being 40.69, 39.36 and 40.53 mg per dl, which are higher than the results of the present study.

The findings of the present study are contradictory to and the values are lower than those of Adegun *et al*. (2018) who observed that the triglyceride values of Yankasa rams fed on diets containing *Panicum maximum* at the rate of 0.50, 1.00, 1.50 and 2.00 per cent were significantly higher compared to those fed on an unsupplemented control, the values being 64.44, 69.77, 67.22 and 69.77 mg per dl, respectively, in the treatment groups and 47.78 mg per dl, in the control group.

5.2.7. Economics

The feed cost per kg body weight gain of experimental kids fed on rations T1, T2 and T3 given in Table 17 and graphically represented in Figure 14, reveal that the values were Rs. 172.22, 141.88 and 149.91, respectively.

These results are in complete agreement with the results of Sreekutty (2017) who observed that Malabari kids fed on a diet containing 10 per cent cashew apple waste (CAW) had the lowest, but non significant, cost per kg gain, as compared to those fed on a kid starter with 20 per cent CAW and unsupplemented control, the values being Rs. 208.59, 139.97 and 130.55 for the 0, 10 and 20 per cent CAW supplemented groups, respectively.

Obeidat and Gharaybeh (2011) reported that Black goat kids fed on sesame hull at the rate of 10 and 20 per cent, had a significantly lower cost per kg gain compared to an unsupplemented control group, which is in partial agreement with the results of the present study.

The findings of Hasanuzzaman (2013) who observed lower feed cost per kg gain in calves fed on 50 per cent sea buck thorn cake as a replacement for ground nut cake and Roshma (2014) who reported that kids fed on kid starter with 20 per cent Ksheerabala residue had the lowest cost per kg gain compared to those fed on

10 per cent and unsupplemented control, are contradictory to the results of the present investigation.

An overall critical evaluation of the results of the present investigation reveal that brahmi gritham residue can be safely incorporated in kid starter up to 20 per cent without affecting the growth performance of the kids and better results can be achieved at 10 per cent level of incorporation as evinced by the lower and better FCE and lower cost per kg gain in kids of T2, fed on 10 per cent brahmi gritham residue when compared to those of T3, fed on 20 per cent. This will help in the preparation of a cost effective kid starter instead of costly conventional ingredients, thereby reducing the feed cost and ensuring better returns to the farmers.

6. SUMMARY

A study was conducted to assess the effect of dietary incorporation of ayurvedic pharmaceutic gritham residues on growth performance of Malabari kids. Four ayurvedic pharmaceutic gritham residues, *viz*., indukanta gritham, tiktaka gritham, brahmi gritham and saraswata gritham were tested *in vitro* by *in vitro* gas production technique (IVGPT) to estimate metabolisable energy (ME), digestible organic matter (DOM) and *in vitro* digestible nitrogen (IVDN), the values being 5.60, 5.61, 5.77, 5.34 MJ/kg DM; 55.72, 57.24, 51.93, 58.29 per cent and 24.04, 32.30, 41.45, 16.40 per cent, respectively.

These four ayurvedic pharmaceutic gritham residues were ranked on the basis of a six point scoring system. Individual scores were assigned to the four residues tested and the residue having the highest aggregate score was selected as the best residue which was further tested *in vivo*. Brahmi gritham residue which obtained the highest aggregate score was selected as the best ayurvedic pharmaceutic gritham residue which was used for further *in vivo* study.

Fifteen Malabari kids were selected from the Instructional Livestock Farm Complex (ILFC), Pookode. They were divided into three groups of five each, as uniformly as possible with regard to body weight, age and sex and were randomly allotted to three groups T1, T2 and T3 and were fed on isonitrogenous (24 % CP) and isocaloric (70 % TDN) kid starters without and with 10 and 20 per cent brahmi gritham residue, respectively, formulated as per BIS (2012). The kid starter, so formulated were fed along with *ad libitum* green grass as the sole roughage to meet the requirement of experimental kids, as per ICAR feeding standards (ICAR 2013).

The kids were maintained under uniform management conditions prevailing at ILFC, Pookode. Kid starter and green grass was offered to kids for a period of 90 days. Individual records were maintained for daily feed intake and fortnightly body weight. Blood samples were collected from each kid at the beginning (1st day) and end (90th day) of the trial to estimate haemato-biochemical parameters such as haemoglobin, total protein, aspartate aminotransferase (AST), alanine transaminase (ALT), cholesterol and triglycerides. A digestibility trial of five days duration was conducted towards the end of the feeding trial by total collection method to collect

dung in order to estimate the digestibility coefficient of nutrients. All the obtained data were statistically analysed and techno-economics was calculated.

Chemical composition of ayurvedic pharmaceutic brahmi gritham residue, selected for the *in vivo* study was analysed. It contained 90.00, 14.50, 15.39, 20.00, 11.37, 32.75, 0.68, 38.74, 20.15, 13.97, 1.58 and 2.10 per cent DM, CP, CF, EE, total ash, NFE, acid insoluble ash, NDF, ADF, hemicellulose, Ca and P, respectively.

The average daily dry matter intake was 0.52, 0.56 and 0.57 kg per day, for kids in groups, T1, T2 and T3, respectively and the values were similar ($P>0.05$). The average DMI per 100 kg body weight and DMI per kg metabolic body weight was 4.38, 4.46, 4.55 kg and 0.08, 0.08, 0.09 kg for kids in groups, T1, T2 and T3, respectively and the values were similar ($P>0.05$).

The average initial body weight of kids was similar ($P>0.05$) in all the treatment groups and started increasing from the first fortnight onwards and were similar ($P>0.05$) in kids fed on experimental ration T1, T2 and T3, in all the fortnights except in the second fortnight where the body weight was significantly higher ($P<0.05$) in T2 than T3, with T1 being similar ($P>0.05$) to both T2 and T3. The average daily gain (ADG) and total average body weight gain of kids were 56.44, 64.66, 54.88 g per day and 5.08, 5.82, 4.94 kg, respectively in groups T1, T2 and T3 and were similar ($P>0.05$).

The average value of feed conversion efficiency (kg feed per kg body weight gain) was 4.62, 4.48 and 5.13 for kids in groups, T1, T2 and T3, respectively and the values were similar ($P>0.05$). This indicated that the feed conversation efficiency (FCE) of kids in group T2 was better than those in T1 and T3.

The digestibility coefficient of nutrients were 70.20, 70.91 and 67.31 per cent for DM, 72.27, 73.06 and 69.32 per cent for CP, 67.87, 68.53 and 67.48 for CF, 70.58, 72.78 and 77.47 per cent for EE, 73.49, 74.75 and 69.16 per cent for NFE, 58.82, 61.51 and 58.91 per cent for NDF and 52.15, 56.94 and 50.36 per cent for ADF, for kids in groups, T1, T2 and T3, respectively. The values were similar ($P>0.05$) except ether extract which was significantly higher ($P<0.05$) in T3 than T1, with T2 being similar ($P>0.05$) to both T1 and T3 and NFE which was

significantly higher ($P<0.05$) in T1 and T2 than T3, with T1 and T2 being similar ($P>0.05$).

Various haemato-biochemical parameters such as haemoglobin, total protein, AST, ALT, triglycerides and cholesterol were similar between the three experimental groups and the values were within the normal range for kids.

The cost per kg body weight gain was Rs. 172.22, 141.88 and 149.15 for kids in groups, T1, T2 and T3, respectively, with T2 having lower cost per kg body weight gain, followed by T3 and T1 in ascending order.

An overall critical evaluation of the results of the present study indicate that kids in groups T2 and T3 fed on brahmi gritham residue at 10 and 20 per cent had similar DMI, ADG, FCE, haemato-biochemical parameters, digestibility coefficients of nutrients except EE and NFE and lower cost per kg body weight gain than those of group T1 (control). Among T2and T3 which were more or less comparable and statistically similar, T2 was better than T3 as it had a numerically higher ADG, better FCE and lower cost per kg gain than T3.

From the above results it can be concluded that brahmi gritham residue can be safely incorporated in kid starter up to 20 per cent instead of costly ingredients like yellow maize, without affecting the growth performance of the kids and better results can be achieved at 10 per cent level. This will help in the preparation of a cost effective kid starter instead of costly conventional ingredients, thereby reducing the feed cost and ensuring better returns to the farmers.

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8. ABSTRACT

A study was conducted to assess the effect of dietary incorporation of ayurvedic pharmaceutic gritham residues on growth performance of Malabari kids. Four ayurvedic pharmaceutic gritham residues, *viz*., indukanta gritham, tiktaka gritham, brahmi gritham and saraswata gritham were tested *in vitro* by *in vitro* gas production technique (IVGPT) to estimate metabolisable energy (ME), digestible organic matter (DOM) and *in vitro* digestible nitrogen (IVDN) and were ranked on the basis of a six point scoring system. Brahmi gritham residue which obtained the highest aggregate score was selected as the best ayurvedic pharmaceutic gritham residue which was used for further *in vivo* study.

Three isonitrogenous and isocaloric rations, T1, T2 and T3 without and with 10 and 20 per cent brahmi gritham residues, respectively, were formulated as per ICAR feeding standards (ICAR 2013). Fifteen Malabari kids were selected, divided into three groups of five each and allotted randomly to above three experimental rations and subjected to a feeding trial of 90 days duration.

The average daily gain and total average weight gain of kids were 56.44, 64.66, 54.88 g per day and 5.08, 5.82, 4.94 kg, respectively in groups T1, T2 and T3 and were similar ($P>0.05$). The average daily dry matter intake was 0.52, 0.56 and 0.57 kg per day, for kids in groups, T1, T2 and T3, respectively and the values were similar ($P>0.05$). The average values of FCE of experimental kids fed on rations T1, T2 and T3, were 4.62, 4.48 and 5.13, respectively, and statistical analysis of the data showed that the FCE was similar ($P>0.05$). There was no significant ($P>0.05$) difference in digestibility coefficient of nutrients except ether extract which was significantly higher ($P<0.05$) in T3 than T1, with T2 being similar ($P>0.05$) to both T1and T3 and NFE which was significantly higher ($P<0.05$) in T1 and T2 than T3, with T1 and T2 being similar ($P>0.05$). Haemato-biochemical parameters were similar among the three groups and the values were within the normal range of kids. The cost per kg body weight gain was Rs. 171.22, 141.88 and 149.91 for kids in groups, T1, T2 and T3, respectively.

The results obtained from the present study indicate that kids in groups T2 and T3 showed similar growth as that of T1 (control), T2 being slightly better than T3, as evinced by the lower and better FCE and lower cost per kg body weight gain in T2 than T3.

An overall critical evaluation of the results of the present study indicate that brahmi gritham residue can be safely incorporated in kid starter up to 20 per cent without affecting the growth performance of kids and better results can be achieved at 10 per cent level of incorporation. This will help in the preparation of a cost effective kid starter instead of costly conventional ingredients, thereby reducing the feed cost and ensuring better returns to the farmers.