ISSN 0970-3209
ISSN 2231-6744 (online)

MARCH 2020 | VOL. 37 | #1

I J A N

INDIAN JOURNAL OF ANIMAL NUTRITION

ANIMAL NUTRITION SOCIETY OF INDIA

AN OFFICIAL PUBLICATION OF
ANIMAL NUTRITION SOCIETY OF INDIA
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INDIAN JOURNAL OF ANIMAL NUTRITION

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ACKNOWLEDGEMENT

Animal Nutrition Society of India puts on record its sincere thanks to Indian Council of Agricultural Research, New Delhi for grant of financial support for publication of IJAN

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INDIAN JOURNAL OF ANIMAL NUTRITION
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Indian J. Anim. Nutr. 2020. 37 (1): 1-8
doi: 10.5958/2231-6744.2020.00001.8

Indian Journal of Animal Nutrition

Effect of Diets with Varying Levels of Metabolizable Energy on Lactation Performance and Metabolic Profile of Buffaloes

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ABSTRACT

The present study was conducted to ascertain the effect of feeding varying level of metabolisable energy on the production performance and nutrient utilization of Murrah buffaloes. Sixteen advance pregnant Murrah buffaloes (40-50 d before parturition) were divided into three treatment groups on the basis of most probable production ability (MPPA), (2200±241) and lactation number (3.57±0.95). Duration of feeding trial was 130 days i.e. 40 days pre-partum to 90 days post-partum period. Treatment groups were fed 3 different diets as low metabolizable energy (LME), medium metabolizable energy (MME) and high metabolizable energy (HME), at 85%, 100% and 115% of ICAR, 2013 ME requirements respectively. Concentrate mixture, maize green and wheat straw were offered to individual animal as per experiment protocol. As per diet offered, ME intakes was higher in HME followed by MME and LME while metabolizable protein (MP) and crude protein (CP) intakes were similar in all experimental groups. Metabolic trial of 7 days duration was conducted at after 60 days of post-partum feeding and it was observed that apparent digestibility (%) of DM, organic matter (OM) and CP were statistically similar among groups. Neutral detergent fibre (NDF) digestibility was higher in HME group as compared to LME and MME. There was no significant change in blood biochemical profile i.e. NEFA, IGF-1, glucose, BUN, total protein, albumin, globulin, AST and IgG, on feeding different levels of metabolizable energy. The nitrogen balance was not affected by different levels of ME in the diet. HME group had significantly higher milk yield and FPCM (Kg/day). The outcome of the current study indicates that fat and protein corrected milk significantly improved at 115% higher ME with respect to ICAR, 2013 nutrient requirements.

Key words: Metabolizable energy; Metabolizable protein; Murrah buffalo; Nutrient Utilization; Metabolic Profile

INTRODUCTION

Buffaloes (*Bubalus bubalis*) occupy an important position among the domesticated livestock, with 105.3 million buffaloes, India contributes about 56.7% of the total world buffalo population. The Murrah is a popular buffalo breed in the tropics, having the highest potential to boost production from buffalo husbandry. To establish buffalo husbandry on a scientific basis for commercial purposes, there is a need to establish the nutrient requirements for buffalo to achieve full genetic potential.

The transition period for a Murrah buffaloes is critical period which is from 3 week pre-partum until 3 week postpartum (Esposito *et al.,* 2014). The term transition is to underscore the important physiological, metabolic, and nutritional changes occurring in this time frame. Imbalanced or deficient nutrition alone contributes more than 80% to the reproductive problems (Khan *et al.,* 2011). Among the all nutrients, energy, is one of the most critical nutrients which may affect production performance of buffaloes (Jabbar *et al.,* 2013). During transition period dairy animals require more energy than they are able to consume resulting in the NEBAL (energy expenditure is higher than intake then the energy balanced is negative) and the concomitant loss of body weight (Bell, 1995). Earlier studies (Grummer and Carroll, 1988; Gong *et al.,* 2002) reported that sufficient dietary energy is an important factor in lactating animals which may prevent metabolic disorders. There is need of refinement of nutrient requirement for buffaloes during transition period. There is paucity of data on effect of varying level of metabolisable energy intake on the productivity of buffaloes and impact of such variations on nutrient

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utilisation and metabolic status of animals. Keeping in view of above, the present study was planned to evaluate the effect of high and low energy intakes compared to ICAR, 2013 feeding recommendations on production performance, nutrient utilisation and blood biochemical profile of buffaloes on varying plane of metabolizable energy.

MATERIAL AND METHODS

The experimental protocols that were developed in this study fully complied with the ethical principles of animal experimentation prepared by Institutional animal ethic committee (IAEC)-NDRI.For the present experiment, sixteen advance pregnant Murrah buffaloes (40-50 d before parturition) were selected from the herd of Livestock Research Centre of Institute. The buffaloes were randomly divided into three treatment groups i.e. LME (n=5), MME (n=5) and HME (n=6) group on the basis of MPPA (2294, 2167 and 2155 in LME, MME and HME respectively), and lactation number (3.80, 3.41 and 3.52 in LME, MME and HME respectively).

$$\text{MPPA} = \frac{u + nr}{1 + (n-1)r\,(x+u)}$$

Where, u – population mean

r – Repeatability of lactation milk

x – Average of lactation yield

n - Number of lactation records

Total duration of the feeding trial was 130 days i.e. 40 days pre-partum to 90 days post-partum. The requirement of ME of experimental animals in the MME group were fulfilled as per ICAR, 2013 nutrient requirements, whereas animals in treatment group 1 (LME) and group 2 (HME) were fed a rations having 15% less and 15% more ME as compared to MME. The varying levels of energy were ensured by adjusting the energy content of 3 different concentrate mixtures which were otherwise iso-nitrogenous in nature. Concentrate mixture, green fodder (maize) and wheat straw was fed to the animals as total mixed ration (TMR), in varying ratio as per experiment protocol. Before the start of the experiment, all animals were properly de-wormed. The animals were fed twice a day and fresh clean water was made available.

Physical compositions of different concentrate mixture are presented in Table 1. Throughout the study period, the measured quantity of diet was offered daily in the morning and evening to individual animals and orts were collected the next morning to determine daily feed intake. The feed sample during pre and post-partum periods were collected weekly and composited every three weeks to analyze dry matter, crude protein, ash, and ether extract AOAC (2005), acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL) (Van Soest *et al.,* 1991). Total digestible nutrients (TDN), digestible energy (DE), metabolizable energy (ME) and metablizable protein (MP) of the dietary samples were calculated as per NRC (2001).

The buffaloes were milked two times a day and daily milk production was recorded and samples were collected fortnightly for analysis of total solid, fat, solid

Table 1. Ingredient composition (% DM) of concentrate mixture used for different energy levels groups

Feed ingredient(%)	LME	MME	HME
Maize grain	24.0	34.0	39.0
Deoiled rice bran	24.5	16.5	12.0
Wheat bran	17.5	18.5	15.5
Mustard oil cake	-	12.0	10.5
Cotton seed cake	12.5	-	-
Soyabean meal	18.5	16.0	20.0
Mineral mixture	2.0	2.0	2.0
Salt	1.0	1.0	1.0
Total	100	100	100

not fat, and protein by using a Milk-O-Scan analyzer (Foss Electric, Conveyor 4000). The total solids in milk were calculated by the addition of milk fat% and SNF%. FPCM (Fat and Protein Corrected Milk) was calculated using Di Palo's equation (1992):

$$Y=1+0.01155\ [(X-40) + (Z-31)]$$

Where: Y is the quantity (kg) of FPCM equivalent to 1 kg of milk produced;

X and Z are the grams of fat and protein contained in 1 kg of milk produced

Blood samples were taken from the jugular vein using heparinized vacutainer in the morning before offering food. Plasma was obtained by centrifuging at 3,000×g for 10 min and frozen at -20ºC for later analysis of blood parameters. IgG and IGF-1 was quantified by Bioassay Laboratory technique ELISA kit (Cat no-E0010BO and E0016BO respectively) and based on the principle of competitive enzyme immunoassay technique. Blood urea nitrogen (BUN), aspartase aminotransfrase (AST), total protein, albumin and globulin were determined by using diagnostic reagent kit provided by Recombigen Laboratories Pvt. Ltd. (New Delhi).

After 60 days of post-partum feeding a metabolic trial was conducted for 7 days duration. Daily faeces of individual animals were collected for 24 h and pooled in plastic buckets covered with a lid, while urine was collected for 24 h and pooled in plastic cans. An aliquot of fecal sample for dry matter estimation (1/50) and N estimation (1/500 preserved in 20 % H_2SO_4) was collected daily from individual animal during the metabolic trial. Representative samples for urine was collected from individual animals from total urine collection of 24 hours. The urine samples was then pooled and preserved in plastic bottles containing 20 ml of 40% H_2SO_4. Samples of feed offered (wheat straw, green maize and concentrate mixtures) and orts were also collected daily, and representative samples were kept for dry matter (DM) estimation. Dried samples of faeces, feed offered, and orts were ground through a 1-mm sieve using a Wiley mill. Ground samples were stored in plastic containers and labelled for subsequent use in chemical and biochemical estimations.

For the study of cervical (diameter of cervix) and uterine involution (diameter of both uterine horn) was checked by using Ultra Sonography technique (USG) (UST-8520-5 Aloka, probe-6.5 MHz, Japan) on days 7, 14, 21, 28, 35 and 42.

Statistical analysis

Data on various parameters (body weight, DMI, milk yield) were analyzed by one way ANOVA whereas blood biochemical parameters was assessed by repeated measures analysis of variance and further analyzed with regression procedure using method of Snedecor and Cochran (2004) and the Statistical Analysis System (2000). Data is presented as Mean ± SE. Differences with probabilities ($P<0.05$) were considered significant. The mathematical models used were *Yij=*

Table 2. Chemical composition of concentrate mixture, maize fodder and wheat straw

Chemical composition (g/kg)	Concentrate mixture			Maize(Green)	Wheat Straw
	LME	MME	HME		
Dry matter	891.7	896.8	895.3	215.0	908.9
Organic matter	923.0	928.4	929.6	897.1	885.4
Crude protein	191.6	195.5	197.8	84.0	3.40
Ether extract	32.0	33.0	34.0	13.3	9.90
Neutral detergent fiber	282.0	265.0	246.0	363.2	682.0
Metabolizable protein	128.9	123.5	128.4	65.0	0.0
Metabolizable energy (MCal/kg)	2.82	2.92	3.32	1.96	1.65

ME and MP were calculated as per method given by NRC (2001)

Table 3. Effect of feeding varying levels of ME on Nutrient intake of Murrah buffaloes

Parameters	LME	MME	HME
	Before calving		
Body weight (kg)	626.4±7.6	616.6±16.5	620.4±14.8
DM (g/ kg W $^{0.75}$)	90.66±0.44	91.32±1.16	91.74±0.78
CP(g/ kg W $^{0.75}$)	7.82±0.2	7.91±0.06	7.86±0.05
TDN (g/ kg W $^{0.75}$)	40.32^a±0.37	45.50^b±0.18	48.53^c±0.77
ME (KJ/ kg W $^{0.75}$)	616.88^a±4.71	701.61^b±6.34	745.75^c±13.12
MP (g/ kg W $^{0.75}$)	4.72±0.15	4.67±0.04	4.73±0.18
	After calving		
Body weight (kg)	570.8±4.8	560.3±9.6	574.2±4.8
DM (g/ kg W $^{0.75}$)	127.97^a±1.79	128.06^a±1.11	135.86^b±1.22
CP(g/ kg W $^{0.75}$)	14.72±0.18	14.62±0.19	14.90±0.20
TDN (g/ kg W $^{0.75}$)	60.63^a±0.57	70.64^b±0.68	80.27^c±0.85
ME (KJ/ kg W $^{0.75}$)	936.40^a±7.62	1072.99^b±11.60	1205.70^b±12.72
MP (g/ kg W $^{0.75}$)	7.80±0.48	7.77±0.38	7.53±0.36

$^{(a,b,c)}$ Means with a different superscripts in a row differ significantly (P<0.05)

$\mu+Ai+ei+Ti+(A\ X\ T)+eij$ and $Yi=\ \mu+Ti+ei$ for blood parameters and other parameters, respectively.

Where *Yij and Yi* is the dependent variable (BW; DMI; MY; Nutrient digestibility; Blood biochemical parameters etc), is the overall mean, *Ti* is the effect of *i*th treatment (LME, MME and HME), *Ai* is the fixed effect of *i*th treatment, ei is the variability within treatment group, eij is the variability from animal and time and is the residual error of the *i*th observation.

RESULTS AND DISCUSSION

The detail chemical composition of feed ingredients is presented in Table2. Body weight and intake of various nutrients before and after calving are presented in Table 3. CP and MP intakes were similar in all the groups. TDN and ME intakes significantly varied among treatment groups, being highest in HME followed by MME and LME groups respectively, as per feeding protocol. The apparent digestibility (Table 4) of DM, OM and CP was similar in all groups. The digestibility of EE, NDF and ADF was adversely affected in LME group. However the digestibility of EE, NDF and ADF were similar in HME and MME treatments groups. N excretion in faeces, nitrogen excretion via urine and N outgo in milk were not affected by the different levels of ME in diet (Table 5). Nitrogen balance (g/d) was statistically similar in all experimental groups.

The effect of different ME levels on milk yield

Table 4. Effect of feeding varying levels of ME on digestibility of nutrients (%) in Murrah buffaloes

Particular	LME	MME	HME
DM (%)	62.77±0.76	65.28±1.47	65.15±1.32
OM (%)	67.93±1.17	67.35±1.48	70.53±1.29
CP (%)	63.14±1.36	64.38±2.35	65.39±1.29
EE (%)	67.94^a±0.90	71.70^b±0.95	72.92^b±1.11
NDF (%)	50.31^a±1.16	52.82^{ab}±1.74	55.65^b±0.94
ADF (%)	31.86^a±0.97	35.39^b±1.15	35.37^b±0.83

$^{(a,\ b)}$ Means with a different superscripts in a row differ significantly (P<0.05)

Table 5. Effect of feeding varying levels of ME on nitrogen balance (g/day) during digestibility trial in Murrah buffaloes

Particulars	LME	MME	HME
N intake	292.91±7.04	280.82±5.54	294.46±9.30
N in feces	109.17±11.95	102.11±19.41	103.89±13.83
N in Urine	100.02±6.74	100.26±15.81	102.99±4.54
N in milk	60.91±4.63	55.24±4.06	61.74±1.19
N outgo	270.11±6.43	257.62±6.85	268.63±10.57
N balance	22.8±2.39	23.2±3.56	25.83±2.18

and composition is presented in Table 6. Significantly higher milk production (kg/day) was observed in the HME (10.97) in comparison to LME (10.42). The FPCM (kg/day) was significantly higher in HME (14.00) as compared to LME (13.42) and MME (13.37). The milk components of i.e. total solid, fat, solid not fat and protein did not vary on feeding rations with varying ME level.

The result of metabolic profile pertaining to immunity is depicted in Table-7. IGF-1 (ng/ml) and IgG (μg/ml) were similar on feeding varying ME rations. BUN (mg/dl), total protein (mg/dl), albumin (mg/dl), globulin (mg/dl) and AST (U/L) concentrations were also similar in different treatment groups.

The calf mortality was not observed in MME and HME group whereas two calf mortality were there in LME. Calf birth weight was 35.2, 32.5 and 33.66 in LME, MME and HME, respectively. Period required for complete uterine involution was 50, 47 and 47 days in the LME, MME and HME groups respectively, which was higher in LME group. This may be due to incidences of metritis in LME group.

McNamara *et al.* (2003) found that feeding of diets high in energy density pre-partum improved transitional success. In the present study feeding of high energy diet in pre-partum improved postpartum DMI (Fig 1) of HME group than LME and MME group. Similarly, dry matter intake in the ruminants was increased by energy concentration in the diets (Nair *et al.* 2004; Gaafar *et al.* (2011). In contrast to our result, Wang *et al.* (2010), reported that animal fed high energy diets during pre-partum period had lower DMI compared with those on lower energy diets and Aghaziarati *et al.* (2011) reported that varying energy density, did not affect the DM intake. In the present study high energy density might have resulted in improvement in DMI. CP and MP intakes were not affected due to variations in ME levels. In the present study digestibility of EE, NDF and ADF were improved in high energy diet group than low energy diet group whereas DM, OM and CP remained similar in all experimental group (Table-4). Higher NDF levels diets are associated with depressed NDF and DM digestibility (Ahmed *et al.,* 2014; Tjardes *et al.,* 2002).

Table 6. Effect of feeding varying levels of ME on Milk yield and milk composition of Murrah buffaloes

Parameters	LME	MME	HME
Milk yield (Kg/day)	10.42[a]±0.10	10.60[ab]±0.13	10.97[b]±0.10
FPCM (Kg/day)	13.42[a]±0.14	13.37[a]±0.16	14.00[b]±0.13
FPCM (Kg/kg DMI)	0.89±0.09	0.90±0.01	0.88±0.09
TS (%)	17.22±0.09	17.40±0.10	17.53±0.15
Fat (%)	7.02±0.08	7.09±0.07	7.04±0.06
SNF (%)	10.19±0.04	10.27±0.14	10.49±0.10
Protein (%)	3.87±0.05	3.97±0.14	3.88±0.03

(a,b,c) Means with a different superscripts in a row differ significantly ($P<0.05$)

Table 7. Effect of different levels ME on Metabolic profile in Murrha buffaloes

Parameters	LME	MME	HME
BUN (mg/dl)	13.22±0.29	13.38±0.26	13.53±0.30
TP (mg/dl)	6.94±0.14	6.86±0.16	7.32±0.13
Albumin (mg/dl)	2.7±0.12	2.94±0.14	3.18±0.11
Globulin (mg/dl)	4.17±0.13	3.91±0.15	4.14±0.12
AST (U/L)	37.07±1.80	35.17±1.80	34.21±1.64
IgG (µg/ml)	37.30±2.39	35.17±2.39	39.33±2.18
IGF-I (ng/ml)	112.19±3.15	114.83±3.15	122.52±2.88

El-Ashry *et al.* (2003) and Gaafar *et al.* (2011) observed that buffaloes fed the highest energy level recorded the highest digestibility of ether extract. Ether extract content was relatively high in HME and source of additional fat was oilseed cakes and cereals grain, mainly through concentrate mixture, which is more digestible. This might be the reason for better digestibility of ether extract.

In the present study increased ME intake (Table-3) in HME group, might have contributed to improved milk yield. These results are in agreement with Patton *et al.* (2006), who reported that increasing the dietary energy up to recommended level within 1st month of lactation enhanced the milk yield. Broderick (2003) reported that increasing the dietary protein and energy gave the linear increase in the milk yield. However, in contrary to present study, Jabbar *et al.* (2013) observed that feeding 20% above NRC recommended levels did not show changes in milk yield, but feeding 20% below NRC recommendation there was detrimental effect on milk production. In the present study the milk components were not influenced by varying dietary energy levels. The results are in agreement with the findings of Aghaziarati *et al.* (2011) who concluded that enriched dietary energy and protein did not affect milk fat and protein. Likewise, Mustafa *et al.* (2017) also reported that milk production and composition were not affected by feeding an energy-rich diet (added dietary fat) to dairy animals. However, in contrast to our result Bovera *et al.* (2002) and by Gaafar *et al.* (2011) observed increase in milk protein on feeding high energy content diet. The FPCM yield in HME group was better than LME and MME groups, but FPCM yield per kg of DMI did not vary among the different dietary groups. In support with our findings Bovera *et al.* (2002) reported that feeding higher energy diet lead to higher FPCM yield compared to energy deficient diet and Gaafar *et al.* (2011) reported that high energy diet significantly improved 7 % FCM yield.

In the present study difference in dietary energy content did not affect IGF-1 and IgG levels of transitional buffaloes. In contrast to our result, Mustafa *et al.* (2017) observed that lower IgG levels in low energy fed group. The AST (U/L) in all the groups was similar (Table-7) and within the physiological limits; hence, no impairment in liver function is observed in all the groups. It was also observed that blood urea level was not affected by different energy levels this may also be due to feeding of iso-nitrogenous diet to all experimental groups. However, Bovera *et al.* (2002) found that blood urea concentration was higher in group which was supplied higher energy and protein in their total ration.

Improved nutrition of the late-gestation cow has been postulated to reduce the incidence of reproductive issues (Goff, 2006). Earlier reports (Qureshi and Ahmad 2008; Khan *et al.,* 2011) indicated a mean post-partum uterine involution time of 34.30±1.33 days in dairy buffaloes. In our study the involution time is on higher side to above reported results. Miettinen (1990) reported that in dairy cows, a low energy level in early puerperium delayed uterine involution and onset of ovarian activity and prolonged service period. The birth weight calves is within the normal limits and no variation was observed.

CONCLUSIONS

It was concluded that increasing energy supplementation at 15% higher than ICAR-2013 feeding recommendation may improve the FPCM yield and fiber digestibility with no adverse effect on blood biochemistry and DM digestibility in Murrah buffaloes.

ACKNOWLEDGMENT

Author gratefully acknowledge to Director, ICAR-National Dairy Research Institute, Karnal. The work was supported by Indian Council of Agriculture Research Institute, Delhi.

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Received on 10-02-2020 and accepted on 07-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 9-13
doi: 10.5958/2231-6744.2020.00002.X
Indian Journal of Animal Nutrition

Effect of Supplementing Molasses Based Multi-Nutrient Liquid Supplement (MMLS) on Nutrient Intake, Digestibility and Growth Performance of Buffalo Calves

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ABSTRACT

Twenty-one buffalo calves (111±4.53 kg BW, 6-8 months age) were assigned to 3 groups (T_1, T_2 and T_3) consisting of 7 animals each in a completely randomized block design. Concentrate mixture composition was remained the same for all three groups; however, concentrate to wheat straw ratio were 60:40, 50:50 and 40:60 in groups in T_1, T_2 and T_3, respectively. Additional molasses based multi-nutrient liquid supplement (MMLS) was provided in T_2 and T_3 groups @ 5% and 10% DMI respectively. Daily intake of green oats, dry matter (DM), OM, NDF and ADF did not differ significantly (P>0.05) among groups. However, concentrates and EE intake were significantly (P<0.01) higher in calves of T_1 group followed by T_2 and T_3. Wheat straw (kg/d), CP (kg/d, kg/d $W^{0.75}$) and DCP (kg/d, kg/d $W^{0.75}$) intake were significantly (P<0.01, P<0.05) higher in MMLS treated groups when compared to control. The digestibility coefficient of DM, OM, CP, EE, NDF and ADF did not differ significantly among groups. Initial and final body weight, total weight gain, ADG, DMI and FCR were also comparable (P>0.05) among the groups. Reducing the amount of concentrate and replacing the reduced amount by MMLS @5% and 10%, depending on the concentrate to roughage ratio can increase the ADG and thus growth rate of buffalo calves without any adverse effects on DMI and digestibility of nutrients.

Key words: Buffaloes calf, Digestibility, Feed intake, Growth performance, MMLS

INTRODUCTION

Natural calamities, urbanization and rise in human population had an adverse impact on availability of animal feeds. Therefore, ruminants thrive mainly on poor quality feeds and pastures, which are having low content of nutrients and high content of lignin and silica; that limit their efficient utilization by ruminants. Animal nutritionists, have proved that the nutritive value of these crop residues can be enhanced if deficient nutrients are supplemented (Makkar, 2002; Singh and Singh, 2003). Addition of urea and molasses was found promising when either fed with or sprayed over poor quality roughages, or used as a urea-molasses (Maneerat *et al.,* 2015) as these supplements are good source of non-protein nitrogen, energy, minerals and vitamins. Moreover, liquid feed supplements offer an alternative delivery vehicle for supplemental fat, protein, and rumen-fermentable carbohydrates, minerals and vitamins in rations for lactating dairy cows (Ankita *et al.,* 2016). Little research has been done on molasses based multi-nutrient liquid supplement (MMLS) for improving the performance of ruminants. Therefore, an attempt was made to evaluate the effect of feeding MMLS on nutrient intake, nutrient digestibility and growth performance of male buffalo calves.

MATERIALS AND METHODS

The experiment was conducted for 126 days at Animal Nutrition Laboratory, ICAR-Indian Veterinary Research Institute, Izatnagar. Twenty-one buffalo calves (111±4.53 kg BW, 6-8 months age) were assigned to 3 groups *i.e.*, T_1, T_2 and T_3, consisting of 7 animals each in a completely randomized block design. Composition of the compounded concentrate remained the same for all three groups except that the amount of concentrate were given as 60%, 50% and 40% of the total requirements in groups in T_1, T_2 and T_3 and additional MMLS was provided in T_2 and T_3 groups

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@ 5% and 10% DMI after mixing with respected amount of concentrate taken for each animal. The ingredient and chemical composition of feed ingredients fed to the experimental animals is presented in Table 1.

All the buffalo calves were offered daily a weighted amount of respective concentrate mixture and/ or MMLS in the morning at 10.00 AM to meet their nutrient requirements for maintenance and growth as per the guidelines of Kearl (1982) feeding standard. Wheat straw (*ad lib*) and green oats (10 kg) were provided after ensuring complete consumption of the concentrate mixture. Wheat straw refusals were weighted daily on the next morning to estimate consumption per day and sampled at weekly intervals for subsequent analysis of DM to assess the average DMI during the experimental period. All the animals were offered fresh and clean tap water free choice twice daily. The BW of the individual calf was recorded at fortnightly intervals in the morning before feeding and watering. A metabolism trial was conducted after 126 days of experimental feeding to assess the intake and digestibility of nutrients. Body weight of the experimental calves were recorded before and after metabolism trial on two consecutive days. During the trial, the buffalo calves were housed in individual metabolism cages fitted with removable feeders and arrangements for quantitative collection of faeces and urine separately. The trial lasted for 9 days with a 3 days adaptation period to accustom the animals to cages prior to 6 days collection and measurement period. Samples of feed offered and refused were collected daily quantitative estimation of intake. Faecal and urine outputs during 24 hours were recorded. A sub-sample of the faeces (1/100) was collected and dried at 80±2°C for 24 hours in a forced-draft oven for DM estimation. Pooled samples of 6 days for each animal were ground and stored for chemical analysis. The samples of feed offered, residue left and faeces voided were analyzed for proximate compositions as per standard procedures of Association of Official Analytical Chemists (AOAC,

Table 1. Ingredients and chemical composition of feeds offered

Particulars	Concentrate	MMLS	Wheat straw	Green oats
Crushed maize	35	-	-	-
Soyabean meal	30	-	-	-
Mustard Cake	05	-	-	-
Wheat bran	27	-	-	-
Cane molasses	-	77.0	-	-
Neem coated urea	-	10.0	-	-
DMSC	-	10.0	-	-
Mineral mixture	02	2.0	-	-
Common salt	01	1.0	-	-
Chemical composition				
OM (%)	90.85	87.03	92.45±0.08	90.59±0.21
CP (%)	22.23±0.13	35.36±0.06	3.15±0.09	8.93±0.14
EE (%)	2.14±0.07	1.32±0.01	1.28±0.06	2.06±0.06
Total ash (%)	8.79±0.49	12.97±0.01	8.73±0.14	8.26±0.31
NDF (%)	32.65±1.05	7.3±0.10	80.84±0.68	65.37±1.23
ADF (%)	9.95±0.25	6.16±0.12	51.86±0.41	36.61±1.26
Ca (5)	0.75±0.04	1.36±0.19	0.24±0.01	2.19±0.12
P (5)	0.41±0.06	0.43±0.02	0.13±0.01	0.52±0.18

DMSC: Deoiled mahua seed cake

2002). Data obtained were subjected to analysis of variance (ANOVA) using SPSS software (v11.0) and treatment means were ranked using Duncan's multiple range tests. Significant variance between treatments were measured at P<0.05. Statistical analysis were carried as for the procedures of Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Data pertaining to mean feed intake and apparent digestibility of nutrients in different groups are presented in Table 2. Wheat straw intake was significantly (P<0.01) higher in calves of T_3 group. Calves of T_2 groups had an intermediate position between animals of T_3 and T_1 groups. Ankita *et al.* (2016) also observed higher intake of straw DM in MMLS supplemented group. The basal diet became more palatable due to incorporation of urea and molasses as evidenced from increase in wheat straw intake by MMLS treatment groups. The daily intake of DM, OM, NDF and ADF from oat fodder did not differ significantly (P>0.05) among treatments. However, EE intake was found to be higher in control group. The reduction of EE intake in the MMLS treated groups might be due to the higher EE content of concentrate mixture as compared to MMLS as evident from chemical composition. Similar results were also obtained by Anuraj *et al.* (2017) whilst 15% and 30% of the concentrate mixture were replaced by MMLS. On the other hand, CP intake was significantly higher in MMLS supplemented groups as compared to non-supplemented group.

EE digestibility was found to be lower than that of ADF. It may be due to supplementation of urea as a part of MMLS (Wu *et al.,* 2005). Data pertaining to plane of nutrition, ADG and FCR are presented in Table 3. Content of DCP (%) and DCP intake (g/d or g/kg $W^{0.75}$) was significantly (P<0.05, P<0.01) higher in T_3 followed by T_2 and T_1. On the other hand, there was no

Table 2. Mean intake (kg/d) and digestibility (%) of various nutrients in different groups

Particulars	Treatments			SEM	P value
	T_1	T_2	T_3		
Dry matter					
DMI (kg/day)	5.47±0.21	5.55±0.20	5.38±0.26	0.21	0.41
Digestibility	63.17±2.15	64.53±2.36	65.97±3.60	2.65	0.43
Organic matter					
Intake	4.95±0.12	5.08±0.12	4.81±0.10	0.11	0.42
Digestibility	64.73±1.12	65.05±1.27	66.87±0.90	1.07	0.22
Crude protein					
Intake	0.52^{b}±0.01	0.62^{a}±0.04	0.66^{a}±0.02	0.01	<0.01
Digestibility	69.42±1.24	70.49±2.17	69.21±2.82	1.90	0.79
Ether extract					
Intake	0.09^{a}±0.00	0.09^{ab}±0.00	0.08^{b}±0.00	0.00	<0.01
Digestibility	50.28±3.05	50.67±3.13	54.71±3.20	2.15	0.55
NDF					
Intake	2.37±0.06	2.32±0.08	2.46±0.13	0.05	0.56
Digestibility	61.39±1.28	58.98±2.24	64.07±3.79	1.52	0.41
ADF					
Intake	1.59±0.04	1.54±0.53	1.68±0.09	0.07	0.32
Digestibility	53.35±1.62	54.10±2.86	56.86±2.59	2.04	0.02

^{abc}Means values with different superscripts within a row differ significantly (P<0.05)(P<0.01)

Table 3. Effect of MMLS on nutritive value, plane of nutrition and growth of buffalo calves

Particulars	Treatments			SEM	P value
	T_1	T_2	T_3		
CP intake (g/day)	520^b	621^a±22.24	660^a±15.02	18.01	<0.01
DCP intake (g/day)	361^c±24.23	437^b±20.45	456^a±19.21	20.02	<0.01
DCP intake, g $W^{0.75}$	7.2^b±0.25	8.5^{ab}±0.23	8.76^a±0.25	0.21	<0.01
DOM, g $W^{0.75}$	64.64±0.16	64.46±0.45	61.88±0.26	0.29	0.55
TDN, gd^{-1}	3364±184.21	3470±90.32	3377±100.34	85.99	0.96
TDN, $gW^{0.75}$	67.93±1.23	67.72±1.17	65.06±2.15	1.55	0.81
Nutrient density					
DCP (%)	6.59^b±0.43	7.87^{ab}±0.45	8.47^a±0.74	0.56	<0.05
TDN (5)	61.50±0.97	62.52±0.84	62.76±1.31	0.84	0.55
Body weight (kg)					
Initial	111±4.53	111.43±3.61	112.27±4.67	4.29	0.97
Final	182.09±7.61	190.43±4.9	194±9.94	7.76	0.54
Total gain	71.09±3.83	79±2.93	81.73±5.29	4.13	0.19
ADG (g/day)	560±28.12	630±20.18	650±20.15	0.03	0.19
Voluntary feed intake					
DMI (kgd^{-1})	5.47±0.15	5.55±0.17	5.38±0.21	0.15	0.75
Total DMI (kg)	689.22±25.25	699.3±20.23	677.88±23.25	20.45	0.12
DMI (%)	3.00±0.02	2.92±0.01	2.76±0.02	0.01	0.19
FCR	9.5±1.10	8.9±.0.95	8.3±0.96	0.88	0.07

[abc]Means values with different superscripts within a row differ significantly (P<0.05)(P<0.01)

significant (P>0.05) difference among the groups for the intake of DOM, TDN and TDN content of the diets. Results of this study corroborated well with those of Sahoo *et al.* (2004) who reported significant (P<0.01) increase in CP and DCP intake in the supplemented groups compared to control due to addition of urea through urea-molasses supplement and comparable intake of DM, DOM and TDN in all the groups, which is in agreement with our findings.

The digestibility coefficient of DM, OM, CP, EE, NDF and ADF did not differ significantly (P>0.05) among treatment groups. Similarly, Mohini and Singh (2010) also observed non-significant changes in digestibility of DM, OM and CP in crossbred dairy cows fed urea molasses mineral block (UMMB) replacing 35% of concentrate mixture and fed standard ration without UMMB. Initial and final BW, BW gain, DMI and FCR were comparable among the groups. In agreement with the result, Choubey *et al.* (2010) reported increase in BW gain of UMMB treated groups.

CONCLUSION

The findings of the present study revealed that reducing the amount of concentrate and replacing the reduced amount by MMLS @ 5% and 10% depending on the concentrate to roughage ratio can increase the ADG and thus growth rate of buffalo calves without any adverse effects on feed intake and digestibility of nutrients.

ACKNOWLEDGEMENTS

The authors are thankful to Director, IVRI, Izatnagar for providing necessary facilities to complete this study. The financial assistance provided to first author by ICAR, New Delhi is duly acknowledged.

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Received on 28-02-2020 and accepted on 17-05-2020

Indian J. Anim. Nutr. 2020. 37 (1): 14-20
doi: 10.5958/2231-6744.2020.00003.1

Indian Journal of
Animal Nutrition

Effect of Challenge Feeding on Prepartum and Postpartum Dry Matter Intake in Sahiwal Cattle in the Arid Region of Rajasthan

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ABSTRACT

The present study was carried out with the objective of investigating the effect of challenge feeding on prepartum and postpartum dry matter intake in Sahiwal cattle. The present study was conducted on eighteen healthy, advance pregnant Sahiwal cattle from 60 days prepartum to 120 days postpartum. The animals were divided into two groups *i.e.* control and treatment on the basis of milk yield, parity and body weight. The animals in control group were given standard ration while in challenge fed (treatment) group, the animals were given additional amount of concentrate mixture. Both the groups were offered *ad libitum* dry fodder during entire period of study. The mean DMI (kg) in control and treatment group cows during prepartum period was 8.37±0.35 and 9.34±0.36 kg/d, respectively which did not differ significantly between treatments. The postpartum DMI was significantly higher (P<0.05) in treatment group (11.04±0.10 kg) as compared to control group (9.38±0.06 kg).

Key words: Challenge feeding, Concentrate mixture, DMI, Postpartum, Sahiwal

INTRODUCTION

India has a great population of indigenous cows but the performance of these animals is not upto their genetic potentials. The lactation yield of our indigenous cattle is very low. In rural areas indigenous animals are often fed with low quality feeds and agricultural byproducts which have low nutritive value. In our country there is an acute shortage of green especially leguminous fodder as most of the land area is utilized for food grains production and the milch animals are deprived of good quality fodders. In addition to this, in India, concentrate feeding to animals is neglected during dry period as well as in milking stage due to poor economic condition of livestock farmers, so these dairy animals are deprived of essential nutrients. These nutrients are very much essential to fulfill the requirements of growth and maintenance of fetus, placenta and uterus as well as to replenish the body tissue losses due to milk production postpartum. This inadequacy of concentrate feeding along with low availability of good quality green and leguminous fodders is the major reason behind the poor productivity of our indigenous cattle population.

The period from two months pre-calving to three months post calving which includes the transition period is the most stressful period in the annual cycle of dairy cow. It is physiologically and nutritionally a very stressful period, particularly as feed intake is reduced, while the demand for support of foetal growth and initiation of milk synthesis are increased. During late gestation, feed intake is reduced (Hernandez-Urdenata *et al.,* 1976; Johnson and Otterby, 1981; Olsson, 1996; Murphy, 1999), particularly in the last few days of pregnancy. This period is very important for the animals to augment body reserve to meet the demands of growing foetus and to avoid negative energy balance peripartum. The scope of the present study was to investigate the response of the challenge feeding on prepartum and postpartum dry matter intake in Sahiwal cattle assigned to different feeding levels during the prepartum and postpartum period.

MATERIALS AND METHODS

The present study was conducted at the Livestock Research Station, Kodamdesar, RAJUVAS, Bikaner (Rajasthan) from 1st October'18 to 30 June'19. Eighteen (18) pregnant Sahiwal cattle were selected 2

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Table 1. Prepartum feeding schedule

Days prepartum	Control group	Treatment group (Challenge fed group)
60 days to 22 days	Forage - *ad lib.* Concentrate - 2 kg/day	Forage - *ad lib.,* Concentrate - 3.5 kg/day
21 days to 0 day	Forage - *ad lib.* Concentrate - 3.5 kg/day	Forage - *ad lib.,* Concentrate - 3.5 kg +250 gm/day till it reaches 1% body weight

months prior to calving according to data obtained from breeding records of animals. These pregnant animals were distributed into two groups based on parity, body weight and milk yield of previous lactations to maintain homogeneity among experimental animals. The same process was adopted until there were nine animals in each treatment group. The experimental animals were separated from the main herd 7-10 days before start of experiment to acclimatize these experimental animals in the new suggested environment.

During last two months of gestation specified quantity of concentrate according to treatment plans were offered to animals once in a day after weighing in spring balance in the morning (Table 1). Dry fodder was offered *ad libitum*. Wheat straw was the main sources of dry fodder provided to animals. Weighed quantity of dry fodder was provided once in a day in the morning. Some leftover was a must as an indicator of *ad libitum* feeding. The leftover was collected and weighed to record actual amount of feed consumed by the animals.

For a period of 120 days after the calving all the animals were given control and treatment diets as per feeding plan (Table 2). Postpartum concentrate feeding was done twice a day in two equal installments along with sodium-bicarbonate to avoid bloat, tympany and indigestion due to overeating of concentrates. Dry fodder was provided *ad libitum* to animals.

Daily intake of concentrate and roughage was recorded for individual animals. Measured quantities of concentrates and roughage were offered to animals and the leftover was collected next day in the morning and weighed. The leftover was subtracted from the initial feed supplied to know the actual amount of feed consumed by an animal. Dry matter of dry fodder and concentrate were estimated by drying the samples at 100±1°C overnight in hot air oven.

Statistical analysis

Data collected from this experiment were statistically analyzed as per Snedecor and Cochran (1994) for two groups by using statistical ‘t’ test. Data were expressed as Mean±S.E. For calculation of Mean and S.E, descriptive statistics was used. Comparable means differed significantly, if $P<0.05$ *i.e.* at 5 % level of significance.

RESULTS AND DISCUSSION

The data on means±SE of total daily dry matter intake per cow by control and treatment group during the prepartum period is presented in Table 4. The

Table 2. Postpartum feeding schedule

Days postpartum	Control group	Treatment group (Challenge fed group)
1st two weeks	Forage - *ad lib.*Concentrate for maintenance - 2 kg/day, Forage - *ad lib.*Concentrate for maintenance - 2 kg/day	Concentrate for production - 1 kg/3 kg of milk Concentrtae for production – 1 kg/3 kg of milk+ 500 gm concentrate/day till free choice level
2nd week onwards to 16th week	Forage - *ad lib.* Concentrate for maintenance - 2 kg/day, Concentrate for production - 1 kg/3 kg of milk	Forage - *ad lib.* Concentrate – Free choice

Table 3. Mean±SE of daily dry matter intake (kg) from concentrate and dry fodder by control and treatment group during prepartum period

Weeks before calving	Feedstuff			
	Concentrate		Dry fodder	
	Control	Treatment	Control	Treatment
1.	1.77±0.003	3.10±0.004	6.06±0.10	6.21±0.16
2.	1.77±0.003	3.11±0.003	6.45±0.26	6.61±0.21
3.	1.77±0.002	3.11±0.002	6.78±0.17	7.31±0.23
4.	1.78±0.002	3.11±0.001	6.98±0.20	6.69±0.19
5.	1.79±0.001	3.12±0.001	6.76±0.18	6.49±0.22
6.	3.11±0.001	3.41±0.017	6.12±0.14	6.15±0.15
7.	3.07±0.003	3.49±0.020	5.41±0.31	5.16±0.26
8.	3.06±0.002	3.43±0.013	4.38±0.08	4.68±0.22
Overall	2.26^{a}±0.075	3.23^{b}±0.02	6.12±0.12	6.11±0.13

*Means bearing different superscripts differ significantly (P<0.05)

overall means of daily dry matter intake for the two month prepartum period were 8.37±0.35 and 9.34±0.36 kg for control and treatment group, respectively. The difference in the means of daily dry matter intake of the two treatment groups during the prepartum period were found to be non- significant but higher by about 970 gm per day in treatment group as the cows of treatment group were supplemented only one kg of concentrate mixture over the control group for most of the prepartum period. The means of daily dry matter intake per cow through concentrate mixture ranges from 1.77 to 3.06 kg for control group with an overall mean of 2.26 kg and from 3.10 to 3.43 kg for treatment group with an overall mean of 3.23 kg during the prepartum feeding period (Table 3). The means of daily dry matter intake per day through dry fodder ranged from 4.38 to 6.06 kg for control group with an overall mean of 6.12 kg and from 4.68 to 6.21 kg with an overall mean of 6.11 kg for treatment group during the prepartum period. The dry matter intake from concentrate mixture was significantly (P<0.05) higher in the treatment group of cows as compared to control group of cows which was on expected lines as the treatment group of cows were offerred additional amount of concentrate mixture as per the experimental plan. The mean daily matter intake through concentrate mixture intake

Table 4. Mean±SE of total daily dry matter intake (kg) by control and treatment group during prepartum period

Period (In weeks)	Control group	Treatment group
1.	7.82±1.06	9.31±0.95
2.	8.21±0.97	9.71±1.05
3.	8.55±0.99	10.42±1.00
4.	8.76±1.04	9.81±1.07
5.	8.53±1.10	9.60±1.04
6.	9.23±1.00	9.56±1.09
7.	8.48±1.04	8.65±1.06
8.	7.42±0.91	7.66±0.95
Overall	8.37±0.35	9.34±0.36

progressively increased from first to sixth week of feeding and then showed a decline in last two weeks before parturition in control group whereas in treatment group the mean daily matter intake through concentrate mixture intake progressively increased from first to seventh week of feeding and then showed a decline in last week before parturition. This decline in the dry matter intake from concentrate mixture prior to parturition may be attributed to stress caused by approaching parturition during which the appetite of animal falls drastically.

The mean daily dry matter intake from dry fodder per cow for the control and treatment group during prepartum period was 6.12±0.12 kg and 6.11±0.13 kg, respectively which did not differ significantly between the control and treatment group. The mean daily intake of dry fodder per cow for the control and treatment group during prepartum period was 6.31±0.12 kg and 6.30±0.13 kg, respectively. The dry matter intake through dry fodder in both the groups showed an increasing trend from first week to fourth week but declined continuously from fifth week to last week of prepartum feeding. Increased size of foetus resulting in decreased GIT capacity as well as high concentrate feeding are the possible reasons for this decline in dry fodder intake in last month of gestation.

The means of total daily dry matter intake per 100 kg body wt. during prepartum period of the animals of the control and treatment group were 2.13±0.09 % and 2.37±0.09 %, respectively which also did not differ significantly.The results obtained regarding dry matter intake during prepartum period in the present study are in agreement to those reported by Kale and Tomer (1991), Panigrahi *et al.* (2005), Kamboj *et al.* (2016), Naik *et al.* (2016) and Raval *et al.* (2019) who observed that feeding on a higher plane prepartum do not affect

Table 5. Mean±SE of daily dry matter intake (kg) from concentrate and dry fodder by control and treatment group during postpartum period

Weeks after calving	Feedstuff			
	Concentrate		Dry fodder	
	Control	Treatment	Control	Treatment
1.	3.18±0.18	4.05±0.23	4.63±0.32	3.88±0.38
2.	3.87±0.27	5.79±0.37	4.73±0.38	4.07±0.48
3.	4.10±0.27	5.93±0.35	4.82±0.44	4.31±0.57
4.	4.33±0.28	6.13±0.39	4.88±0.40	4.26±0.57
5.	4.74±0.27	6.53±0.40	4.96±0.43	4.37±0.52
6.	4.86±0.34	7.12±0.39	5.13±0.45	4.53±0.67
7.	4.80±0.35	7.42±0.36	5.12±0.46	4.53±0.58
8.	4.75±0.35	7.37±0.35	5.16±0.46	4.47±0.61
9.	4.64±0.35	7.27±0.31	5.21±0.48	4.58±0.44
10.	4.44±0.32	7.07±0.22	5.25±0.50	4.63±0.61
11.	4.30±0.28	6.97±0.45	5.31±0.32	4.69±0.58
12.	4.16±0.25	6.77±0.46	5.26±0.38	4.74±0.60
13.	3.91±0.27	6.63±0.42	5.41±0.32	4.69±0.60
14.	3.83±0.26	6.52±0.42	5.60±0.33	4.80±0.55
15.	3.72±0.19	6.38±0.47	5.60±0.29	4.96±0.64
16.	3.52±0.17	6.23±0.45	5.78±0.39	5.01±0.52
Overall	4.20^{a}±0.08	6.51^{b}±0.11	5.18^{a}±0.10	4.53^{b}±0.14

*Means bearing different superscripts differ significantly (P<0.05) dry matter intake significantly. On the other hand, Vande Haar *et al.* (1999), Keady *et al.* (2001), Guo *et al.* (2007) and Ojha *et al.* (2015) have reported that higher feeding regime prepartum increased dry matter intake significantly.

The data on means±SE of total daily dry matter intake per cow by control and treatment group during the postpartum period is presented in Table 6. The overall means of daily dry matter intake during 120 days of postpartum period were 9.38±0.06 kg and 11.04±0.10 kg for control and treatment group, respectively. The mean daily dry matter intake of the treatment group was significantly higher ($P<0.05$) than the control group during the postpartum period.

The mean daily dry matter intake from concentrate mixture per animal for the control and treatment group during the postpartum period was 4.20±0.08 kg and 6.51±0.11 kg, respectively (Table 5). The overall mean daily dry matter intake from concentrate mixture during postpartum period was significantly ($P<0.05$) higher for the treatment group as the animals of treatment group were offered *ad lib.* concentrate mixture, whereas the control group was offered concentrate mixture based on their milk production. The total concentrate mixture intake per animal for the control and treatment group was 279.63±18.42 kg and 460.91±14.62 kg during 120 days postpartum period and significant difference was observed as shown in Table 7. As the milk yield of animals increased, the concentrate mixture intake also increased continuously from first to sixth week in control group and from first to seventh week in treatment group of postpartum experimental period to replenish the body tissue losses that occurred due high milk production. Thereafter milk yield gradually declined, therefore concentrate mixture intake also decreased continuously.

The mean daily dry matter intake from dry fodder per animal for control and treatment group of animals during the postpartum period was 5.18±0.10 kg and 4.53±0.14 kg (Table 5). The dry matter intake through dry fodder during postpartum period in control

Table 6. Mean±SE of total daily dry matter intake (kg) by control and treatment group during postpartum period

Weeks after calving	Control group	Treatment group
1.	7.82±0.17	7.93±0.20
2.	8.61^{a}±0.15	9.85^{b}±0.16
3.	8.92^{a}±0.21	$10.24^{b\pm}$0.26
4.	9.22^{a}±0.17	10.39^{b}±0.22
5.	9.69^{a}±0.19	10.89^{b}±0.18
6.	9.99^{a}±0.18	11.65^{b}±0.29
7.	9.92^{a}±0.16	11.94^{b}±0.27
8.	9.91^{a}±0.14	11.84^{b}±0.29
9.	9.84^{a}±0.17	11.85^{b}±0.17
10.	9.72^{a}±0.20	11.71^{b}±0.21
11.	9.61^{a}±0.12	11.66^{b}±0.17
12.	9.42^{a}±0.15	11.52^{b}±0.17
13.	9.32^{a}±0.07	11.31^{b}±0.20
14.	9.43^{a}±0.10	11.32^{b}±0.15
15.	9.31^{a}±0.12	11.34^{b}±0.20
16.	9.30^{a}±0.30	11.24^{b}±0.13
Overall	9.38^{a}±0.06	11.04^{b}±0.10

*Means bearing different superscripts differ significantly ($P<0.05$)

Table 7. Mean±SE of total feed intake (kg) by control and treatment group during postpartum period

Control group		Treatment group	
Feedstuff	**Intake**	**Feedstuff**	**Intake**
Concentrate	279.63[a]±18.42	Concentrate	460.91[b]±14.62
Dry fodder	336.26[a]±5.25	Dry fodder	294.33[b]±4.93

*Means bearing different superscripts differ significantly (P<0.05)

group was significantly higher than treatment group. This difference in the amount of dry fodder consumed by control and treatment group may be due to the fact that animals of control group consumed less concentrate than animals of treatment group. The total dry fodder intake per animal for control and treatment group during postpartum period was 336.26±5.25 kg and 294.33±4.93 kg with a significant difference as shown in Table 7. The mean dry fodder intake per day for the control group (5.34±0.10 kg) was significantly higher than treatment group (4.67±0.14 kg).

The total dry matter intake/animal/day per 100 kg body weight basis for the eight week postpartum period was 2.38±0.02 % and 2.80±0.03 % for control and treatment group of animals, respectively. The differences in the total dry matter intake/animal/day per 100 kg body weight basis of control and treatment group during the postpartum period were significant (P<0.05).The results obtained regarding dry matter intake during postpartum period in the present study are in close agreement to those reported by Chaudhary and Jat (2013), Kamboj *et al.* (2016), Medhi *et al.* (2016), Naik *et al.* (2016) and Raval *et al.* (2019) who reported that dry matter intake increased significantly during postpartum period. On the other hand, Vande Haar *et al.* (1999), Keady *et al.* (2001), Agenas *et al.* (2003), Dann *et al.* (2006) and Guo *et al.* (2007) observed that feeding on a higher plane do not affect dry matter intake during postpartum, which is dissimilar to present study.

CONCLUSIONS

It is concluded that challenge feeding increased dry matter intake during postpartum. However, during prepartum period, Even though challenge feeding caused a numerical increase in dry matter intake the differences were non-significant. The decline in dry matter intake in last week before parturition was least in treatment group as compared to control group due to challenge feed offered to treatment group as challenge feed reduce the stress.

ACKNOWLEDGEMENTS

The authors thankfully acknowledged the financial support and facilities provided by College of Veterinary and Animal Science, RAJUVAS, Bikaner to carry out the research work.

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Received on 02-06-2020 and accepted on 30-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 21-25
doi: 10.5958/2231-6744.2020.00004.3

Indian Journal of
Animal Nutrition

Effect of Replacement of Conventional Feeds by *Prosopis juliflora* Pods and *Citrullus lanatus* Seed Cake on Haemato-Biochemical Parameters in Marwari Goats

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ABSTRACT

An experiment was conducted to observe the effect of incorporation of mesquite (*Prosopis juliflora)* pods and watermelon (*Citrullus lanatus)* seed cake in complete feed with sixteen male Marwari goat kids of uniform conformation and age, divided into four groups. Four complete feed designated as T_1, T_2, T_3 and T_4 were formulated. T_1 served as control having all the conventional ingredients; whereas, barley of control was replaced by mesquite pods in T_2, cotton seed cake was replaced by watermelon seed cake in T_3 and both barley and cotton seed cake were replaced by mesquite pods and watermelon seed cake in T_4, respectively. All the four complete feeds were iso-nitrogenous and nearly iso-caloric. Haemato-biochemical parameters *viz.* haemoglobin, PCV, total serum protein and blood glucose, were worked out at fortnightly interval for 105 days of all individual animals. All parameters were found well within the normal range, *i.e.* 8.38, 8.26, 8.09 and 8.11 for haemoglobin (%), 27.87, 27.59, 27.78 and 27.87 for PCV (%), 72.03, 72.63, 69.66 and 71.66 for blood glucose (mg/dl), 7.26, 7.29, 7.17 and 7.33 for serum protein (g/dl) in T_1, T_2, T_3 and T_4 groups, respectively. It was concluded that dietary treatments had no adverse effect, but highly significant effect of period on haemato-biochemical parameters were observed in Marwari goat kids. Thus, barley and cottonseed cake could be safely and effectively replaced by mesquite pods and watermelon seed cake alone or in combination in the complete feed of goats.

Key words: *Citrullus lanatus,* Haemato-biochemical parameters, Iso-nitrogenous, Marwari, Mesquite *Prosopis juliflora*

INTRODUCTON

The use of alternative feed resources which are adaptive to long dry seasons is important for animal production in arid areas worldwide (Gusha *et al.,* 2015). Agro-industrial byproducts and non-conventional feeds such as *Prosopis juliflora* pods and watermelon seed cake may be economically advantageous in reducing feeding costs and can play an important role in feeding of sheep and goats under various management systems (Obeidat and Shdaifat, 2013). Availability of *Prosopis juliflora* pods worldwide was estimated to be about 2-4 million metric tonnes (Sawal *et al.,* 2004), whereas global production of watermelons was 118 million tonnes (FAOSTAT, 2018). Though many of the farmers in the dry areas of Rajasthan do not utilize these pods for livestock feeding but the goats browse these entire pods and seeds while grazing in the field or are fed by some owners in the form of concentrate. Formulation of complete feed having non-conventional ingredients replacing conventional ingredients in the feed has been worked out extensively (Talpada *et al.,* 2002; Abo-Zeid *et al.,* 2017). Use of biotechnology in this regard has not only improved the efficiency of the conventional ingredients, but also allowed scientists to use non-conventional feed resources that are often cheaper and readily available (Chharang *et al.,* 2019).

Prosopis juliflora or Vilayati babul is a very variable, evergreen tree or shrub distributed in the arid part of tropical and sub-tropical regions. The ripen highly palatable pods produced as fruit, are moderate in crude protein (12 %) and rich in free sugar (15-17 %) giving sweet taste to it. Studies have shown that it can be effectively used in the feeding of livestock and it has about 7 % DCP and 75 % TDN (Talpada *et al.,* 1979). Similarly, watermelon (*Citrullus lanatus*) previously called as *Citrullus vulgaris*, is also a naturally grown

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xerophytes found in abundance in hot arid and semi- arid areas. The seeds obtained from this plant are gaining commercial importance due to its high oil contents and cake is obtained as by product (Chharang *et al.,* 2005). After extraction of oil from seeds, huge edible biomass is available for the feeding of animals having about 20.42 % DCP and 52.73 % TDN (Pal and Mahadevan, 1968). Therefore, the objective of study was to evaluate the effect of incorporation of non-conventional feeds like mesquite pods and watermelon seed cake in complete feed on haemato-biochemical parameters of goats.

MATERIALS AND METHODS

Sixteen Marwari goat kids of 7-8 months age and of uniform conformation were selected and divided by completely randomized block design into four groups of four animals in each, were subjected to feeding trial of 105 day followed by a seven days duration digestibility trial. Four iso-nitrogenous and nearly iso-caloric complete rations were formulated (Table 1) on dry matter basis according to Indian feeding standards (ICAR, 1985) and were designated as T_1, T_2, T_3 and T_4. In T_1 (control), barley and cotton seed cake were incorporated in complete feed as conventional energy and protein sources. Whereas, in T_2 the barley of control was replaced by non-conventional mesquite pods, in T_3 cotton seed cake of control was replaced by non-conventional watermelon seed cake and in T_4 both barley and cotton seed cake were replaced by mesquite pods and watermelon seed cake (Table 2).

For ascertaining physiological status of health associated with the effect of inclusion of non-conventional feeds, routine haematological and biochemical studies were made during the feeding trial of 105 days at fortnight intervals before feeding in animals of all treatment groups. The blood was drawn from jugular vein in sterilized test tubes. For haematological examination, EDTA was used as an anticoagulant at the rate of 1 mg per 5 ml of blood. Haematological studies were performed soon after collection of blood *viz.*, haemoglobin content (Hb) and packed cell volume (PCV) were determined by standard methods, as recommended by Jain (1986). For separation of serum, blood was collected in second tube, without anticoagulant, and kept in slanting position. These tubes were incubated for 1 hour at 37ºC. Blood clots were broken and tubes were centrifuged at 2500 rpm for 30 minutes. The serum was analysed for total serum protein (Doumas *et al.,* 1981) and blood glucose (Oser, 1976). The statistical analysis for different

Table 1. Chemical composition of experimental complete feeds and different feed ingredients (per cent dry matter basis)

Feed ingredients	DM	OM	CP	EE	CF	NFE	Ash	Ca	P
Complete feeds									
T_1	91.84	90.88	13.94	2.81	22.19	52.00	9.06	1.15	0.44
T_2	92.48	90.28	14.05	3.16	25.85	47.28	9.66	1.22	0.41
T_3	91.64	90.96	13.62	3.15	24.75	49.50	8.98	1.15	0.37
T_4	92.28	90.36	13.73	3.50	28.41	44.78	9.58	1.22	0.34
Feed ingredients									
Sewan grass	91.81	92.49	4.62	1.78	32.82	53.07	7.51	1.27	0.05
Barley	88.70	95.79	11.62	1.75	4.51	77.91	4.21	0.16	0.33
Mesquite pods	91.88	92.78	12.16	3.48	22.78	54.36	7.22	0.51	0.19
Cottonseed cake	92.18	90.37	25.74	6.56	23.39	34.68	9.63	0.31	1.18
Watermelon seed cake	91.07	90.84	23.95	8.46	37.60	20.83	9.16	0.34	0.78
Guar korma	96.66	91.98	45.83	3.92	7.67	35.51	8.02	1.27	0.16
Min. mixture	96.78	-	-	-	-	-	96.78	29.60	12.35
Common salt	96.23	-	-	-	-	-	96.23	-	-

Table 2. Parts composition of experimental complete rations

Ingredients	T_1	T_2	T_3	T_4
Sewan grass	50	50	50	50
Barley	20	-	20	-
Mesquite pods	-	20	-	20
Cotton seed cake	18	18	-	-
Watermelon seed cake	-	-	18	18
Guar korma	10	10	10	10
Mineral Mix	01	01	01	01
Salt	01	01	01	01

parameters in this study was analyzed using conventional statistical procedure as suggested by Steel and Torrie (1980).

RESULTS AND DISCUSSION

The animals were in excellent condition throughout the experimental period without any signs of abnormal health. Feeding non-conventional feeds to the goat kids for 105 days did not affect their health or growth. It was observed that all the parameters *viz.,* Hb, PCV, blood glucose and total serum proteins estimated for four treatment groups were well within the normal range (Table 2 and 3).

The data when subjected to statistical analysis showed no significant effect of treatments *i.e.* replacement of conventional ingredients by non-conventional resources. The more or less similar values of haemoglobin content were recorded in this study for different treatment groups and were well within the normal range (Swenson, 1984). Similar non-significant effect supporting the results of present investigation have also been noticed by Sastry *et al.* (1973); Talpada and Shukla (1988); Gujrathi *et al.* (1982); Swami (1995); Sharma (2001); Bhatt *et al.* (2007); Eldaw *et al.* (2016); Alagbe (2018) on replacing conventional energy and protein sources by mesquite pods and matira seed cake in the diet of ruminants.

Statistical analysis of data revealed non-significant effect of treatment and block and highly significant ($P<0.01$) effect of period. The findings of present investigation for PCV were in accordance with the findings of previous reports (Sastry *et al.,* 1973; Gujrathi *et al.,* 1982; Talpada and Shukla, 1988; Swami, 1995; Sharma, 2001; Daramola *et al.,* 2005; Eldaw *et al.,* 2016; Alagbe, 2018) involving replacement of conventional concentrate ingredients with mesquite pods and matira seed cake. The normal PCV values of experiment contradict the low PCV observed by Mahgoub *et al.* (2008) for sheep fed non-conventional

Table 3. Haemoglobin and PCV (%) at fortnight intervals in kids of all treatment groups

Period (105 days)	Haemoglobin (%)				PCV (%)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
0	6.80±0.09	6.97±0.09	6.85±0.20	6.85±0.18	24.50±2.60	24.00±1.47	24.75±1.80	25.00±1.96
15	7.42±0.08	7.32±0.11	7.30±0.18	7.37±0.05	25.75±2.53	25.25±1.11	25.50±1.89	26.25±1.38
30	7.60±0.10	7.52±0.16	7.53±0.15	7.57±0.06	27.00±2.35	26.50±0.87	26.50±1.85	27.00±1.47
45	8.25±0.29	8.22±0.31	7.88±0.17	7.93±0.12	28.00±1.96	27.25±0.85	27.00±1.68	27.50±1.19
60	8.63±0.37	8.57±0.42	8.18±0.15	8.18±0.18	28.25±1.80	28.00±0.71	27.50±1.55	28.00±1.47
75	8.92±0.49	8.88±0.51	8.55±0.19	8.45±0.23	28.75±1.38	28.75±1.11	28.75±1.11	29.00±1.47
90	9.37±0.31	8.98±0.46	9.03±0.27	8.95±0.33	29.25±1.38	30.25±0.63	30.75±1.44	29.75±1.31
105	10.08±0.41	9.63±0.56	9.43±0.36	9.55±0.36	31.50±0.65	30.75±0.75	31.50±1.26	30.50±1.19
Overall Mean ±SE	8.38±0.21	8.26±0.19	8.09±0.16	8.11±0.16	27.87±0.70	27.59±0.50	27.78±0.64	27.87±0.55

Table 4. Blood glucose (mg/dl) and total serum proteins (g/dl) at fortnight intervals in kids of all treatment groups

Period (105 days)	Blood glucose (mg/dl)				Total serum proteins (g/dl)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
0	57.25±3.09	49.25±6.86	60.25±2.69	57.25±2.39	5.83±0.28	5.93±0.25	6.00±0.15	7.17±0.15
15	68.75±5.95	71.25±2.72	65.75±2.10	78.50±0.29	6.43±0.23	6.45±0.19	6.53±0.19	6.80±0.12
30	74.00±2.89	79.75±1.60	74.50±2.63	79.25±2.32	7.11±0.11	7.08±0.16	6.88±0.21	7.11±0.11
45	79.50±3.52	85.50±3.12	79.50±0.96	84.00±3.24	7.38±0.14	7.37±0.19	7.02±0.25	7.30±0.09
60	81.00±3.54	82.75±3.12	73.75±0.85	78.75±3.75	7.65±0.09	7.48±0.09	7.41±0.22	7.66±0.08
75	73.00±3.03	73.00±3.85	69.25±0.85	65.00±4.38	7.79±0.04	7.89±0.05	7.75±0.08	7.72±0.05
90	70.75±3.30	69.75±3.82	67.75±1.65	65.75±3.75	7.92±0.05	8.04±0.07	7.88±0.09	7.89±0.04
105	72.00±3.03	69.75±2.69	66.50±3.80	64.75±4.61	8.02±0.09	8.10±0.09	7.92±0.10	7.99±0.09
Overall Mean ±SE	72.03±1.67	72.63±2.22	69.66±1.22	71.66±1.92	7.26±0.14	7.29±0.14	7.17±0.13	7.33±0.11

diet. However, it was noticed that with the increase in the haemoglobin content there was a correspond increase in PCV.

The statistical analysis of data did not reveal any significant effect of treatment and block but revealed highly significant (P<0.01) effect of period on glucose level. The blood glucose level obtained in present investigation for different treatment groups were found to be well within the normal range of 40-80 mg/100 ml reported by Swenson (1984) and were in line with the results of earlier replacement studies conducted by Sastry *et al.* (1973); Gujrathi *et al.* (1982); Talpada and Shukla (1988); Swami (1995); Sharma (1997); Sharma (2001); Dhanotiyo (2004); Okonkow, *et al.* (2010); Babeker and Elmansoury (2013) reported no significant effect on inclusion of non-conventional ingredients in the diet of kids and other ruminants on blood glucose.

The statistical analysis of data revealed non-significant effect of treatment but highly significant (P<0.01) effect of block and period. The values for total serum proteins obtained in this investigation regarding non-significant effect of treatment are in corroboration with the earlier findings of Sastry *et al.* (1973); Gujrathi *et al.* (1982) and Swami (1995) in calves, and Sharma (1997) in sheep, Sharma (2001) in goats, Eldaw *et al.* (2016) in goats and Alagbe (2018) in rabbits.

CONCLUSIONS

On the basis of the results, it appears that incorporation of mesquite pods and watermelon seed cake alone or in combination in the complete feed of goats is quite safe. There was no change in haemoglobin, PCV, blood glucose and total serum protein values observed.

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Received on 28-12-2019 and accepted on 18-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 26-30
doi: 10.5958/2231-6744.2020.00005.5

Indian Journal of Animal Nutrition

Mineral Mixture Feeding Enhances Dairy Animals Productivity: A Study of Bihar, India

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ABSTRACT

Dairying is not only an integral part of small-holder farming system, but it is also providing a significant source of livelihood for landless households in Bihar, India. A shift in the contribution by different sectors to the State Gross Domestic Product (SGDP) in Bihar has been observed as contribution of livestock sector has increased from 22 to 40 percent and at the same time agriculture sector contribution has decreased from 45 to 20 percent during last two decades. The per-capita milk availability in Bihar is meager (239 g/d) compared to India's average (375 g/d) in 2017-18 as productivity of animals is low due to poor feeding based on crop residue and limited concentrates. The present study was carried out on 510 dairy animals to examine the effects of mineral mixture on livestock productivity in Bihar. After introducing (50 grams) mineral mixture in the feed, average milk yield, fat and SNF content increased by 6.2%, 5.3% and 1.8%, respectively. Feeding mineral mixture to dairy animals, milk yield increased by 0.49 L/d/animal. At the same time fat content and SNF content also increased by 0.20 and 0.15 points. On average, farmers benefitted from increased net profits by ₹ 15.8/d/animal. It shows that the dairy farmers can increase their revenue from increased milk sales in terms of higher quantity (yield) and quality (fat and SNF). The mineral mixture feeding also showed positive effects on health and reproductive performance in terms of animal appearance and, timely conception and least incidence of ectoparasites.

Key words: Bihar, Dairy animals, Fat, Mineral mixture, Milk yield, SNF

INTRODUCTION

Dairying is not only an integral part of small-holder farming systems, but also source of livelihood for landless households in Bihar, India. It has been observed that there has been a shift in the contribution by different sectors to the State Gross Domestic Product (SGDP) in Bihar, as contribution of tertiary sector has increased from 22 to 40 percent and at the same time agriculture sector contribution has decreased from 45 to 20 percent during last two decades. In agriculture livestock SGDP contribution is about 40 percent and milk contribution to livestock sector is about 30 per cent (GoB 1993, 2013).

Bihar's share of milking cattle and buffaloes is about 6.8 per cent and it contributes about 5.2 per cent of the national milk production (GoI, 2018). Bihar figures ninth in milk production in the country. The milk production in the state witnessed tremendous increase in last one decade from 2.5 million tons in 2000-01 to 9.2 million tons in 2017-18 (GoI 2006, 2018). Nevertheless, the per-capita milk availability in Bihar is meager (239 g/d) compare to India average (375 g/d) in 2017-18 as productivity is low and no increase in productivity of animals except indigenous cows, main reason behind it is feeding is mainly depends on crop residues with some green fodder and limited concentrates. Constraints to improving these feeding practices include limited farm resources, weak support services and inadequate knowledge on nutrient requirements and contents are central issues in improving livestock productivity in Bihar.

The present study examines the effects of mineral mixture on livestock productivity in comparison to non-feeding of mineral mixture. Farmers feeds residues with either individual concentrate components or commercial feed. But animals also need other micro-nutrients which is not adequately available in crop residues, green fodder and concentrates fed to animals. Mineral deficiency in dairy animals results into reduced growth, deficiency diseases, decreased milk production,

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reproductive disorders and decreased immunity. During the past decade, significant advances have been made in understanding the effects of trace-element supplements on the milk production of dairy cows (Bhausaheb *et al.,* 2014).

MATERINALS AND METHODS

The data for this study is collected from 510 dairy farmers feeding the mineral mixture to their 510 dairy animals (396 cows and 114 buffaloes). The experimental trials were conducted among the households with dairy animals who are members of self-help groups (SHGs) and Kisan club and in some cases not attached to any group. One animal from each household was selected. The experimental trials were conducted in six districts of Bihar (Begusarai, Bhojpur, Muzaffarpur, Patna, Samastipur and Vaishali) during 2014-15. A structured questionnaire was used to collect the data from all farmers, which consisted of the 3 days control (farmer's feeding practices) and 6 days experimental data on mineral mixture, milk yield, fat content and SNF content following the standards management practices of ILRI-CSISA project.

The feeding trials consisted of the following feeding practices: the dairy farmers use crop residues with commercial cattle feed supplemented with individual concentrate components such as crushed maize or/and oil cakes. But animals also required other micro-nutrients in their regular diets to help enhancing metabolic functions and lead to improved milk production and reproduction efficiency in dairy animals. Supplementation of bio-available minerals through mineral mixture is of paramount importance as the minerals are not synthesized in the animal's body. Keeping this in view, mineral mixture trials were conducted to see the effect on animals in comparison to non-feeding of mineral mixture. For this a quality chelated mineral mixture is used to feed animals per day 50 g/animal. The mineral mixture was introduced through a combination of participatory trainings on nutrition and feeding and farm-based trials.

RESULTS AND DISCUSSION

It was observed that the dairy farmers were not feeding mineral mixture before the trials (Table 1). After introducing the mineral mixture at 50 grams per day in feed, average milk yield, fat content and SNF content increased ($P<0.05$) by 6.2%, 5.3% and 1.8% respectively. The results showed that dairy farmers could increase their revenue from increased milk sales in terms of higher quantity (yield) and quality (fat and SNF contents). The mineral mixture feeding also showed positive effects on health and reproductive performance in terms of animal appearance and, early timely conception and least incidence of ectoparasites.

The results presented in Table 2 shows that farmers have introduced mineral mixture feeding by 55 g/d/animal and milk yield increased ($P<0.05$) by 0.49 L/d/animal, fat content by 0.20 points, and SNF content by 0.15 point (Table 2). The highest milk yield increase

Table 1. Input and output of control and experimental animals

District	Milk yield (L)		Fat (%)		SNF (%)	
	C	E	C	E	C	E
Begusarai	$9.72^{a}\pm0.45$	$10.35^{a}\pm0.45$	$3.96^{a}\pm0.10$	$4.12^{a}\pm0.09$	$8.50^{a}\pm0.02$	$8.60^{a}\pm0.03$
Bhojpur	$6.88^{bc}\pm0.36$	$7.20^{bc}\pm0.36$	$5.88^{b}\pm0.36$	$6.09^{b}\pm0.35$	$8.02^{b}\pm0.29$	$8.14^{b}\pm0.28$
Muzaffarpur	$6.15^{b}\pm0.32$	$6.80^{b}\pm0.32$	$3.55^{c}\pm0.04$	$3.82^{a}\pm0.08$	$8.45^{a}\pm0.03$	$8.64^{a}\pm0.03$
Patna	$8.24^{c}\pm0.43$	$8.50^{cd}\pm0.44$	$4.75^{d}\pm0.01$	$4.92^{c}\pm0.01$	$8.26^{ab}\pm0.00$	$8.37^{ab}\pm0.01$
Samastipur	$7.15^{bd}\pm0.36$	$7.72^{bc}\pm0.37$	$3.41^{c}\pm0.06$	$3.68^{a}\pm0.08$	$8.28^{ab}\pm0.03$	$8.52^{a}\pm0.04$
Vaishali	$9.02^{a}\pm0.47$	$9.56^{ad}\pm0.47$	$3.63^{ac}\pm0.06$	$3.76^{a}\pm0.06$	$8.50^{a}\pm0.02$	$8.61^{a}\pm0.02$
All	7.86±0.17	8.35±0.18	3.81±0.05	4.01±0.06	8.42±0.02	8.57±0.02

^{a,b,c,d}Values bearing different superscripts in a column differ significantly ($P<0.05$); C: control/farmer's feeding and E: experimental feeding trial

Table 2. Changes in output of experiment animals

District	Milk yield (L/d)	Fat (%)	SNF (%)
Begusarai	0.63^{a}±0.04	0.16^{a}±0.02	0.11^{a}±0.01
Bhojpur	0.32^{b}±0.03	0.21^{a}±0.09	0.11^{ab}±0.06
Muzaffarpur	0.64^{a}±0.03	0.26^{a}±0.06	0.19^{bc}±0.01
Patna	0.26^{b}±0.08	0.17^{a}±0.01	0.11^{ab}±0.01
Samastipur	0.57^{a}±0.02	0.27^{a}±0.03	0.24^{c}±0.02
Vaishali	0.53^{a}±0.03	0.14^{a}±0.01	0.10^{a}±0.01
All	0.49±0.02	0.20±0.02	0.15±0.01

^{a,b,c,d} Values bearing different superscripts in a column differ significantly (P<0.05)

(0.64 L/d/animal) was reported by Muzaffarpur farmers in comparison to other districts. Fat and SNF content increase were higher in Samastipur compared to other districts.

On an average, FCM yield increased by 0.9 L/d/animal (Fig. 1). The lowest FCM yield increase was reported by Patna farmers (0.7 L/d/animal) and the highest in Begusarai farmers (1.05 L/d/animal).

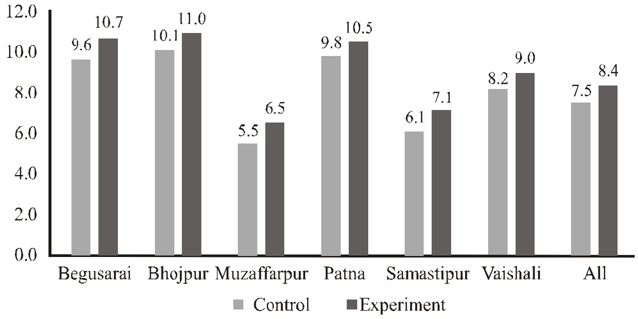

Fig. 1. Fat correct milk (FCM) yield per experiment animal across districts

On an average 150 grams of FCM milk yield increased by feeding 50 grams of mineral mixture. The highest FCM yield was observed in Bhojpur and lowest in Samastipur district. The cost of mineral mixture/L milk produced was (₹ 0.72). Muzaffarpur district showed the highest price gap (₹ 0.93) in cost of mineral mixture/L of milk produced while Bhojpur district showed the lowest cost (₹ 0.55) (Fig. 3).

Figure 4 provides the economics of the experimental feeding trial using mineral mixture in feed. The results show that on an average farmers gained from the new feeding practice, *i.e.,* achieved positive net profits estimated at ₹ 15.8/d/animal.

Similar to the present findings, Noeek *et al.* (2006), Singh *et al.* (2008), Hackbart *et al.* (2010), Somkuwar *et al.* (2011), Tiwari *et al.* (2013), Mohsina *et al.* (2014), Singh *et al.* (2016) and Gupta *et al.* (2017) reported significant increase in milk yield in mineral supplemented animals as compared to un-supplemented group of dairy animals. Garcia-Lopez *et al.* (1988) observed increased fat percent in milk of mineral supplemented cows as compared to un-supplemented cows.

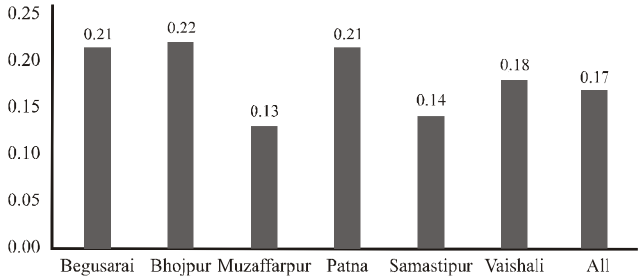

Fig. 2. Fat corrected milk (FCM) yield (L/d) per 50 grams of mineral mixture

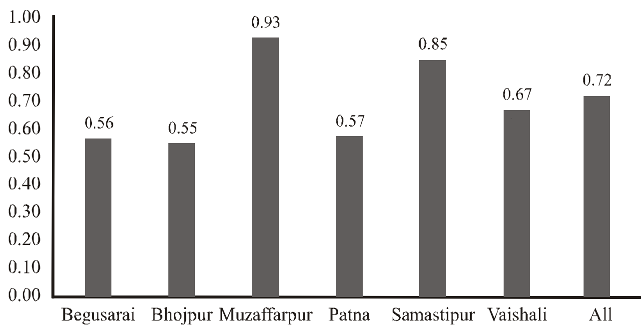

Fig. 3. Cost of mineral mixture per litre of fat correct milk (FCM) yield

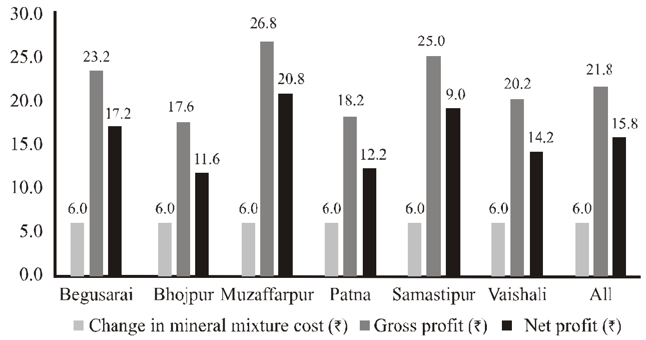

Fig. 4. Economics of feeding mineral mixture (per day/animal)

However, Wu *et al.* (2000), Sharma *et al.* (2002), Rabiee *et al.* (2010), Begum *et al.* (2010), Pandey *et al.* (2018), found no significant difference in the milk yield and milk components of cows due to either commercial or area specific mineral mixture supplementation from that of un-supplemented group of dairy animals.

The observed variability in levels of benefits is likely due to the variability in the levels of animal health and production stages during the feeding trials. The lowest benefit was reported in Bhojpur district and the per animal/d benefit was ₹ 11.6 only, the highest observed benefit was in Muzaffarpur district at ₹ 20.8, which is higher than other five districts. There is need to explore the methods to promote mineral mixture feeding on regular basis to the larger section of farmers in the state.

CONCLUSIONS

Mineral mixture feeding trial shows that introducing the 50 grams mineral mixture per day in feed enhances the dairy animal's milk yield by 0.49 L/d/animal. At the same time fat and SNF content also increased by 0.20 and 0.15 points, respectively. On an average, farmers benefitted from increased income by ₹ 15.8/d/animal. It shows that mineral mixture feeding on regular basis to animals are beneficial for farmers, though the other benefits gained by feeding mineral mixture is not measured. Farmers gains instantly by feeding mineral mixture in terms of milk yield, fat and SNF increase apart from other benefits which farmers generally do not consider while feeding animals.

Keeping in view the economic benefit of feeding mineral mixture, there is a need to promote feeding mineral mixture among farmers. Some farmers consider that it is costly, so one could provide the mineral mixture preparation techniques to farmers to reduce the mineral mixture feeding cost by preparing mineral mixture at their own. However, the government and non-government institutions should make effort to popularize the mineral mixture feeding amongst the larger section of dairy farmers through demonstration, mass communication, print media.

ACKNOWLEDGEMENTS

This research was conducted as part of the Cereal Systems Initiative for South Asia (CSISA) project funded by the Bill & Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID).

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Received on 14-01-2020 and accepted on 06-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 31-38
doi: 10.5958/2231-6744.2020.00006.7
Indian Journal of Animal Nutrition

Effects of Formic and Propionic Acid as Silage Additive on Haematology and Biochemical attributes in Growing Cattle

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ABSTRACT

This study aimed to evaluate the effect of formic and propionic acid, alone or in combination as silage additive on haematological and biochemical attributes in growing Sahiwal cattle. A total of 24 growing Sahiwal heifers were randomly allocated into four groups (n=6) on body weight (117±5.0 kg) and age (10±2.0 months) basis. The experimental heifers either received a basal total mixed ration (TMR) having ensiled sorghum fodder without organic acids (S_C) or were fed on TMR having silage preserved with 0.5% formic acid ($S_{0.5\%FA}$), 0.5% propionic acid ($S_{0.5\%PA}$) or 0.25% formic acid and 0.25% propionic ($S_{0.25\%FA+0.25\%PA}$). Feeding of silage treated with formic and propionic acids did not exert any effect on dry matter intake (DMI) while average daily gain (ADG) and feed efficiency were better (P<0.05) in $S_{0.5\%FA}$ group. Treatments, days of feeding and their interaction did not affect red blood cells (RBCs) count, granulocyte count, lymphocytes count, mean corpuscular volume (MCV), mean cell haemoglobin (MCH) and mean corpuscular hemoglobin concentration (*MCHC*). However, white blood cells (WBCs) and platelet (PLT) count were significantly lower (P<0.05) in $S_{0.5\%FA}$ group and haemoglobin (Hb) concentration and packed cell volume (PVC) value in 0.5% $S_{0.5\%PA}$ group. No significant differences in the alanine transaminase (ALT), aspartate aminotransferase (AST) and creatinine were observed among four different groups, however; mean plasma alkaline phosphatase (ALP) concentration was higher in $S_{0.5\%PA}$ group. Treatments did not affect plasma Ca and P levels. In conclusion, feeding of silage preserved with formic and propionic acid, alone or in combination had no adverse effect on performance, haematological attributes and liver and kidney function test.

Key words: Biochemical, Cattle, Formic acid, Haematology, Propionic acid, Silage

INTRODUCTION

India is gifted with the large diversity and largest livestock population in the world with 299.6 million populations of cattle and buffaloes (DAHDF, 2012). Inspite of achieving the highest milk production, the performance of Indian cattle has been extremely poor and average productivity of livestock is lower compared to the world average. Poor performance of indigenous cattle is due to more populations of nondescript animals and deficiency of quality feed and fodders. While the livestock population is increasing, the gap between the requirement and availability of feed and fodder is increasing primarily due to decreasing area under fodder cultivation and reduced availability of crop residues as fodder. The country faces a net deficit of 35.6% green fodder, 10.9% dry crop residues and 44% concentrate feeds (IGFRI, 2013). This clearly indicates that as most of the livestock are underfed, they are not able to perform optimally. It is imperative to arrange sufficient good quality feed and fodder for efficient utilization of the genetic potential of the various livestock species and sustainable improvement in productivity.

The only way to meet the increasing fodder needs of livestock is to look for alternative options of fodder, silage being one of them. Silage is green succulent roughage preserved more or less in its original condition, with a minimum deterioration and minimum loss with respect of various nutritive constituents of fodders (Satter and Reis, 2012). Silage quality can be variable and the only way to effectively control the quality is by the use of additives. Silage additives are added to improve the fermentation process, reduce losses, improve aerobic stability and hygienic quality of the

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silage, limit secondary fermentation, and increase the nutritive value of the silage, resulting in increased animal production (Merensalmi and Virkki, 1991). Organic acids like formic and propionic acids as silage additives are effective in reducing yeast and molds which are responsible for the aerobic deterioration of silages. The use of silage with a high content of fermentation acids may result in a substantially lower energy yield for rumen microorganisms than the use of silage of restricted fermentation (Chamberlain, 1987). In terms of animal performance, feed intake and live weight gain were higher with formic acid-treated silage than untreated or inoculant-treated silages (Haigh *et al.*, 1987). Forage ensiled with formic acid has produced weight gains or milk production equal to or greater than wilted untreated silage (Waldo and Derbyshire, 1971). Forage ensiled with propionic acid brings about an increase in silage intake, which leads to increased live weight gain (Nadeau and Arnesson, 2016). The objective of this study was to examine the relative merits of formic and propionic acid, alone or in combination as silage additives on haematological attributes and liver and kidney function tests in growing Sahiwal cattle.

MATERIALS AND METHODS

Animal care procedures were approved (approval number, 121/IAEC/18) and conducted under the established standard of the Institutional Animal Ethics Committee (IAEC), constituted as per the article number 13 of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) rules laid down by the Government of India.

In the present study, the green sorghum fodder (*Sorghum bicolor*) with moisture content of 65-72% was ensiled either without organic acid (S_c) or with 0.5% formic acid ($S_{0.5\%FA}$) or 0.5% propionic acid ($S_{0.5\%PA}$) or combination of each formic and propionic acid at 0.25 % each ($S_{0.25\%FA+0.25\%PA}$). The whole fodder was chopped into 2-3 cm pieces by using tractor operated forage chopper (Ensiladeria JF40Max, NB Maquinas Ltd., Brazil). After treatment, chopped fodder was packed in polythene bags (1.5 meters in height and 0.5 meter width) having capacity of 50 kg. After 90 days of ensiling, prepared silage was fed to the experimental animals of respective group.

A total of 24 growing Sahiwal heifers were selected from the cattle herd maintained at LFC, DUVASU, Mathura. Experimental animals were housed in a well-ventilated shed having the proper arrangement for individual feeding and watering without having access to the other animal's diet. Deworming of all the experimental animals were done before the start of the experiment by oral administration of Fentas bolus (Intas Pharmaceuticals Pvt. Ltd., India) at the dose level of 10 mg/kg body weight. Animals were let loose every fortnightly for exercise. The nutrient requirements of experimental heifers were met by the feeding of total mixed ration (TMR) consisted of concentrate: silage: wheat straw in the proportion of 40:40:20 following NRC (2001) guidelines. Selected heifers were randomly allocated into four groups (n=6) on body weight (117±5.0 kg) and age (10±2.0 months) basis. The experimental heifers either received a basal TMR having silage without additives (S_C) or were fed on TMR containing 0.5% formic acid ($S_{0.5\%FA}$), 0.5% propionic acid ($S_{0.5\%PA}$) and 0.25% formic acid and 0.25% propionic ($S_{0.25\%FA+0.25\%PA}$) added silages. Ingredients and nutrients composition of TMR fed in different groups are presented in Table 1. TMR was prepared daily by hand mixing and offered at 0900 h in all tests. The calves were fed the TMR in such an amount that at least 5% refusals were left daily per animals. Fresh drinking water was offered *ad libitum* twice daily at 0800 h and 1700 h.

The experimental calves were monitored daily for DMI and fortnightly for growth performance and feed efficiency measures. To increase the accuracy of the estimation of ADG, calves were weighed at fortnight intervals in the early morning (0600 h) before offering feed and water. Feed conversion ratio (FCR) and feed conversion efficiency (FCE) were observed as feed efficiency measures. Feed-to-gain ratio or FCR was calculated by the amount of DMI (kg) required for unit (per kg) weight gain by animals during the trial period. FCE was calculated as the ratio between ADG (kg) and DMI (kg) by animals during the trial period. The representative samples of TMR offered and residue left were dried in a hot air oven at 60ºC till a constant weight was attained and ground in a Wiley mill to pass a 1-mm sieve. Processed samples were pooled animal wise and stored at the dry place for the further analysis of DM (Method 973.18c), CP (Method 4.2.08), EE (Method 920.85), and total ash (Method 923.03) as per methodology of AOAC (2005). aNDFom, aADFom and ADL were determined according to the procedures described by Van Soest *et al.* (1991).

Peripheral blood samples were collected in heparinized vacutainer tubes (BD Franklin, USA) by venipuncture of anterior vena cava at 0, 30, 60 and 90 days post-treatment for the analysis of haematological and plasma attributes. A fraction of whole blood was used for analysis of RBCs count, WBCs count, PLT count, granulocytes count, lymphocytes count, Hb concentration, PVC or HIT value, MCV, MCH and *MCHC* by using automatic analyzer (Celltac alpha CM, Nihon, Kohden, Pvt. Ltd, Surat, India). Remaining amount of blood samples were centrifuged at 3000 rpm for 30 min to separate the plasma from packed erythrocytes. Plasma samples were stored at -20ºC until further analysis of ALT, AST, ALP, creatinine, Ca and P levels by using the automated biochemical analyzer

Table 1. Ingredients and nutrients composition of TMR fed during feeding trial (g/kg DM basis or as mentioned)

Attributes	Treatments[α]			
	S_C	$S_{0.5\%FA}$	$S_{0.5\%PA}$	$S_{0.25\%FA+0.25\%PA}$
Ingredients composition				
Sorghum silage	400	400	400	400
Wheat straw	200	200	200	200
Mustard oil cake (solvent extract)	128	128	128	128
Ground barley grain	104	104	104	104
Gram husk	80	80	80	80
Wheat bran	80	80	80	80
Micronutrient mixture[β]	8	8	8	8
Chemical composition				
DM 652.9	654.1	653.3	654.5	
CP 126.8	126.2	127.1	126.8	
EE 31.7	31.4	32.1	32.6	
Ash 87.0	87.4	88.8	88.6	
aNDFom	560.4	553.6	561.2	556.0
aADFom	317.2	314.0	318.4	320.0
ADL 62.1	64.4	62.2	62.1	
Total CHO	754.5	754.9	752.1	752.0
NFC 194.1	201.3	190.9	196.0	
Ca 7.2	7.1	7.3	7.2	
P 3.2	3.2	3.3	3.2	
ME, MJ/kg DM	8.28	8.24	8.20	8.24

[α]Sc, silage without organic acid; $S_{0.5\%\ FA}$, silage with 0.5% formic acid; $S_{0.5\%\ PA}$, silage with 0.5% propionic acid; $S_{0.25\%FA+0.25\%PA}$, silage with 0.25% of formic and propionic acid; [β]Micronutrient mixture consisted (kg^{-1}) of 700,000 IU of vitamin A, 70,000 IU of vitamin D_3, 250 mg of vitamin E, 190 g of Ca, 90 g of P, 50 g of Na, 19 g of Mg, 1.2 g of Cu, 9.6 g of Zn, 1.5 g of Fe, 6.0 g of Mn, 325 mg of I, 150 mg of Co, 10 mg of Se.

(BS-120 Chemistry Analyzer, Shenzhen Mindray Biochemical Electronics Co. Ltd.).

Data of the study were subjected to analysis of variance using the General Linear Model (GLM) procedure of the Statistical Software Package (SPSS for windows, V21.0; Inc., Chicago, IL, USA). The effect of formic and propionic acid as silage additive on performance, haematology and plasma attributes were analyzed by using the following model:

$$Yijk=\mu + Ti + Dj + (T\times D)ij + eijk$$

Where; *Yijk* is dependent variable, *ì* is overall mean of the population, *Ti* is mean effect of the treatment, *Dj* is mean effect of days of sampling (j=0, 30, 60 and 90 days of dietary treatment), *(T×D)ij* is effect of the interaction between treatment and period and *eijk* is unexplained residual element assumed to be independent and normally distributed. Individual animals were used as the experimental unit for all data. The statistical difference between the means was determined by using "Tukey's honest significant difference (HSD) test". Significance was determined at P<0.05 and the values are presented in the tables.

RESULTS AND DISCUSSION

Daily DMI, ADG and feed efficiency in S_{C}, $S_{0.5\%FA}$, $S_{0.5\%PA}$ and $S_{0.25\%FA+0.25\%PA}$ groups are depicted in Table 2. Treatments did not affect DMI while ADG was better (P<0.05) in $S_{0.5\%FA}$ group. FCR showed significant (P<0.05) effect of treatment and found better in heifers of $S_{0.5\%FA}$ group than that of other groups. Although the FCE was observed numerically higher in $S_{0.5\%FA}$ group but overall mean values showed non-significant effect in four different groups.

The main factors affecting silage intake were palatability, forage digestibility, rumen degradability and the concentrations of nitrogen and fibre fractions (Steen *et al.,* 1998). The intake response to formic acid ensiled fodder observed in the current experiment has also been reported previously with dairy cows (Waldo *et al.,* 1971). In contrary to the findings of the present study, research reviewed by Thomas and Thomas (1988) shows that addition of formic acid to grass silage increased voluntary intake by 9%. A study with sheep indicated a 13% increase in intake of grass silage treated with formic acid (Rooke *et al.,* 1988). No significant differences occurred, but all data favoured formic acid treated silage over untreated silage. Formic acid appeared to reduce the concentration of acetic acid and ammonia, which are fermentation products that have been implicated in the regulation of silage intake (Gill *et al.,* 1988; Thomas and Thomas, 1988). Additionally, formic acid restricts fermentation and protein degradation during ensiling, which can have a positive effect on animal performance (Winters *et al.,* 2001).

Results suggest that sorghum silage treated with preservatives has the potential to replace fodder in diets fed to growing cattle. Woolford (1984) reported only high percentages of unbuffered propionic acid (1.0 to 3.0% of the DM) were deemed to be effective inhibitors of aerobic deterioration of silage. Such high application rates often improved DMI and growth (Mann and McDonald, 1976). Results of a study carried out by Nadeau *et al.* (2000) revealed that formic acid added silage resulted in higher feed intake and improved growth performance. The amounts of the additives (0.25 to

Table 2. Effect of silage preservatives on the performance

Attributes	Treatments				SEM	P-value$^{\alpha}$		
	Sc	$S_{0.5\%FA}$	$S_{0.5\%PA}$	$S_{0.25\%FA+0.25\%PA}$		T	D	T×D
DMI, kg/d	4.76	4.90	4.63	4.75	0.25	0.619	0.042	0.798
ADG, kg/d	0.514^{b}	0.591^{c}	0.463^{a}	0.504^{ab}	0.03	<0.001	0.398	0. 046
FCR	8.92^{ab}	8.59^{a}	9.62^{b}	9.45^{b}	0.24	0.046	0.578	0.882
FCE	0.120	0.127	0.110	0.112	0.01	0.556	0.429	0.994

[a-c]Mean values within a row with unlike superscript letters were significantly different for each dietary treatment (P<0.05); $^{\alpha}$T represents the main effect of treatment; D represents the main effect of days of feeding trial; T×D represents the interaction between the main effects of treatment and days.

0.5%) that we used in our study were considerably less than those used in previous studies. In the present study, significantly improve FCR was found in $S_{0.5\%FA}$ group as compared to other groups which is in accordance to the findings of O'Kiely and Moloney (1994). Winters *et al.* (2001) reported 26% improvement in feed efficiency in steers fed direct-cut formic acid-treated grass silage (3.3 L/ton).

The RBCs count, granulocyte count, lymphocytes count, MCV, MCH and MCHC showed non-significant effect of treatments (Table 3). Whereas, WBCs and PLT count were significantly lower (P<0.05) in 0 $S_{0.5\%FA}$ group and Hb concentration and PCV values were lower (P<0.05) in $S_{0.5\%PA}$ group. The RBCs (7.98-8.65×10^6/µl blood), WBCs (11.10-14.91×10^3/µl blood), PLT count (252.38-333.00×10^3/µl blood), Hb (8.96-10.05 g/100 blood) and PCV (29.18-32.65%) were in the range as reported by Singh *et al.* (2019). No valid justification available regarding the role of organic acid treated silage on haematological attributes. Variation in WBCs, PLT, Hb, PCV or HIT, and MCHC could be due to biological factors. MCHC value varies significantly in the last month of study however; the slight change in MCHC may also result from the hemolysis of the analyzed material (Brucka-Jastrzebska *et al.,* 2007). The Hb content and PCV of blood in cattle significantly (P<0.05) increased with the use of organic acid in water during the thermal stress conditions (Ali *et al.,* 2013). While in birds, organic acid supplementation increased RBC count, WBC count and Hb content (Vinus *et al.,* 2017). Abdel Raheem (2016) revealed that there were no significant differences between different experimental groups in Hb concentration, WBCs, RBCs count, PCV, MCV, MCH and MCHC and lymphocyte percentage on feeding of organic acid to broiler Chickens. Al-Saad *et al.* (2014) showed that

Table 3. Effect of silage preservatives on haematological and biochemical parameters

Attributes	Treatments				SEM	P-value$^{\alpha}$		
	Sc	$S_{0.5\%FA}$	$S_{0.5\%PA}$	$S_{0.25\%FA+0.25\%PA}$		T	D	T×D
Haematological attributes								
RBC count, 10^6/µl	8.65	7.98	8.36	8.65	0.16	0.069	0.392	0.629
WBC count, 10^3/µl	14.03^{ab}	11.10^{a}	14.91^{b}	13.03^{b}	0.82	<0.001	0.611	0.429
PLT count, 10^3/µl	322.75^{ab}	252.38^{a}	333.00^{b}	315.58^{ab}	18.20	0.023	0.449	0.721
Granulocytes count, %	29.83	30.20	33.51	29.70	0.91	0.742	0.493	1.000
Lymphocytes count, %	63.90	63.48	63.23	65.70	0.56	0.879	0.583	0.998
Hb level, g/100 ml	9.38^{ab}	9.21^{ab}	8.96^{a}	10.05^{b}	0.23	0.011	0.429	0.671
PCV, %	31.26^{ab}	30.34^{ab}	29.18^{a}	32.65^{b}	0.54	0.018	0.177	0.442
MCV, fl	36.36	38.30	35.24	38.57	0.80	0.075	0.539	1.000
MCH, pg	10.93	11.63	10.84	11.85	0.25	0.086	0.662	0.791
MCHC, g/100 ml	30.28	30.38	30.72	30.70	0.11	0.083	0.331	0.522
Biochemical attributes								
ALT, IU/L	6.37	6.17	6.60	6.32	0.19	0.083	0.429	0.728
AST, IU/L	26.41	25.59	27.03	27.10	1.35	0.381	0.118	0.332
ALP, IU/L	27.63^{a}	29.28^{a}	32.15^{b}	28.04^{a}	1.02	<0.001	0.093	0.591
Creatinine, mg/100 ml	1.19	1.17	1.18	1.21	0.01	0.400	0.483	1.000
Ca, mg/100 ml	9.70	9.71	10.10	10.14	0.62	0.091	0.392	0.889
P, mg/100 ml	6.46	6.33	6.21	5.88	0.18	0.401	0.755	1.000

[a-c]Mean values within a row with unlike superscript letters were significantly different for each dietary treatment (P<0.05); [α]T represents the main effect of treatment; D represents the main effect of days of feeding trial; T×D represents the interaction between main effects of treatment and days.

feeding of propionic acid in diets resulted in an increase in WBC concentration while there was no effect on Hb and PCV values. Vinus *et al.* (2017) found that propionate feeding increases RBC, WBC and Hb concentrations significantly ($P<0.05$) than untreated groups. Supplementation of salts of organic acids reduced the number of heterophils and improved the lymphocytes count in different treatments as compared to the control group. Abdel-Hamid and Omar (2019) suggested that there was an increased concentrations of RBC, WBC and Hb when diet treated with various level of formic acid as compared to the control group in rabbits. EL Naggar *et al.* (2017) investigated the effect of formic and citric acid and concluded that increased RBCs and Hb as compared to control.

Studied biomarkers of liver and kidney function tests in present study were ALT, AST, ALP and plasma creatinine levels (Table 3). No significant differences in the ALT, AST and creatinine were observed among four different groups. However, mean plasma ALP concentration was higher in $S_{0.5\%PA}$ group. In this study, biomarkers of liver and kidney function tests have been used to monitor and evaluate health and nutritional effect of silage preservatives in growing cattle. The information regarding the effect of feeding of organic acid added silage on biochemical parameters is lacking. Plasma parameters values measured were within the normal range for healthy dairy animals as recorded by George *et al.* (2010); Wood and Quiroz-Rocha (2010). Although plasma AST level in last month of study shows significant results but value was within the reference range (Radostits *et al.,* 2000). Plasma ALP was found significant during the whole duration of study but value were within range (18-153 IU/L) and does not exert adverse effect (Latimer *et al.,* 2003). Different levels of organic acid showed a non-significant effect on serum GOT, GPT, uric acid and creatinine concentrations as reported by El-Shenway and Ali (2016) and Abdel-Fattah *et al.* (2008). Finding of Ragaa *et al.* (2016) also showed that formic acid supplementation did not affect AST, ALT and uric acid levels. Naggar *et al.* (2017) observed that supplementation of formic and citric acid decreased serum AST and ALT levels compared to control group. Creatinine, the waste product produced via the catabolism of phospho-creatine is a basic parameter reflecting kidney function (Stojevic *et al.,* 2005). In the present study; plasma creatinine level observed was 1.17-1.21 mg/100 ml that fell within the physiological range as observed by Radostits *et al.* (2008) and Smith (2009). In a study conducted by Naggar *et al.* (2017) it was reported that supplementation of formic and citric acid decreased serum creatinine levels as compared to unsupplemented group.

The results show that addition of silage preservatives does not alter the plasma concentration of Ca and P. Observed mean values of Ca were within the range of 9.70-10.14 mg/100 ml. Similarly, serum concentration of P ranged from 5.88-6.46 mg/100 ml, which was within physiological range as reported by Latimer *et al.* (2003). Similar to the findings of the present study, Vinus *et al.* (2017) reported similar serum Ca level in organic acid as well as unsupplemented group while serum P level was improved in organic acid-treated groups. In contrast to the findings of the present study, Jongbloed *et al.* (2000) and Hernandez *et al.* (2006) observed a positive interaction among organic acids and plasma Ca and P levels in growing pigs. Abdel-Fattah *et al.* (2008) also found higher plasma Ca and P in organic acid group than those given unsupplemented diet. They concluded that the increase in Ca and P level in plasma produced by addition of organic acid may be attributed to lowering of GI tract pH by using these acids, which increases the absorption of such minerals from gut into blood.

CONCLUSIONS

The findings of this study revealed that feeding of silage preserved with 0.5% formic acid in heifers improved growth performance and feed conversion while feed intake remains similar. Feeding of formic and propionic acid, alone or in combination as silage additive did not exert any adverse effect on haematological and biochemical attributes as values ranged within normal physiological range.

ACKNOWLEDGMENTS

The authors would like to thanks the staff of the Department of Animal Nutrition and Livestock Farm Complex, DUVASU, Mathura, India. The authors also gratefully acknowledge Dr. Brijesh Yadav for assistance during the analysis of hematological and biochemical attributes. The fund for this study was provided by the University under Indian Council of Agricultural Research Grant, New Delhi, India.

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Received on 12-06-2020 and accepted on 30-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 39-43
doi: 10.5958/2231-6744.2020.00007.9

Indian Journal of
Animal Nutrition

Effect of Feeding of Hydroponics Maize Green Fodder with and without Supplementation of Probiotics (*Saccharomyces cerevisiae*) on Feed Consumption in Gir Calves

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ABSTRACT

Present investigation was undertaken to determine the chemical composition and assessment of feed consumption of hydroponics maize fodder with and without supplementation of probiotic (*Saccharomyces cerevisiae*) in Gir calves. Total 36 male Gir calves of almost same age group were distributed equally by completely randomized block design in nine groups. Calves in group T_1 were treated as control and were fed basal feed and concentrate mixture as per requirement. For calves in T_2, T_3, T_4 and T_5 groups, 25%, 50%, 75% and 100% of crude protein (CP) supplied through concentrate mixture was replaced by hydroponics maize fodder, respectively, whereas in T_6, T_7, T_8 and T_9 groups, 25% 50%, 75% and 100% of CP supplied through concentrate mixture was replaced by hydroponics maize fodder alongwith probiotics (*Saccharomyces cerevisae*), respectively. The results indicated that hydroponics maize fodder had shown good nutrient profile such as crude protein, ether extract and nitrogen free extract in present experiment whereas yeast was found to be richer source of calcium and phosphorus. There was highly significant effect ($P<0.01$) of treatments and periods (15 days to 120 days) on dry matter intake (DMI) and organic matter intake. It was revealed that the DMI was found to be decreased with feeding of the hydroponics maize fodder in Gir calves but incorporation of probiotic (*Saccharomyces cerevisiae*) improved DMI.

Key words: Chemical composition, Dry matter intake, Gir calves, Hydroponics maize fodder, Organic matter intake

INTRODUCTION

Green fodder and concentrate are the quintessential for optimum health, growth, productive and reproductive performance in dairy animals. For sustainable dairy farming, quality green fodder should be fed regularly to dairy animals (Naik *et al.,* 2012). The health, growth and production of dairy animals are adversely affected due to unavailability of good quality green fodder and concentrate. Continuous production of green fodder in sufficient quantities is a challenging task. Traditional production of green grasses not only requires large land area, plenty of water, labour, fertilizers and a lot of management problems but it also has low nutritional value. Faster industrialization has squeezed area under pasture land, adversely affecting the grazing based production systems. Shortage of land, long growth time (50-65 days), labour, fertilizer and manure requirements for cultivation, unavailability of same quality throughout the year, lack of irrigation facilities, water scarcity and natural calamities due to climate change are the major obstacles for conventional green fodder and grain production. Technology advancement in industry and farming systems has introduced hydroponics technology for green fodder production. In the prevailing dairy farming system, where quality and quantity of grazing is continuously decreasing, the hydroponics grown green fodder could be a novel way of feeding dairy animals to improve productivity. Due to many constraints in the conventional green fodder cultivation, hydroponics technology may become an alternative not only for the green fodder but may also replace some part of concentrate in farm animals (Naik *et al.,* 2012).

Further, use of natural feed additives in dairy cattle ration has potential for improvement in growth and production. There is a strong need for natural feed additives acceptable for consumers interested in organic

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food. However, there is no information on the effects of probiotics along with hydroponically grown maize fodder in cattle. Chemical composition and feed intake are usually considered as a preliminary index for the assessment of quality of feed. Hence, the present investigation was undertaken to determine the chemical composition and assess the feed consumption of hydroponics maize fodder with and without supplementation of probiotic (*Saccharomyces cerevisiae*) in Gir calves.

MATERIALS AND METHODS

The per cent chemical composition of hydroponics maize green fodder, yeast (*Saccharomyces cerevisiae*),concentrate mixture and basal roughage was determined. The production of hydroponics maize was done in a hydroponics chamber of Ayurvet Progreen Machine. Clean maize seeds were soaked with tap water in gunny bags for 24 hours and thereafter were distributed in trays @ 2 kg per tray in 1.5-2.0 cm layer thickness. Harvesting of hydroponics fodder was done on day 8^{th} after planting. Around 11 -14 kg hydroponics maize fodder was harvested daily from each tray on the 8^{th} day and was fed to the animals as per experimental protocol. Total of 36 male Gir calves of almost similar age group (add age= and BW=) were selected randomly and distributed equally by completely randomized block design in nine groups. All the animals were offered basal feed *ad lib.* Calves in group T_1 were treated as control and were fed basal feed and concentrate mixture as per requirement. For calves in T_2, T_3, T_4 and T_5 groups, 25%, 50%, 75% and 100% of CP supplied through concentrate mixture was replaced by hydroponics maize fodder, respectively, whereas in T_6, T_7, T_8 and T_9 groups, 25% 50%, 75% and 100% of CP supplied through concentrate mixture was replaced by hydroponics maize fodder along with probiotics (*Saccharomyces cerevisae*), respectively. Daily allowance of concentrate and / or hydroponics maize fodder and roughage were offered to meet their nutrient requirements. Dry matter intake (DMI) and organic matter intake (OMI) was calculated at fortnight intervals as g/d, kg/100kg b. wt. and g/kg $W^{0.75}$ in different treatment groups.

The data obtained in the experiment were analyzed using statistical procedures as described by Snedecor and Cochran (1994) and significance of mean differences were tested by Duncan‘s New Multiple Range Test (DNMRT) as modified by Kramer (1957).

RESULTS AND DISCUSSION

The per cent chemical composition of hydroponics maize green fodder, yeast (*Saccharomyces cerevisiae*), concentrate mixture and basal roughage are presented in Table 1. The chemical composition of hydroponics maize fodder in the present investigation was in close agreement with that of Thadchanamoorthy *et al.* (2012). Hydroponics maize fodder had shown good nutrient profile in terms of content of CP, EE and NFE in the present experiment. Yeast was found to be comparatively richer source of calcium and phosphorus. The chemical composition of yeast was also in accordance to the earlier reports of El-Ghani (2004) and Rekha *et al.* (2005). The chemical

Table 1. Chemical composition of experimental feed (% DM basis)

Attributes	DM	On % DM basis										
		OM	CP	EE	CF	NFE	TA	NDF	ADF	HC	Ca	P
Hydroponics maize fodder	18.25	96.99	18.68	3.56	8.62	66.13	3.01	34.76	15.96	18.80	0.27	0.42
Probiotic (*S.cerevisiae*)	99.39	93.64	39.56	2.74	3.63	47.71	6.36	-	-	-	1.83	0.76
Concentrate mixture	89.73	88.66	20.06	3.35	10.00	55.25	11.34	38.49	20.67	17.82	1.34	0.56
Wheat straw	91.18	89.01	3.14	1.09	39.05	45.73	10.99	75.01	52.39	22.21	0.30	0.10

composition of hydroponics maize fodder was almost same as that of concentrate mixture except total ash, calcium and phosphorus. These findings corroborate with the reports of earlier workers (Banerjee, 1988; Verma *et al.,* 2015).

The mean values of dry matter intake expressed as kg/100kg BW. ranged between 2.83 to 3.12 whereas mean values of dry matter intake in terms of g/kg $W^{0.75}$ ranged from 94.89 to 103.12 in different treatment groups (Table 2). Data pertaining to dry matter intake in terms of g/d, kg/100kg b. wt. and g/kg $W^{0.75}$ at fortnights are presented in Table 3. he results of statistical analysis of data (Table 4) revealed highly significant effect (P<0.01) of treatments (T_1 to T_9) (*i.e.* hydroponics maize fodder with and without *Saccharomyces cerevisiae*) and periods (15 d to 120 d) on DMI in terms of g/d, kg/100 kg b. wt. and g/Kg $W^{0.75}$. Further, comparison of mean values of DMI revealed significant variations among the groups with highest DMI in group T_1 and lowest in group T_5. While comparing the treatment groups with respect to supplementation of probiotic, it was observed that there was significantly higher mean DMI in group T_6, T_7, T_8 and T_9 as compared to groups T_2, T_3, T_4 and T_5, thus showing positive effect of supplementation of probiotic on DMI (Table 2).It was revealed that the dry matter intake was found to be decreased with feeding of the hydroponics maize fodder in Gir calves but incorporation of probiotic (*Saccharomyces cerevisiae*) improved dry matter intake.

Highly significant effect of period was recorded on dry matter intake in terms of g/d, kg/100kg b. wt. and g/Kg $W^{0.75}$. Dry matter intake was found to be increased with advancement of age. It could be attributed to increase in dry matter intake with the growing age of calves irrespective of treatment groups (Table 3 and 4). There was significant effect of feeding of hydroponics maize fodder without and with *Saccharomyces cerevisiae* on dry matter intake in Gir calves. Similar findings were also reported by Verma *et al.* (2015) in calves, Nugrohoa *et al.* (2015) in cows, Gebremedhin (2015) in goats and Ata (2016) in lambs; fed hydroponics barley fodder or hydroponics maize fodder. Improvement in DMI in calves fed yeast culture diets were also reported by Wohlt *et al.* (1991); Erasmus *et al.* (1992); Cole *et al.* (1992); Putnam *et al.* (1997); Heinrich (2004) and Lesmister *et al.* (2004).

In contrast, few workers observed no significant difference in DMI in animals fed with artificially grown fodder *viz.* Rule *et al.* (1986) and Reddy *et al.* (1988) in cows; and Rajendra *et al.* (1998) and Saidi and Omar (2015) in sheep. However, none of them used hydroponics maize fodder in calves. Singh *et al.* (1998) and Titi *et al.* (2008) reported reduced dry matter intake in calves with addition of yeast culture in the diet. DM intake was a limiting factor for sole feeding of hydroponics fodder in cows (Pandey and Pathak, 1991). Supplementation of yeast culture in the diet increased digestion, particularly fibre fraction of the diet, leading to improved feed intake (Hassan *et al.,* 2016).

Table 2. Average feed consumption (DMI and OMI) in different treatment groups in Gir calves

Unit	Treatment								
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Dry matter intake									
g/d	3710.84^{a}	3650.03^{cd}	3624.74^{d}	3595.2^{e}	3555.08^{f}	3687.52^{ab}	3654.53^{c}	3626.00^{d}	3586.27^{e}
kg/100 kg b.wt.	3.12^{a}	3.03^{ab}	2.96^{bc}	2.83^{d}	2.85^{d}	3.03^{ab}	2.93^{c}	2.84^{d}	2.88^{cd}
g/kg $W^{0.75}$	103.12^{a}	100.39^{b}	98.52b^{c}	94.89^{c}	95.25^{c}	100.86^{ab}	98.29^{c}	95.52^{c}	96.19^{c}
Organic matter intake									
g/d	3307.46^{c}	3287.57^{d}	3302.86^{cd}	3309.34^{c}	3311.50^{c}	3339.78^{ab}	3340.82^{a}	3354.07^{a}	3358.51^{a}
kg/100 kg b.wt.	2.78^{b}	2.80^{ab}	2.72^{c}	2.72^{c}	2.73^{c}	2.83^{a}	2.71^{c}	2.70^{c}	2.70^{c}
g/kg $W^{0.75}$	91.83^{c}	93.79^{ab}	92.50^{bc}	90.32^{d}	91.20^{cd}	94.12^{a}	90.34^{d}	90.81^{d}	90.38^{d}

Rows with different superscript differ significantly

Table 3. Average feed consumption (DMI and OMI) at fortnight intervals in Gir calves

Period (days)	Dry matter intake			Organic matter intake		
	g/d	kg/100 kg b.wt.	g/kg $W^{0.75}$	g/d	kg/100 kg b.wt.	g/kg $W^{0.75}$
15	3046.57^{h}	2.94^{b}	93.97^{d}	2787.15^{h}	2.55^{g}	81.60^{h}
30	3075.04^{g}	2.81^{c}	91.12^{e}	2813.20^{g}	2.61^{f}	84.62^{g}
45	3233.08^{f}	2.81^{c}	92.66^{d}	2958.55^{f}	2.66^{e}	87.52^{f}
60	3459.24^{e}	2.87^{c}	95.35^{c}	3165.44^{e}	2.71^{d}	90.36^{e}
75	3665.73^{d}	2.91^{bc}	97.52^{c}	3354.60^{d}	2.78^{c}	92.65^{d}
90	3849.60^{c}	2.92^{b}	99.15^{b}	3520.35^{c}	2.84^{b}	96.93^{c}
105	4258.76^{b}	3.10^{ab}	106.43^{a}	3898.22^{b}	2.90^{a}	99.71^{ab}
120	4469.95^{a}	3.14^{a}	108.73^{a}	4090.86^{a}	2.88^{ab}	100.18^{a}

Columns with different superscript differ significantly

The mean values of organic matter intake in terms of g/d; kg/100 kg b. wt.; and g/kg $W^{0.75}$ ranged between 3287.57 and 3358.51; 2.70 and 2.83; and 90.32 and 94.12, respectively (Table 2).

The results of statistical analysis of data (Table 4) revealed highly significant ($P<0.01$) effect of treatments *i.e.* feeding of hydroponics maize fodder with and without supplementation of *Saccharomyces cerevisiae* on organic matter intake in terms of g/d, kg/100 kg b. wt. and g/kg $W^{0.75}$. Likewise, effect of period was also observed as highly significant in terms of g/d, kg/100 kg b. wt. and g/kg $W^{0.75}$.

Further, comparison of mean values of organic matter intake in different treatment groups in terms of g/d showed significant variations among the groups with significantly high organic matter intake in groups fed supplemental Saccharomyces *cerevisiae.* The lowest organic matter intake was seen in group T_2 *i.e.* 25% CP of concentrate mixture replaced through hydroponics maize green fodder without supplementation of *Saccharomyces cerevisiae* (Table 2). There was significant effect of hydroponics maize fodder without and with supplementation of probiotic (*Saccharomyces cerevisiae*) on organic matter intake in Gir calves. Similar findings have also been reported by Naik *et al.* (2014) in lactating cows, Verma *et al.* (2015) in Haryana male calves, Naik *et al.* (2015) in cows and Gebremedhin (2015) in goats fed hydroponics fodder. Pal *et al.* (2010), Reena Kamal *et al.* (2013) and Yirga (2015) reported significant effects of supplementation of yeast on feed consumption.

CONCLUSION

Dry matter intake was found to be decreased with feeding of the hydroponics maize fodder in Gir calves but incorporation of probiotic (*Saccharomyces cerevisiae*) improved dry matter intake. Dry and organic matter intake was found to be increased with advancement of age.

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Received on 04-06-2020 and accepted on 25-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 44-47
doi: 10.5958/2231-6744.2020.00008.0

Indian Journal of
Animal Nutrition

In-Vitro Study on Dissolution Profiling of Choline Chloride Encapsulated by Different Microencapsulation Technologies and Active Forms

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ABSTRACT

An *in-vitro* dissolution study was conducted to determine the effect of various microencapsulation technologies commercially employed to protect choline chloride from rumen mimic dissolution and absorption in intestinal mimic solution using two different type of actives (Liquid choline chloride 75% and choline chloride crystal 98%). This study shows that choline chloride crystals granulated by using carbohydrate matrix and coated by hydrogenated vegetable oils through top-spray fluid bed process technology have minimal dissolution of 11.14% in rumen mimic solution, liquid choline chloride granulated and further coated by hydrogenated vegetable oils through top-spray fluid bed process shows 34.71% dissolution, Liquid choline chloride absorb on silicon dioxide and coated by hydrogenated vegetable oils by pan coating shows dissolution of 82.69%, Liquid choline chloride emulsified and spray congealed shows dissolution of 84.6% while liquid choline chloride dispersed with hydrogenated vegetable oils solubilised 100% in rumen mimic solution. Results from study concluded that choline chloride active taken in crystal form granulated with cellulose based polymer and coated through fluid bed top-spray process technologies have minimal degradation in mimic rumen solution and thus maximum rumen bypass efficacy.

Key words: Choline Chloride, Rumen, Microencapsulation, Fluid bed process, Dissolution

INTRODUCTION

Choline chloride, (2-hydroxy)- trimethyl ammonium chloride $C_5H_{14}ClNO$is a highly hygroscopic substance used in feed for choline supplementation. In cattle choline apart from other functions (membrane integrity, neurotransmission, fat mobilization from liver and methyl group donation) has been observed to increase milk production. Unprotected choline in rumen is not effective as measured by digestibility studies due to complete or partial degradation by rumen microbes before it even reaches the intestine (Erdman and Sharma, 1991). Hence, supplementation of unprotected choline (conveniently as it is salt and choline chloride) is ineffective way to increase the choline supply. Therefore, Rumen-protected form of choline has been developed to deliver choline with less degradation to the small intestine for absorption (Pawar *et al*., 2015). Rumen protected form of choline increases the supply of choline to the small intestine with increasing milk yield and milk components or alleviating development of fatty liver syndrome (Hartwell *et al*., 2000). Type of technology used in manufacturing rumen protected choline has a direct effect on its rumen protection. Therefore, this study was undertaken to study the efficacy of different microencapsulation techniques on rumen protection of choline chloride.

MATERIALS AND METHODS

Analytical grade of potassium dihydrogen phosphate, sodium hydroxide, sodium bicarbonate, disodium hydrogen phosphate decahydrate, sodium chloride, potassium chloride, magnesium chloride, magnesium chloride, conc HCl were procured from Merck. Oxalic acid was procured form Rankem, Diethylamine and acetone were procured from Fisher scientific. Pepsin(1:3000), pancreatin(8X usp) were procured from sigma Aldrich.

Mimic rumen solution: Mc Dougall Buffer solution: pH 6.5, Each litre of Mc Dougall buffer solution contained 7.43 g of sodium bicarbonate, 7.0 g of disodium hydrogen phosphate, 0.34 g of sodium chloride, 0.43 g of potassium chloride, 0.10 g of Magnesium chloride, 0.05 g of calcium chloride.

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Mimic Abomasum solution: Clarks Lub Buffer pH 2.0, Each litre of Clarks Lub Buffer solution contained 3.73 g of potassium chloride, 2.1 g of Conc HCl, 1 g of Pepsin (1:3000)

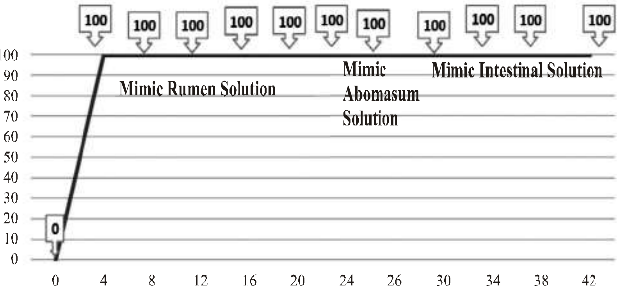
Mimic Intestinal Solution: pH7.8: Each litre of Mimic Intestinal solution contained potassium dihydrogen phosphate 68 g and 3.0 g of pancreatin (8X) USP.

Comparative *in-vitro* dissolution studies were done mimicking the *in-vivo* condition in dairy cattle. All Sample were developed in-house by different technologies. Samples were coded as A,B,C,D & E based on technology used Sample A: Liquid choline chloride adsorb on silica and mixed with hydrogenated vegetable oil by solid dispersion technique Sample B: Liquid choline chloride emulsified and spray congeal by hydrogenated vegetable oils by spray freezing technology Sample C: Liquid choline chloride adsorb on silica, granulated and coated by hydrogenated vegetable oil in pan coater Sample D: Liquid choline chloride adsorb on silica, granulated and coated by hydrogenated vegetable oil via fluid bed processor technology Sample E: Choline chloride crystal granulated with cellulose based polymers and further coated by hydrogenated vegetable oil mix by fluid bed process technology. All products developed were having assay of 33.5% minimum determined with HPLC and non-aqueous titrimetric both.

USP -1 type apparatus with six paddle was used for determination of dissolution profile of all samples. Other conditions maintained included temp 39ºc and rpm of 100. Mimic rumen solution study was done for 24 h and sampling was done at interval of four hours. This solution was replaced with mimic abomasum solution for 2 h and sampling was done at the end of 26^{th} h which again was replaced with mimic intestinal solution for 12 h and sampling was done at the interval of 4 h upto 42 h. Each time in sampling interval, 5 ml of solution was taken out and replaced with fresh equivalent amount of media solution. The pipetted out samples were filtered and analyzed in HPLC in isocratic condition and detector in positive polarity.

RESULTS AND DISCUSSION

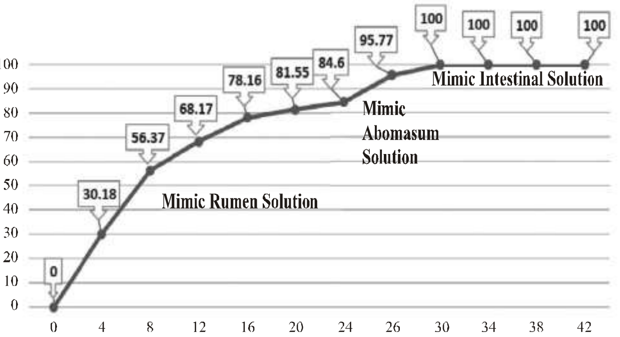
Graph 1: Dissolution profile of sample A



Sample A: Liquid choline chloride dispersed in hydrogenated vegetable oil matrix

Cumulative release profile of sample A shows 100% release within four hours in mimic rumen solution Eventually, cumulative release profile in Mimic abomasum solution and Mimic intestinal solution was also obtained 100%. It indicates that technique of solid dispersion with hydrogenated vegetable oils do not coat enough to resist its dissolution in given conditions.

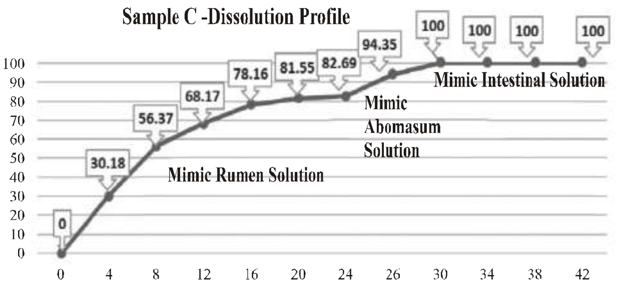
Graph 2: Dissolution profile of sample B



Sample B: Liquid choline chloride emulsified and spray congeal by Spray freezing technology

Cumulative release profile of Sample B shows 84.6% of claimed choline chloride released in 24 hours under rumen mimic solution, 95.77% released in abomasum while 100% released in intestine. Sample B was manufactured by mixing liquid choline chloride in melted hydrogenated vegetable oil and emulsified. The emulsified mix is further sprayed in cooling tower to congeal the fat matrix containing choline chloride resulting in microspheres of choline chloride.

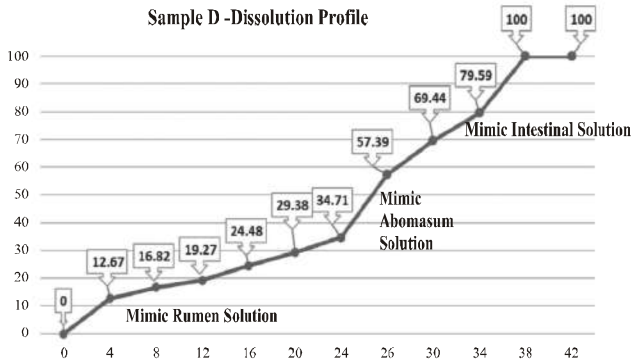
Graph 3: Dissolution profile of sample A



Sample C: Liquid choline chloride adsorb on silica, granulated and coated by hydrogenated vegetable oils by pan coating

Choline chloride in sample C was released 82.69% of claim in rumen mimic solution, 94.35% in abomasum and 100% in intestinal solution. It was manufactured by adsorbing liquid choline chloride on fine silicon dioxide granulated by adding binding agents and further coated with melted hydrogenated vegetable oil in pan coater resulting in microcapsules. This is an extension of core shell technology.

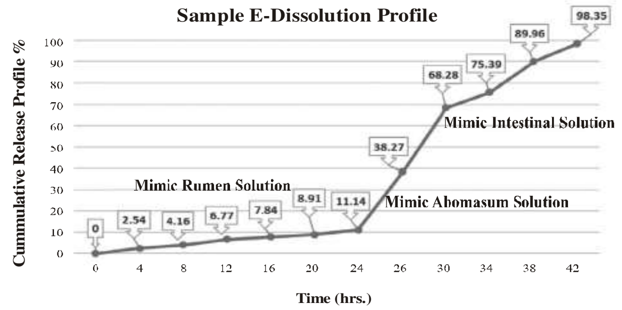
Graph 4: Dissolution profile of sample D



Sample D: Liquid choline chloride absorbed on silica, granulated and coated by hydrogenated vegetable oil by fluid bed processor technology

Cumulative release profile of Sample D shows choline chloride release of 34.71% in rumen solution, 57.39% in abomasum solution and 100% in intestinal solution. It was manufactured by absorbing liquid choline chloride on fine silicon dioxide granulated by adding binding agents and further coated with melted hydrogenated vegetable oil in fluid bed process te chnology. This results in microcapsules via core shell technology.

Graph 5: Dissolution profile of sample E

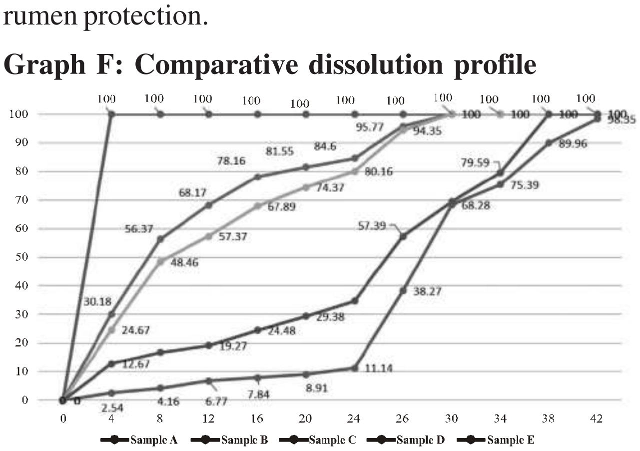


Sample E: Choline chloride crystal granulated with carbohydrate matrix and further coated by Hydrogenated Vegetable Oils by fluid bed process technology

Cumulative release profile of Sample E shows choline chloride release of only 11.14% in rumen solution followed by 38.27% in abomasum solution and sequential release of upto 98.35% in intestinal solution. It was manufactured by using choline chloride 98% crystal as active which were initially granulated and further coated with mix plant based vegetable oil. Coating was based on core shell technology where individual active is binded and coated to form microencapsulates.

There was significant difference in solubility of choline chloride microencapsulated product using different actives and technologies employed. Product made with choline chloride crystal with fluid bed process technology had shown minimum solubility in rumen mimic solution, thus maximum rumen protection while active (liquid choline chloride absorbed on silica and dispersed with hydrogen vegetable oils showed maximum solubility in rumen mimic solution and thus no rumen protection.

Graph F: Comparative dissolution profile



S. No.	Technology	Dissolution in Rumenmimic solution pH 6.5 (0-24 h)	Dissolution in Abomasum mimic solution pH 2.0 (24-26 h)	Dissolution in Intestinal mimic solution pH 7.8 (26-38 h)
1	Solid Dispersion	100%	100%	100%
2	Spray Congealing	84.6%	95.77%	100%
3	Pan coating	82.69%	94.35%	100%
4	Fluid Bed Process with liquid choline chloride as active	57.39%	69.44%	100%
5	Fluid Bed process with choline chloride crystals as active	11.14%	38.27%	98.35%

CONCLUSIONS

Choline chloride is well known nutrient used for non- alcoholic fatty syndrome (NAFS). However, it is degraded by microbes in rumen if not protected. True protection is necessary for actual use by animal at intestine. Choice of active and technology of coating effects the choline availability at intestine. Product (Sample C,D,E) which are coated by core-shell technology (FBP & Pan coating) are more protected from rumen degradation as compared to product (Sample B) manufactured by spray congealing technology (matrix coating) and product manufactured by solid dispersion technology (Sample A). Choice of active also has a direct impact on release profile. Choline chloride in crystal form is more preferred form for microencapsulation as compared to liquid choline chloride.

ACKNOWLEDGEMENT

The authors are thankful to Jubilant Life Science to provide facility and active to complete the batch trials and experimentation.

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Received on 13-02-2020 and accepted on 06-07-2020

Indian J. Anim. Nutr. 2020. 37 (1): 48-56
doi: 10.5958/2231-6744.2020.00009.2

Indian Journal of
Animal Nutrition

Ensuring Nutritional Security of Animals by Mixed Cropping of Sorghum and Guar under Varying Nutrient Management

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ABSTRACT

An experiment was carried out to analyse productivity and quality of fodder sorghum and guar as influenced by nutrient management under mixed cropping and in *kharif* season of 2018 tested in factorial randomized complete block design with four seed rate combinations of sorghum and guar along with six nutrient management treatments in three replications. The productivity of crops was evaluated in terms of fodder yield and quality in form of dry matter, organic matter, ash, crude protein, ether extract, total carbohydrates, fibre fractions (NDF, ADF, ADL and hemicellulose), total digestible nutrients, dry matter intake and dry matter digestibility. Results revealed that total green fodder and dry matter yield was higher in sole sorghum but it was at par with 75% sorghum + 25% guar. Mixed cropping treatments performed better in comparison to sole crops for different quality parameters in both crops. Among nutrient management, treatments 100% RDF, 100% RDF+ PGPR and 100% RDF+ seaweed extract recorded higher fodder production as well as fodder quality in both crops which was not statistically different from75% RDF + seaweed extract treatment. The results revealed that seed rate of 75% sorghum + 25% guar in mixed cropping with the application of 75% RDF + seaweed extract produced higher quality fodder for animals.

Key words: Fodder yield and quality, Guar,, Mixed cropping, Nutrient management, Seed rate, Sorghum

INTRODUCTION

Agriculture and its allied sectors are the backbone of Indian economy. Farmers along with crop production follow livestock rearing practice as it provides employment to the farmer's family during lean periods and act as a buffer in case of crisis like crop failure, *etc.* India is a home for 535.78 million livestock (20^{th} livestock census). Despite India's huge livestock production and its first rank in milk production, the productivity of Indian animals is too low (due to improper and inadequate nutrition, breeding and adaptability problem, *etc.*) and this factor increases the cost of milk production. The cost of feeding alone constitutes about 60-70% of the gross expenses of livestock production which is the most dominant reason behind the low productivity. The demand for feed is increasing with the growing livestock population and will extend till 1012 mt of green fodder and 631 mt of dry forage by the year 2050. With present rate of growth in forage resources, there will be 18.4 % deficit in green fodder and 13.2% deficit in dry fodder in the year 2050 (IGFRI Vision, 2050). Hence, to achieve the higher productivity there is a need to bridge the gap between demand and supply of feed resources for farm animals. Among different feeds, green forages are the most important as these show immediate result and supply all the essential nutrients including water to the animals. Animal may get green forage through forest, pasture or grazing land but the cultivated fodders are most important. Different fodder crops can be grown in *kharif* (sorghum, maize, cowpea, guar, *etc.*), *rabi* (berseem, lucerne, oats, chinese mustard, *etc.*) and *zaid* season to ensure the year round green fodder supply for the animals. Feeding cereals and grasses as sole may cause protein deficiency and a legume alone causes bloat in animals. So, feeding a mixture of cereals and legumes by growing them in mixed cropping may help to overcome the problem of protein deficiency as well as bloating to maintain better health and productivity of animals.

Mixed cropping is the sowing of two or more crops at a time span in the field without any definite row

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pattern and sowing is done after mixing the seeds in an optimum ratio. In mixed cropping selection of crops is most important. Sorghum (*Sorghum bicolor* L. Moench), annual cereal fodder crop occupying largest area among different fodder crops grown in India can be taken as a main crop in mixed cropping. It is used in the form of green fodder, hay and silage as the stalks are of sweet juicy nature and hence liked by the animals. It has around 28.1% DM, 8.2% CP, 57.9% NDF, 35% ADF, 3.3% lignin, 1.9% EE and 9.1% ash (feedipedia.org). To enrich the fodder with protein clusterbean (*Cyamopsis tetragonoloba L.*), an important short duration annual fodder legume herb (popularly known as Guar) can be selected as a component crop with sorghum in mixed cropping. Being a leguminous crop it improves the fertility status of soil by nitrogen fixation and reduces the nitrogen requirement of companion or succeeding crop in rotation. Guar fodder (on dry matter basis) contain 25.2% crude protein, 0.9% ether extract, 48.9% NDF, 33.3% ADF, 43.6% NFE, 16.5% ash and 1.8 M cal/kg ME (NDDB, 2012).

Quality or nutritional composition of the fodder crop directly depends upon the nutrient uptake by the fodder crop from soil. Hence, balanced nutrient management taking care of nutritional requirement of plant and animal is of utmost importance. Although incorporation of legume component in mixed cropping helps to achieve nutrient economy by its ability of fixing atmospheric nitrogen, but supplementation from external nutrient sources is required. Also the depleting soil fertility is demanding organic source of nutrients (Manures, Bio-fertilizers, seaweeds *etc.*) alongwith the chemical fertilizers due to their ability to sustain the soil physical and chemical properties. Knowing the need, the availability of new organic sources like seaweed and plant growth promoting rhizobacteria (PGPR) is increasing in the market but their role in fodder crop production in not yet tested. Seaweeds are the macroscopic multicellular marine alga (brown, red or green) often colonizing in the coastal parts of the world oceans and are rich source of mineral elements like N, P, K, Ca, Mg, Fe, Mn, Zn and Cu and also of many vitamins and enzymes. Plant growth promoting rhizobacteria are tailor made consortia which can be utilised to solubilise and mineralise the native pool of nutrients in soil. keeping all these in mind, the above field experiment was carried out to assess the nutritional quality of fodders grown under different nutrient management under mixed cropping of sorghum and guar in irrigated condition.

MATERIALS AND METHODS

The experiment was conducted at research farm of Agronomy Section, ICAR-National Dairy Research Institute, Karnal (during *kharif* season of 2018) located at 29º45' N latitude, 76º58' E longitude and at an altitude of 245 m above mean sea level (MSL). Having sub-tropical climate zone the place receives rainfall from both southwest and northeast monsoons and faces extremes of both high and low temperature. According to the average meteorological data of 2018 (August to September), the highest rainfall of 25.89 mm was recorded in 39th standard week (24thSeptember-30th September), and there was no rainfall in 37th, 40th and 41st standard weeks during the crop period. The highest and lowest relative humidity were recorded in 39th standard week (95.57%, 24th-30th September) and 42nd standard week (33.57%, 15th-21stOctober), respectively. The evaporation rate (5.77 mm/day) and maximum temperature (33.57ºC) were highest in 31st standard week during the crop period.

The soil of the experimental field was clay loam in texture, neutral to alkaline in reaction and low in available nitrogen, medium in organic carbon, available phosphorus and available potassium. The experiment was laid out in factorial randomized complete block design (FRBD) with four seed rate combinations of sorghum and guar (S_1 - sole sorghum, S_2 - sole guar, S_3 - 75% sorghum + 25% guar and S_4 - 60 % sorghum + 40 % guar) along with six nutrient management treatments (N_1 - 100% RDF, N_2 - 100% RDF + PGPR, N_3 - 100% RDF + seaweed extract, N_4 - 75% RDF + PGPR, N_5 - 75% RDF + seaweed extract and N_6 – 50% RDF + PGPR + seaweed extract) in three replications. Seed rate used for sorghum was 30 kg ha^{-1} and guar was 40 kg ha^{-1}. RDF for sorghum and guar were 60 kg N ha^{-1}, 20 kg N ha^{-1} (half dose as basal), 40 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} (full dose as basal) for sorghum and guar, respectively which were supplied though urea, DAP and MOP, respectively. PGPR liquid culture was used for seed treatment @ 50 ml diluted with 1 lit. water for application on seeds required for one acre of field. As a source of seaweed extract, *Sagarika* (a commercial product) was used which was sprayed in early morning hours after the dew has evaporated at the rate of 1-2 ml lit.$^{-1}$ of water. All recommended agronomic practices were followed during the cultivation of crops.

To eliminate border effect two rows on both sides were discarded and the net plot area was harvested separately from each plot to record the final green fodder yield. Fresh weight of the sorghum and guar fodder was recorded per plot from the harvested plants. The harvested green forage yield was weighed in kg plot^{-1}and then converted into qha^{-1}.The sorghum and guar fodder samples were dried at 60°C and grounded (Wiley mill) to pass through one mm screen for analysis of quality parameters. The quantitative analysis of different macronutrients in feeds and fodder was done by Weende or proximate analysis and for analysis of cell wall constituents (Van Soest *et al.,* 1991). Computation of TDN, DMI and DMD was done according to Lithourgidis *et al.* 2006 method and SPSS 19.0 Version was used to analyze the experimental data for its test of significance.

RESULTS AND DISCUSSION

Agronomic practices especially seed rate and nutrient management play a vital role in the yield of fodder crops (Fig. 1 and Fig. 2). Green fodder yield and dry matter yield of sorghum as well as guar crop depicted decreasing trend with decreasing seed rate under the seed rate treatments of mixed cropping. However significantly higher total green fodder yield and dry matter yield (331.45 qha^{-1}and 69.50 q/ha) were

Table 1. Effect of different seed ratio and nutrient management on DM, OM and Ash content of sorghum and guar fodder

Treatments	DM (%)		OM (%)		Ash content (%)	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates						
S1	20.98	-	90.67	-	9.33	-
S2	-	21.17	-	88.64	-	11.36
S3	21.00	21.10	90.57	88.90	9.43	11.10
S4	21.04	21.13	90.38	88.79	9.62	11.21
SEm±	0.04	0.06	0.06	0.03	0.06	0.03
CD (p=0.05)	NS	NS	0.16	0.09	0.16	0.09
Nutrient sources						
N1	20.91	21.01	90.43	88.66	9.57	11.34
N2	20.89	20.85	90.42	88.62	9.58	11.38
N3	20.88	20.92	90.41	88.64	9.59	11.36
N4	21.17	21.43	90.69	88.93	9.31	11.07
N5	20.93	21.06	90.45	88.72	9.55	11.28
N6	21.26	21.52	90.85	89.09	9.15	10.91
SEm±	0.05	0.08	0.08	0.05	0.08	0.05
CD (p=0.05)	0.15	0.24	0.23	0.13	0.23	0.13

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, DM = Dry matter and OM = Organic matter

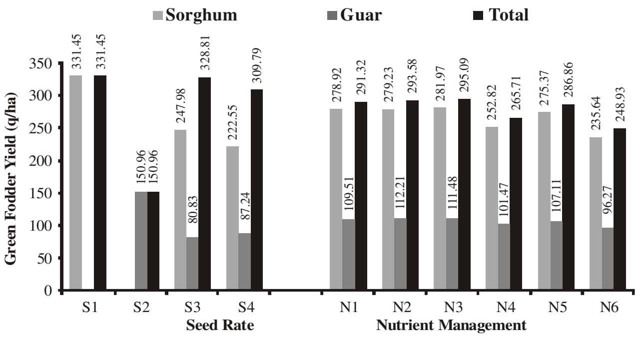

Fig. 1: Effect of different seed ratio and nutrient management on green fodder yield (q/ha) of sorghum and guar fodder

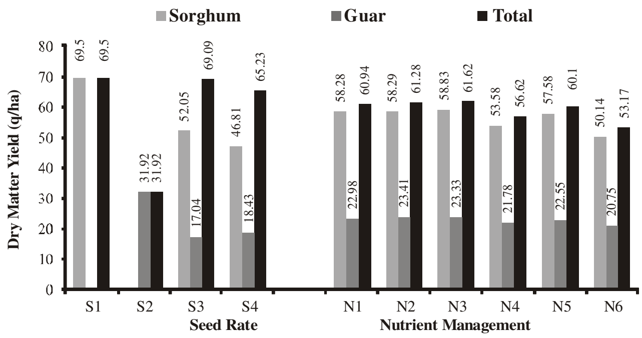

Fig. 2: Effect of different seed ratio and nutrient management on dry matter yield (q/ha) of sorghum and guar fodder

recorded with sole sorghum over rest of the treatments except treatment with seed rate in ratio of 75% sorghum + 25% guar (328.81 qha^{-1} and 69.09 q/ha). Nutrient management treatments depicted an increasing trend in fodder yield with the increasing dose of RDF and thus significantly higher yields were recorded by employing 100% RDF + seaweed extract (295.09 q/ha and 61.62 q/ha) over the treatments N_4 and N_6, but remained at par with 100% RDF + PGPR (293.58 q/ha and 61.28 q/ha), 100% RDF(291.32 q/ha and 60.94 q/ha) and 75% RDF + seaweed extract (286.86 q/ha and 60.10 q/ha). Surve *et al.* (2007), Yadav *et al.* (2007), Agarwal *et al.* (2014) and Htet *et al.* (2016) also reported similar results.

Table 2. Effect of different seed ratio and nutrient management on CP, EE and Total CHO of sorghum and guar fodder

Treatments	CP (%)		EE (%)		Total CHO (%)	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates						
S1	6.99	-	1.80	-	81.88	-
S2	-	19.15	-	1.25	-	68.24
S3	7.11	19.07	1.87	1.31	81.60	68.52
S4	7.02	19.04	1.86	1.37	81.49	68.38
SEm±	0.03	0.07	0.04	0.07	0.08	0.09
CD (p=0.05)	0.09	NS	NS	NS	0.23	NS
Nutrient sources						
N1	7.34	20.15	1.93	1.41	81.17	67.09
N2	7.35	20.22	1.97	1.48	81.10	66.93
N3	7.37	20.19	1.98	1.43	81.06	67.02
N4	6.76	17.44	1.74	1.14	82.19	70.35
N5	7.32	20.13	1.86	1.39	81.28	67.19
N6	6.10	16.37	1.61	1.01	83.14	71.71
SEm±	0.04	0.09	0.06	0.09	0.11	0.12
CD (p=0.05)	0.13	0.27	0.18	0.27	0.33	0.35

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, CP = Crude Protein, EE = Ether Extract and CHO = Carbohydrates

Results of the experiment revealed that quality parameters of sorghum and guar were influenced by seed rate. A critical examination of data presented in table 1, indicated that dry matter content in sorghum increased with mixed cropping whereas in guar it decreased and the dry matter content of sorghum and guar was reported higher in 60 % sorghum + 40% guar and sole guar treatment respectively, but the results were non-significant. Such behavior was due to change in succulency as reported by Ginwal *et al.* (2019) and Tamta *et al.* (2019). Significantly lower organic matter content was reported under 60 % sorghum + 40% guar in sorghum and under sole guar in case of guar. However contrasting results were reported for total ash content as it is negatively correlated with organic matter (Table 5 and 6). These results are in conformity with the findings of Bakhashwain (2010). In sorghum the crude protein (CP) content increased with mixed cropping had reported significantly higher in 75 % sorghum + 25% guar which was at par with 60 % sorghum + 40% guar but in guar sole guar recorded higher CP content. This might be due to presence of higher protein content in leguminous plant as reported by Contreras-Govea *et al.* (2009) and Bakhashwain (2010).The treatment of 75 % sorghum + 25% guar and 60 % sorghum + 40% guar reported higher EE content in sorghum and guar respectively, but the results were non- significant. Increasing ether extract content increases the availability of fat soluble vitamins *viz.* A, D, E and K. These results are comparable to the findings of Ibrahim *et al.* (2012) in maize legume mixtures. Total carbohydrates content in sorghum was significantly superior under sole sorghum whereas in guar it was higher under mixed cropping but the influence was not significant. Significantly higher total CP yield and total ash yield was reported under 75 % sorghum + 25% guar but results were at par with 60 % sorghum + 40% guar for total CP yield. Total EE yield was significantly higher in sole sorghum and at par with 75 % sorghum + 25% guar. These yield results are in

Table 3. Effect of different seed ratio and nutrient management total CP yield, total EE yield and total ash content yield (q/ha)

Treatments	Total CP Yield (qha^{-1})	Total EE Yield (qha^{-1})	Total Ash Yield (qha^{-1})
Seed rates			
S1	4.88	1.26	6.49
S2	6.13	0.40	3.63
S3	6.98	1.20	6.81
S4	6.81	1.13	6.58
SEm±	0.09	0.03	0.07
CD (p=0.05)	0.24	0.08	0.19
Nutrient sources			
N1	6.70	1.08	6.14
N2	6.77	1.11	6.19
N3	6.82	1.12	6.21
N4	5.54	0.88	5.55
N5	6.57	1.04	6.04
N6	4.82	0.76	5.13
SEm±	0.10	0.03	0.08
CD (p=0.05)	0.30	0.10	0.23

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, CP = Crude Protein and EE = Ether Extract

Table 4. Effect of different seed ratio and nutrient management on NDF, ADF and ADL content (%) of sorghum and guar fodder

Treatments	NDF		ADF		ADL		Hemicellulose	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates								
S1	67.62	-	36.51	-	4.78	-	31.11	-
S2	-	45.34	-	33.11	-	5.00	-	12.23
S3	66.95	43.91	35.96	32.16	4.60	4.75	30.99	11.75
S4	66.83	44.16	35.89	32.26	4.57	4.80	30.94	11.90
SEm±	0.04	0.03	0.03	0.04	0.02	0.02	0.05	0.05
CD (p=0.05)	0.12	0.10	0.10	0.11	0.04	0.05	NS	0.13
Nutrient sources								
N1	66.79	44.02	35.81	32.14	4.60	4.80	30.98	11.88
N2	66.77	43.99	35.80	32.13	4.59	4.78	30.97	11.85
N3	66.76	44.01	35.79	32.14	4.58	4.79	30.97	11.88
N4	67.64	44.85	36.46	32.77	4.72	4.88	31.17	12.08
N5	66.89	44.10	35.87	32.19	4.64	4.82	31.02	11.92
N6	67.94	45.84	36.97	33.69	4.79	5.03	30.97	12.14
SEm±	0.06	0.05	0.05	0.05	0.02	0.02	0.07	0.06
CD (p=0.05)	0.16	0.13	0.14	0.15	0.06	0.06	NS	0.19

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, NDF = Neutral detergent fibre, ADF = Acid detergent fibre and ADL = Acid detergent fibre

line with the agreement of Tiwana *et al.* (2008) and Ginwal *et al.* (2019).

Plant cell wall is composed of various fibre fractions to support and protect plant against various biotic and abiotic agents and also provides strength to plant against lodging. Results revealed that these fibre

Table 5. Correlation coefficient (r) between yield and different quality parameters of sorghum fodder

	GFY	DM	OM	Ash	CP	EE	CHO	NDF	ADF	ADL	HC
GFY	1.00										
DM	-0.38	1.00									
OM	0.18	0.59**	1.00								
Ash	-0.18	-0.59**	-1.00**	1.00							
CP	0.26	-0.93**	-0.71**	0.71**	1.00						
EE	0.14	-0.77**	-0.83**	0.83**	0.82**	1.00					
CHO	-0.14	0.88**	0.85**	-0.85**	-0.97**	-0.91**	1.00				
NDF	0.27	0.56*	0.88**	-0.88**	-0.64**	-0.83**	0.78**	1.00			
ADF	0.20	0.60**	0.85**	-0.85**	-0.70**	-0.84**	0.81**	0.90**	1.00		
ADL	0.50*	0.42	0.83**	-0.83**	-0.56*	-0.72**	0.69**	0.95**	0.88**	1.00	
HC	0.21	0.01	0.21	-0.21	0.02	-0.13	0.07	0.39	-0.05	0.32	1.00

Note: GFY = Green fodder yield, DM = Dry matter, OM = Organic matter, CP = Crude protein, EE = Ether extract, CHO = Carbohydrates, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, HC = Hemicellulose, * = correlation significant at 5% level and ** = correlation significant at 1% level

Table 6. Correlation coefficient (r) between yield and different quality parameters of guar fodder

	GFY	DM	OM	Ash	CP	EE	CHO	NDF	ADF	ADL	HC
GFY	1.00										
DM	-0.08	1.00									
OM	-0.62**	0.76**	1.00								
Ash	0.62**	-0.76**	-1.00**	1.00							
CP	0.20	-0.93**	-0.82**	0.82**	1.00						
EE	-0.06	-0.79**	-0.63**	0.63**	0.78**	1.00					
CHO	-0.22	0.94**	0.85**	-0.85**	-1.00**	-0.82**	1.00				
NDF	0.54*	0.72**	0.26	-0.26	-0.69**	-0.71**	0.68**	1.00			
ADF	0.45	0.76**	0.35	-0.35	-0.75**	-0.73**	0.73**	0.99**	1.00		
ADL	0.65**	0.60**	0.08	-0.08	-0.56*	-0.59**	0.53*	0.97**	0.94**	1.00	
HC	0.71**	0.50*	-0.06	0.06	-0.43	-0.53*	0.40	0.89**	0.80**	0.89**	1.00

Note: GFY = Green fodder yield, DM = Dry matter, OM = Organic matter, CP = Crude protein, EE = Ether extract, CHO = Carbohydrates, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, HC = Hemicellulose, * = correlation significant at 5% level and ** = correlation significant at 1% level

fractions (NDF, ADF, ADL and hemicelluloses) decreased with the mixed cropping. Significantly lower fibre fractions (NDF, ADF, ADL and hemicelluloses) in sorghum were reported under 60% sorghum + 40% guar treatment which were at par with 75% sorghum + 25% guar. However, in guar 75% sorghum + 25% guar

Table 7. Effect of seed rate in different seed ratio and nutrient management on TDN, DMI and DMD of sorghum and guar fodder

Treatments	TDN (%)		DMI (g kg/bw)		DMD (%)	
	Sorghum	Guar	Sorghum	Guar	Sorghum	Guar
Seed rates						
S1	54.22	-	1.775	-	60.46	-
S2	-	58.60	-	2.647	-	63.10
S3	54.93	59.84	1.793	2.734	60.89	63.85
S4	55.02	59.70	1.796	2.718	60.94	63.77
SEm±	0.04	0.05	0.001	0.002	0.03	0.03
CD (p=0.05)	0.13	0.14	0.003	0.006	0.08	0.08
Nutrient sources						
N1	55.11	59.85	1.797	2.727	61.00	63.86
N2	55.13	59.87	1.797	2.729	61.01	63.87
N3	55.14	59.86	1.798	2.727	61.02	63.87
N4	54.28	59.05	1.774	2.676	60.50	63.38
N5	55.04	59.80	1.794	2.722	60.96	63.83
N6	53.63	57.85	1.766	2.618	60.10	62.65
SEm±	0.06	0.07	0.002	0.003	0.04	0.04
CD (p=0.05)	0.18	0.20	0.004	0.008	0.11	0.12

Note: S1 = Sole Sorghum, S2 = Sole Guar, S3 =75% Sorghum + 25% Guar, S4 = 60% Sorghum + 40% Guar, N1 = 100% RDF, N2 = 100% RDF+PGPR, N3 = 100% RDF+Seaweed Extract, N4 = 75% RDF+PGPR, N5 = 75% RDF+Seaweed Extract, N6 = 50% RDF + PGPR + Seaweed Extract, TDN = Total digestible nutrients, DMI = Dry matter intake and DMD = Dry matter digestibility treatment recorded significantly lower fibre fractions (NDF, ADF, ADL and hemicelluloses) gives better quality but the results for ADF and ADL were at par with 60% sorghum + 40% guar. These results might be due to increase in the succulence and result had close conformity with the findings of Htet *et al.* (2016) and Mut *et al.* (2017). An appraisal of data presented in Table 7 revealed that total digestible nutrients (TDN), dry matter intake (DMI) and dry matter digestibility (DMD) of sorghum and guar increased with the mixed cropping. In sorghum significantly higher TDN, DMI and DMD were reported under 60% sorghum + 40% guar treatment which were at par with 75% sorghum + 25% guar. Whereas in guar 75% sorghum + 25% guar recorded significantly higher TDN, DMI and DMD but the results for TDN and DMD were at par with 60% sorghum + 40% guar. Cumulative influence of both crops under mixed cropping might be the reason behind the results.

Critical examination of experimental data revealed that nutrient management treatments influenced the quality parameters of sorghum and guar fodder (Table 1, 2, 3, 4 and 7). In sorghum, significantly lower DM, OM, total carbohydrates and fibre fractions (NDF, ADF and ADL) and significantly higher ash, CP, EE, total ash, CP, EE yield, TDN, DMI and DMD were reported under 100% RDF + seaweed extract which were at par with 100% RDF + PGPR, 100% RDF and 75% RDF + seaweed extract. Whereas in guar such results for above mentioned parameters were reported under 100% RDF + PGPR which were at par with 100% RDF + seaweed extract, 100% RDF and 75% RDF + seaweed extract. Trend in quality parameters of crop might be due to the reason that uptake of nutrients in higher amount minerals concentration in plant sap increases due to mainly of nitrogen which helped the plant to increase the amino acid formation and succulency. Similarly, trend reported for quality parameters were highly correlated as depicted in table 5 and 6 by correlation coefficient (r). The results are in tune with similar findings of Ayub *et al.* (2012), Chattha *et al.* (2017), Dutta *et al.* (2019) and Kushwaha *et al.* (2019).

CONCLUSION

Mixed cropping has tremendous scope in improving productivity and quality of fodder crops. Thus, seed rate 75% sorghum + 25% guar with application of 75% RDF + seaweed extract in mixed cropping can be used to ensure supply of quality fodders for animals. For future line of work, in lieu of sorghum and guar, different cereal and legume fodder crops integration can be explored by conducting location specific trials with optimum dose and source of nutrients for better productivity and quality.

ACKNOWLEDGEMENTS

The authors are obliged to Director, ICAR-NDRI, Karnal for providing necessary facilities and financial assistance for carrying out this study.

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Received on 20-02-2020 and accepted on 17-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 57-61
doi: 10.5958/2231-6744.2020.00010.9

Indian Journal of
Animal Nutrition

Effect of Replacement of Maize by Animal Fat on Energy Utilization in Pigs

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ABSTRACT

The experiment was conducted to assess the effect of replacement of maize by different levels of animal fat on energy utilization in Large White Yorkshire (LWY) pigs. Thirty weaned piglets were randomly divided into three groups and were allotted to the three dietary treatments, T_1 (control ration as per NRC, 1998), T_2 (50 percent of maize of control ration replaced by animal fat) and T_3 (100 percent of maize of control ration replaced by animal fat). A Digestibility trial was conducted following total collection method and gross energy was estimated using bomb calorimeter. Gross energy of feed and faeces were 4144.68, 4173.92, 4249.99 and 4102.04, 3834.24, 3453.09 kcal/kg, respectively for T_1, T_2 and T_3 treatments. The apparent digestibility of GE was 85.85, 74.37 and 66.78 percent and the calculated digestible energy of feed was 3558.12, 3104.22 and 2837.90 kcal/kg, respectively for three treatments. The result of this experiment revealed that as the level of replacement of maize by animal fat increases, the efficiency of energy utilization was reduced in pigs fed isocaloric and isonitrogenous diet.

Key words: Animal fat, Energy levels, Feeding of pigs, Maize

INTRODUCTION

Maize forms the major source of energy in the swine feed. Even though, India produces more than 20 million MT of maize per year, it could meet only 60 percent of the requirement in the country. The lower availability coupled with increasing price of maize, necessitates an alternative energy source for incorporation in the swine feed. Animal fat is a byproduct of meat industry and can be included as a source of energy in swine ration. India produces 0.14 million MT of tallow and 0.02 million MT of lard per year (FAO, 2010). The use of fat as an energy source for pigs has been shown to increase digestibility of nutrients, improve growth rate and also reduces dustiness of feeds and, increases palatability.

Improved dry matter and nitrogen digestibility and nitrogen and energy retention were found in pigs fed diet with tallow at 0.33 and 0.75 percent of body weight (Galloway and Ewan, 1989), with white choice grease at 10 percent (Li *et al.,* 1990) and with lard at six percent of the diet (Lawrence *et al.,* 1994). Overland *et al.* (1994) reported that the apparent ileal and overall digestibility of crude fat and total fatty acids, apparent digestibility of dry matter, nitrogen and calcium and retention of nitrogen and energy were increased in pigs fed diets with six percent of rendered fat. Reis *et al.* (2000) observed increased apparent digestibility of ether extract and energy in pigs fed diet with eight percent of tallow compared to that with four percent tallow. However, studies on the effect of replacing maize by animal fat on energy utilization was not studied much in India, hence this work was carried out in growing Large White Yorkshire piglets.

MATERIALS AND METHODS

The experiment was conducted to assess the effect of replacement of maize by different levels of animal fat on energy utilization in growing piglets. Thirty weaned female Large White Yorkshire piglets were randomly divided into three groups with five replicates in each group. Each replicate were allotted with two piglets and housed in a single pen. All piglets were housed in the same shed and were maintained under identical management conditions throughout the experimental period of 70 days. Animals were allowed to consume as much as they could, within a period of one hour and the balance feed was collected and weighed after each

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Table 1. Ingredient composition of pig grower and finisher rations, %

Ingredients	Grower rations[1]			Finisher rations[1]		
	T_1	T_2	T_3	T_1	T_2	T_3
Yellow maize	70	35	0	74	37	0
Wheat bran	1.5	31	59.8	3.6	34.7	64.9
Soyabean meal	26.25	25.5	25.0	20.5	19.7	19.2
Animal fat	0	6.5	13	0	7	14
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	0.9	0.4	0	0.65	0.10	0
Calcite	0.85	1.1	1.7	0.75	1.0	1.4
Total	100	100	100	100	100	100
Nicomix AB_2D_3K [1], g	25	25	25	25	25	25
Nicomix BE [2], g	25	25	25	25	25	25
Zinc Oxide[3], g	45	13	0	30	0	0
Oxylock antioxidant [4], g	10	10	10	10	10	10

[1]Nicomix A, B2, D3, K (Nicholas Piramal India Ltd, Mumbai) containing Vitamin A- 82,500 IU, Vitamin B2-50 mg, Vitamin D3-12,000 IU and Vitamin K-10 mg per gram; [2]Nicomix BE (Nicholas Piramal India Ltd, Mumbai) containing Vitamin B1-4 mg, Vitamin B6-8 mg, Vitamin B12-40 mg, Niacin-60 mg, Calcium pantothenate- 40 mg and Vitamin E-40 mg per gram; [3]Zinc oxide (Nice Chemicals Pvt. Ltd., kochi) containing 81.38% of Zn; [4]Oxylock antioxidant (Vetline Ltd., Indore) contains Ethoxyquin, Butylated HydroxyToluene (BHT), Chelators and Surfactantant.

feeding. Clean drinking water was provided *ad libitum* in all the pens throughout the experimental period.

The animals were fed with standard grower ration containing 18 percent of CP and 3265 kcal of ME/kg of feed up to 50 kg body weight and finisher ration with 16 percent CP and 3265 kcal of ME /kg of feed from 50 kg body weight as per NRC (2012). The three groups of piglets were randomly allotted to the three dietary treatments, T_1 (control ration as per NRC, 2012), T_2 (50 percent of maize of control ration replaced by animal fat) and T_3 (100 percent of maize of control ration replaced by animal fat). Ingredient and chemical composition of pig grower and finisher ration were given in the Table 1 and 2. The ration used in this study had similar nutrients as per NRC (2012) recommendations. The animal fat was a mixture of mainly beef fat (tallow), pig fat (lard) and little of poultry fat, obtained from rendering plant of Meat Technology Unit, College of Veterinary and Animal Sciences, Mannuthy, freshly as and when the feed was prepared. Digestibility trial was conducted towards the end of the experiment following total collection method.

Gross energy of feed and faeces were estimated using bomb calorimeter (plain jacket calorimeter, model: 1341, Parr instruments co., USA) to determine the energy utilization of pigs fed three experimental rations.

Data collected on various parameters were statistically analyzed by Completely Randomized Design (CRD) method and means were compared by Duncan Multiple Range Test (DMRT) using Statistical Package for Social Studies (SPSS. 17.0.1v) software.

RESULTS AND DISCUSSION

Data on energy utilization of pigs under the three experimental rations T_1, T_2 and T_3 are presented in Table 3. Gross energy of feed and faeces were 4144.68, 4173.92, 4249.99 and 4102.04, 3834.24, 3453.09 kcal/kg, respectively for T_1, T_2 and T_3 treatments. The gross energy converted as digestible energy was 85.85, 74.37 and 66.78 percent and the calculated digestible energy of feed was 3558.12, 3104.22 and 2837.90 kcal/kg, respectively for three treatments.

The control group (T_1) had higher ($P<0.01$) DE than T_2 and T_3 and the lowest DE was recorded in T_3.

Table 2. Chemical compositionof pig grower and finisher rations

Parameters	Grower rations[1]			Finisher rations[1]		
	T_1	T_2	T_3	T_1	T_2	T_3
Dry matter, %	89.20±0.12	90.56±0.11	91.41±0.13	89.11±0.12	90.41±0.17	91.50±0.18
Crude protein, %	18.25±0.11	18.18±0.17	18.03±0.13	16.39±0.10	16.28±0.06	16.06±0.18
Ether extract, %	3.10±0.05	8.53±0.09	13.69±0.10	3.28±0.06	9.04±0.11	14.11±0.07
Crude fibre, %	3.72±0.11	6.58±0.13	9.42±0.10	3.73±0.07	6.54±0.10	9.40±0.03
Total ash, %	5.64±0.17	9.50±0.20	12.40±0.18	5.54±0.15	9.54±0.12	12.47±0.14
Nitrogen free extract, %	69.29±0.16	57.21±0.21	46.46±0.21	71.06±0.20	58.60±0.30	47.96±0.05
Acid insoluble ash, %	1.10±0.02	4.51±0.09	6.63±0.12	1.04±0.06	4.29±0.13	6.52±0.16
GE, kcal/kg	4132.18±22.92	4134.95±14.98	4212.87±9.21	4165.18±22.24	4203.07±17.05	4448.30±36.74
Calcium, %	0.59±0.01	0.62±0.006	0.78±0.01	0.62±0.02	0.65±0.01	0.77±0.02
Phosphorus, %	0.58±0.01	0.71±0.01	0.85±0.01	0.55±0.02	0.72±0.02	0.83±0.01
Magnesium, %	0.14±0.006	0.24±0.009	0.40±0.007	0.13±0.008	0.25±0.01	0.37±0.02
Manganese, ppm	16.78±0.38	39.14±1.76	69.99±1.18	16.59±0.45	38.76±0.96	69.85±1.31
Copper, ppm	6.35±0.08	9.34±0.06	12.62±0.19	6.15±0.15	9.17±0.08	12.39±0.15
Zinc, ppm	71.52±1.29	67.19±2.23	88.52±1.15	71.39±1.36	64.95±1.47	88.50±1.62

[*]On DM basis; [1] Mean of four values with SE

Reddy (2009) opined that an increase in dietary fibre level by one percent (beyond maximum level) will depress the digestibility of gross energy by about 3.5 percent. T_1 ration had no animal fat whereas T_2 and T_3 had 7 and 14 percent animal fat respectively, could be the main reason for lower energy utilization in growing pigs. Also when maize was replaced by different level of animal fat, wheat bran was added to adjust the ration to make iso-calorious and iso-nitrogenous.

The level of wheat bran in T_1, T_2 and T_3 ration were 3.6, 34.7 and 64.9 percent respectively which could increase crude fibre and acid insoluble ash level from

Table 3. Energy utilization of LWY pigs maintained on the four experimental rations

Parameter	Three experimental rations[1]		
	T_1	T_2	T_3
Average dry matter intake, kg	2.3208±0.07^{ab}	2.4330±0.08^{b}	2.2871±0.04^{ab}
Gross energy of feed, kcal/kg	4144.68	4173.92	4249.99
Gross energy intake, kcal	9618.84±310	10155.02±647	9720.01±179
Dry matter voided, kg	0.3304±0.007^{a}	0.6718±.02^{b}	0.9343±0.03^{c}
Gross energy of faeces, kcal/kg	4102.04±132^{b}	3834.24±94^{ab}	3453.09±69^{a}
Gross energy voided, kcal	1357.35±65^{a}	2580.87±122^{b}	3221.65±102^{c}
Gross energy-digested, kcal	8216.48±304^{b}	7574.15±431^{ab}	6498.36±244^{a}
Percent gross energy as digestible energy	85.85±0.76^{c}	74.37±1.83^{b}	66.78±1.45^{a}
Digestible energy of feed, kcal/kg	3558.12±31.47^{c}	3104.22±76.15^{b}	2837.96±61.48^{a}

[1]Mean of 5 observations; a,b Means of different superscripts within the same row differ significantly; Significant ($P<0.05$)

3.73 and 1.04 percent (T_1 ration-control group) to 6.54 and 4.29 percent (T_2 ration-50 percent maize replacement) and 9.40 and 6.52 percent (T_3 ration-100 percent maize replacement). The increased level of crude fibre and acid insoluble ash in the T_2 and T_3 ration mighthave contributed to the lowered digestibility of energy. Everts *et al.* (1986) observed reduced digestibility of dry matter, organic matter and crude protein with increased level of crude fibre (11.26 percent) in the diet of pigs. Bhar *et al.* (2000) also observed decreased digestibility of dry matter, organic matter, crude fibre, total carbohydrate, nitrogen free extract and energy with increased level of wheat bran (0, 50 and 100 percent maize replacement) in the diet of crossbred pigs. The digestive tract enlarges to accommodate a larger volume of feed rich in crude fibre and the rate of passage of ingesta increases, resulting in reduction in digestibility of nutrients (Ewan, 2000; Lentle and Janssen, 2008). Blair (2007) stated that in pigs higher the crude fibre level in the diet lower will be the digestibility of protein and energy. Sheikh *et al.* (2011) observed a significant reduction in digestibility of dry matter, ether extract, crude fibre, NFE and energy in crossbred pigs fed diet containing paddy grain instead of maize.

Lawrence and Maxwell (1983) found that efficiency of use of digestible energy tended to decrease with added choice white grease (0 to 12 percent). Significant improvement in digestibility of energy as a result of fat supplementation in the diet of pigs was also reported by Li *et al.* (1990) (white choice grease supplemented at 10 percent), Overland *et al.* (1994) (six percent of rendered fat) and Reis *et al.* (2000) (eight percent tallow). However no significant difference in the energy digestibility in pigs by supplementation of tallow at five percent in the diet was observed by Garry *et al.* (2007) and Huang *et al.* (2010).

CONCLUSIONS

Based upon the result of this experiment it could be concluded that as the level of replacement of maize by animal fat increased, the efficiency of energy utilization was reduced in pigs fed isocaloric and isonitrogenous diet.

ACKNOWLEDGMENTS

The authors are very much thankful to Dean, College of Veterinary and Animal Sciences, Mannuthy for providing necessary facilities for successful conduct of the work.

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Received on 17-06-2020 and accepted on 30-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 62-66
doi: 10.5958/2231-6744.2020.00011.0

Indian Journal of
Animal Nutrition

Effect of Feeding Different Levels of *Ajwain* (*Trachyspermum ammi* L.) Powder on Growth Performance and Carcass Characteristics in Japanese quails

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ABSTRACT

An experiment was carried out to study the effect of inclusion of ajwain powder at varying levels on growth performance, carcass characteristics and nutrient utilization in Japanese quails. One hundred and fifty day-old quail chicks were randomly allotted to five dietary treatment groups with 3 replicates of 10 birds for 5 weeks. Ajwain was ground and included at 0% (T_1; Control), 0.25 (T_2), 0.50 (T_3), 0.75 (T_4) and 1.0 (T_5) percent levels in iso-caloric and iso-nitrogenous broiler quail diets to meet the nutrient requirements as per NRC, 1994. Body weight gain and feed intake were recorded while feed efficiency was calculated. Results indicated that inclusion of ajwain powder up to 1.0% level in the diet of Japanese quail had no effect (P>0.05) on body weight gains, feed intake and on feed consumed / kg gain. Similarly, inclusion of ajwain powder up to 1.0% level in the diet had no effect (P>0.05) on carcass characteristics in quails. The feed cost / kg gain decreased by ₹ 1.01 in T_2 while it was increased by ₹ 4.11 in T_3, ₹ 6.84 in T_4 and ₹ 9.55 in T_5 groups of quails fed diets containing ajwain powder up to 1.0% level as compared to the control.

Key words: Carcass characters, Ajwain powder, Production performance, Quail

INTRODUCTION

In recent years, the use of dietary plant derived natural bioactive compounds (phytobiotics) has attracted increased attention to augment performance and health in poultry production. Phytogenics are a group of natural growth promoters (NGP) or phytobiotic growth promoters used as feed additives, derived from herbs, spices or other plants. Phytogenic additives being natural, non-toxic, residue free and their easy availability make them first choice as alternate to antibiotic growth promoters in poultry production. The knowledge regarding the modes of action and aspects of application of phytobiotics as feed additives are quite rudimentary (Windisch *et al.,* 2008). They have multiple effects in birds including appetite stimulation; enhance digestion, and possess immune-stimulant, bactericidal, antiviral, anti-oxidant properties when supplemented in diets for poultry.

Ajwain (*Trachyspermum ammi*) is a medicinal plant that belongs to family Apiaceae (Chatterjee *et al* 2012). Its seeds are used extensively for medicinal purposes as a digestive stimulant and to treat liver disorders (Ishikawa *et al.,* 2001). Ajwain is highly esteemed as a remedial agent for flatulence, flatulent colic, atonic dyspepsia, diarrhoea and in short, as a digestive aid and as an antiseptic (Bentely and Wrimen, 1999). Inconsistent results and inadequate data exist regarding the potential use of ajwain as phytobiotic growth promoter in poultry. Positive effects of ajwain on growth rate, feed conversion ratio (Anurag *et al.,* 2018; Waheed *et al.,* 2017; Valiollahi *et al.,* 2014) and carcass characteristics (Waheed *et al.,* 2017; Falaki *et al.,* 2016) were reported earlier in broilers. However, Kheiri *et al.* (2018) reported that supplementation of ajwain as substitute to AGP in Japanese quails had no effect on body weight, feed intake, feed efficiency and carcass composition and yield. Hence, the present study was undertaken to evaluate the performance of quail in terms of growth rate, carcass yield and economics fed diets containing ajwain powder at varying levels.

MATERIALS AND METHODS

One hundred and fifty, day-old quail chicks were procured and randomly allotted into 5 groups, each with 3 replicates of 10 chicks. Chicks were wing banded and

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weight of the chick was recorded. The experiment was carried out for 5 weeks in a completely randomized design (CRD). During the experiment, ajwain seed was ground and was included at 0% (T_1; Control), 0.25 (T_2), 0.50 (T_3), 0.75 (T_4) and 1.0 (T_5) percent levels in iso-caloric and iso-nitrogenous quail diets (Table 1) to meet the nutrient requirements (NRC, 1994). All the chicks were housed in battery brooders under uniform management conditions. Feed and water were provided *ad libitum*. The feed offered and feed leftover was weighed daily, to quantify the feed utilized. The data for growth rate was recorded at weekly intervals.

Samples of feed were analyzed for proximate principles (AOAC, 2005). At the end of study period (5th week), two birds per replicate and thus a total of 6 birds per experimental diet were randomly selected, weighed and slaughtered. The data on dressing percentage, carcass yield, meat bone ratio, ready-to-cook yield and per cent weight of heart, liver, gizzard and giblet were recorded. All the data were analyzed statistically (SPSS, 17th Version) as per Snedecor and Cochran (1993) and comparison of means was done using Duncan's multiple range tests (Duncan, 1955).

RESULTS AND DISCUSSION

The chemical composition of ajwain powder indicated that the percent DM, OM, CP, EE, CF, NFE, TA and AIA of ajwain powder were 91.34, 92.40, 18.30, 4.84, 9.86, 59.40, 7.60 and 1.52, respectively. The percent NDF, ADF, hemi-cellulose, cellulose, ADL and silica content of ajwain powder were 38.82, 34.34, 4.48, 29.45, 5.09 and 2.82, respectively.

Body weight gain (g), feed intake (g) and FCR under different dietary treatments during the experimental period (0-5 weeks) are presented in Table 2. Incorporation of ajwain powder up to 1.0% level in the diet had no effect (P>0.05) on body weight gain in quails. In corroboration, Kheiri *et al.* (2018) reported that feeding of ajwain @ 2 g/kg diet as substitution to antibiotic growth promoter had no effect (P>0.05) on body weight gain in Japanese quails. Similarly, no effect (P>0.05) on body weight gains upon feeding diets containing ajwain powder were reported by Samadian *et al.* (2016), Samadian *et al.* (2017) and Chowdhury *et al.* (2018) in broiler chicken. Lack of significant effect of ajwain on body weight gain can be attributed to the highly digestible ingredients in the basal diet and the ideal conditions of experimentation. Addition of

Table 1. Ingredient (%) and chemical composition (% DM basis) of quail diets

Constituent/ Diet	T_1 Control	T_2	T_3	T_4	T_5	Cost/kg (₹)
Maize	51.00	51.45	51.30	51.15	51.00	16.00
De oiled rice bran	9.90	10.70	10.70	10.60	10.60	13.50
Soybean meal	31.70	30.20	30.10	30.10	30.00	38.00
Fish meal	5.00	5.00	5.00	5.00	5.00	30.00
Ajwain powder	0.00	0.25	0.50	0.75	1.00	300.00
Di calcium phosphate	0.20	0.20	0.20	0.20	0.20	26.00
Shell grit	1.25	1.25	1.25	1.25	1.25	2.00
Salt	0.25	0.25	0.25	0.25	0.25	3.00
Trace min mix	0.15	0.15	0.15	0.15	0.15	240.00
Feed additives	0.55	0.55	0.55	0.55	0.55	278.50
Total	100	100	100	100	100	
ME* kcal/kg	2900.30	2900.19	2900.09	2900.49	2900.40	
Crude protein (%)	23.99	24.01	24.00	24.01	23.99	
Feed cost/100 kg (₹)	2492.30	2528.30	2597.10	2668.30	2737.10	

*Calculated value

growth promoters to poultry diets may have more impact when the diet used is less digestible (Toghyani *et al.,* 2010). In contradiction, several authors (Tripathi *et al.,* 2013; Valiollahi *et al.,* 2014; Falaki *et al.,* 2016; Waheed *et al.,* 2017; Anurag *et al.,* 2018) reported increased (P<0.05) body weight gain in poultry upon feeding diets containing ajwain powder.

Incorporation of ajwain powder up to 1.0% level in the diet had no effect (P>0.05) on feed intake of quails. However, the feed intake (g) increased numerically in quails fed diets containing 0.25, 0.50 and 0.75% ajwain powder and decreased numerically in quails fed diets containing 1.0% ajwain powder as compared to the control (Table 2). This slight reduction in feed intake at higher doses might be due to increasing repulsive odour and taste of ajwain. In line with the present findings, Samadian *et al.* (2016) reported numerically increased feed intake in broilers fed diets containing ajwain essential oil up to 100 ppm while it decreased at 150 ppm as compared to those fed control diet. Similarly, no effect (P>0.05) on feed intake upon feeding diets containing ajwain powder were also reported by Falaki *et al.* (2016), Samadian *et al.* (2017), Chowdhury *et al.* (2018), Hajiaghapour and Rezaeipour (2018) in broilers and Kheiri *et al.* (2018) in Japanese quails. In contradiction, increased (Valiollahi *et al.,* 2014; Davoodi *et al.,* 2016; Waheed *et al.,* 2017) and decreased (Tripathi *et al.,* 2013) feed intake in poultry upon feeding ajwain in the diet were also reported earlier.

The feed conversion ratio (FCR) was not affected (P>0.05) by incorporation of ajwain powder up to 1.0% level in the diet. Similar findings were also reported earlier in broiler chicken (Falaki *et al.,* 2016; Samadian *et al.,* 2016; Samadian *et al.,* 2017; Chowdhury *et al.,* 2018) and Japanese quails (Kheiri *et al.,* 2018). In contrast, some researchers reported that feeding of ajwain powder or essential oil in the diet resulted in improved feed conversion ratio in Japanese quail (Tripathi *et al.,* 2013) and broilers (Valiollahi *et al.,* 2014; Davoodi *et al.,* 2016; Waheed *et al.,* 2017).

The results pertaining to carcass characteristics are presented in Table 3. The current study revealed that incorporation of ajwain powder up to 1.0% level in the diet had no effect (P>0.05) on carcass yield (g), dressing percent, ready to cook yield (g) and meat to bone ratio as compared to the control. In line with these findings, many researchers reported that incorporation of ajwain powder in the diet had no effect (P>0.05) on carcass yield (Habibi *et al.,* 2016; Falaki *et al.,* 2016; Chowdhury *et al.,* 2018; Kheiri *et al.,* 2018) and dressing percent (Samadian *et al.,* 2017; Chowdhury *et al.,* 2018) in poultry. Increased levels of inclusion of ajwain powder up to 1.0% in the diet of quails had no effect (P>0.05) on ready to cook yield as compared to the control (Table 3). However, inclusion of ajwain powder at 1.0% in the diet resulted in significant decrease (P<0.05) in ready to cook yield (g) as compared to 0.25% level inclusion in the diet.

Similarly, incorporation of ajwain powder up to 1.0% level in the diet had no effect (P>0.05) on per cent weight of heart, liver, gizzard and giblets in quails which was in agreement with the findings of earlier researchers (Habibi *et al.,* 2016; Falaki *et al.,* 2016; Samadian *et al.,* 2017; Chowdhury *et al.,* 2018; Kheiri *et al.* 2018). The effect on carcass characteristics and relative weights of internal organs in several studies conducted with herbs and spices as alternative to

Table 2. Effect of incorporation of ajwain powder in diet on body weight gain, feed intake, FCR and feed cost/kg gain of quails

Parameter	T_1	T_2	T_3	T_4	T_5
Body weight gain (g)	194.30±2.70	205.70±6.70	196.30±4.90	194.20±3.90	190.50±4.20
Overall Feed Intake (g)	630.30±19.70	648.40±10.20	641.50±9.00	637.70±7.20	629.00±16.60
Feed Conversion Ratio	3.24±0.06	3.16±0.07	3.27±0.04	3.28±0.03	3.30±0.02
Feed cost / kg** (₹)	80.81^{a}±1.40	79.80^{a}±1.84	84.92^{b}±1.12	87.65^{bc}±0.79	90.36^{c}±0.67

Values in row bearing different superscripts differ significantly **(P<0.01)

Table 3. Effect of incorporation of CSM in diet on carcass characteristics of quails

Parameter	T_1	T_2	T_3	T_4	T_5
Carcass yield (g)	123.33±4.33	133.00±4.29	127.83±7.19	122.00±2.67	118.50±3.36
Dressing (%)	60.26±1.29	61.52±1.48	60.87±3.20	59.91±1.42	58.97±1.31
Ready to Cook yield* (g)	133.83^{ab}±4.54	144.83^{b}±4.56	138.50^{ab}±7.31	132.00^{ab}±2.58	128.00^{a}±3.25
Meat: Bone ratio	5.36±0.46	5.77±0.05	5.56±0.41	5.22±0.07	4.93±0.13
Heart (%)	2.33±0.21	2.50±0.22	2.17±0.17	2.17±0.17	2.00±0.01
Liver (%)	4.00±0.26	4.50±0.22	4.17±0.31	3.83±0.17	2.67±0.33
Gizzard (%)	4.17±0.40	4.83±0.17	4.33±0.49	4.00±0.26	3.83±0.17
Giblet (%)	10.50^{ab}±0.56	11.83^{b}±0.48	10.67^{ab}±0.33	10.00^{a}±0.37	9.50^{a}±0.43

Values in row bearing different superscripts differ significantly, *(P<0.05)

antibiotic growth promoters in poultry were not consistent. These variations in results obtained in different studies may be attributed to the differences in animal physiology, rearing environments, illness, diet compounds and the ingredients of the essential oils.

There is a significant (P<0.05) increase in feed cost/kg gain (₹) with incorporation of ajwain powder at 0.50, 0.75 and 1.0% in diet as compared to the control (Table 2). However, inclusion of ajwain powder at 0.25% in the diet of quails had no effect (P>0.05) on feed cost / kg gain as compared to the control. The study indicated that the feed cost / kg gain decreased by ₹ 1.01 in T_2 while it is increased by ₹ 4.11 in T_3, ₹ 6.84 in T_4 and ₹ 9.55 in T_5 group of quails fed diets containing ajwain powder at varying levels as compared to the control. Similarly, Anurag *et al.* (2018) reported that dietary supplementation of ajwain up to 0.2% level in the diet of Pratapdhan chicken resulted in highest benefit cost ratio while inclusion at higher levels *viz.* 0.3% in the diet had resulted in lower benefit cost ratio.

CONCLUSION

The current study indicated that incorporation of ajwain powder had no effect on the performance of Japanese quail. However, incorporation of ajwain powder at 0.25% level in the diet resulted in decreased feed cost / kg gain of quails.

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Received on 01-02-2020 and accepted on 06-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 67-73
doi: 10.5958/2231-6744.2020.00012.2

Indian Journal of Animal Nutrition

Effects of feeding Cashew Apple Waste with or without Supplementation of Non-starch Polysaccharide Degrading Enzymes on Nutrient Digestibility and Growth Performance of broilers

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ABSTRACT

The current research was carried out to study the effect of different inclusion level of cashew apple waste (CAW) to improve the ileal digestibility of nutrients and performance of broilers supplemented with non-starch polysaccharides (NSP) degrading enzymes. Two hundred and ten day-old Vencobb broiler chicks divided into 7 groups with 3 replicates of 10 chicks in each. Birds of groups G_1, G_2, G_3 which received CAW at 0, 5 and 10 per cent, respectively. G_4 and G_5 birds fed with 5 per cent CAW, and were additionally fed NSP degrading enzyme at 500 g and 750 g/ton, respectively. Similarly, G_6 and G_7 birds received 10 per cent CAW, and NSP degrading enzyme at 500 and 750 g/ton, respectively. Ileal digestibility values of dry matter, crude protein and crude fibre were significantly (P<0.01) increased in enzyme supplemented group with CAW. Feed intake did not differ significantly (P<0.11) among the groups at 42nd day. Body weight Gain and feed conversion ratio recorded in experimental birds received 10 per cent CAW and NSP degrading enzyme at 750 g/ton was comparable to control group (G_1). However, better feed conversion efficiency (P<0.01) was recorded G_4 and G_5 group birds compared to control (G_1). Thus, CAW could be included in corn, soya bean meal based broiler ration at 10 % level with NSP enzyme at 75 0 g/ton.

Key words: Broilers, Body weight gain, Cashew apple waste, FCR, Ileal digestibility, NSP Enzyme

INTRODUCTION

In India, broiler industry had shown annual growth rate of 11.00 per cent during year 2018 (DAHD, 2018). However, high cost and scarcity of conventional feed ingredients especially for energy and protein sources has led to utilization of agricultural by products/ unconventional feedstuffs in poultry feed formulations to check the ever increasing feeding cost. The inclusion level of un-conventional feedstuffs is limited, because of lack of knowledge on nutritive value, digestibility, anti-nutritive factors, and safety (FAO, 2011).

The use of alternate feedstuffs to replace maize and soya bean meal in poultry feed is practiced by commercial feed formulators considering fiber and non-starch polysaccharides (NSP) content. The NSP's like galactosides (raffinose and stachyose) hemicelluloses, mannans and glucans will not be digested in small intestine of poultry because of lack of endogenous NSP's enzymes like glycosidase, mannase, protease and glucanase (Iirish *et al.,* 1995). Thus, broiler diets with high NSP content might result in gas accumulation and diarrhea and addition of exogenous NSP degrading enzymes are thus recommended to improve the nutritive value of poultry ration (Wu *et al.,* 2005).

Cashew apple (*Anacardium occidentale*) waste (CAW) is one of the by-product from the cashew apple processing industry which is seasonally available in India. About, 65 lakh metric tonnes of cashew apple were wasted in India and 4.97 lakh metric tonnes of cashew apple were wasted in Kerala (Murugan *et al.,* 2015). The CAW can be considered as energy source to replace maize in broiler diets without any adverse effect (Bhamare *et al.,* 2016). Different studies were conducted to study the effects of enzyme as single enzyme and combination of different NSP enzymes in broiler ration with unconventional feedstuffs (Moftakharzadeh *et al.,* 2017). The presence of soluble

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NSP in unconventional feed stuffs like CAW has anti nutritional effect and restricts the inclusion in poultry diet but no research had been conducted. Hence the present experiment was carried out to evaluate ileal digestibility of CAW based diet with NSP enzyme supplementation and their influence on growth performance in broiler diets.

MATERIALS AND METHODS

The sun dried study material CAW was collected after juice extraction of cashew apple from M/S. Plantation Corporation of Kerala (Government of Kerala Undertaking, Kottayam). About 1000 g of sample was dried in a hot air oven at 60^o C for 48 hours and ground to pass through 1mm sieve and preserved in air tight containers for chemical composition analysis. The samples were analyzed for proximate principles as per AOAC (2016) and acid insoluble ash content was analyzed as per BIS (IS: 14826; 2000).The calcium and phosphorus were estimated following procedure of Talapatra *et al.* (1940). Non Starch Polysaccharide (NSP) in terms of Neutral detergent fibre (NDF), Acid detergent fibre (ADF), Acid Detergent lignin (ADL) were analysed for CAW and experimental rations as per Van Soest *et al.* (1991). The difference between NDF and ADF was calculated as hemi-cellulose (HC) content and difference between ADF and ADL is noted as cellulose (C). The cell contents were calculated by 100 – NDF.

Two hundred and ten, day old commercial broiler (Vencobb-400) chicks were weighed individually; wing banded and randomly distributed to seven treatment groups *viz* G_1, G_2, G_3, G_4, G_5, G_6 and G_7 with three replicates of ten chicks in each group. The CAW were included at 0, 5 and 10 per cent in the experimental diets and multi-enzymes were supplemented at 0, 500 and 750 g/ton of feed. The details of experimental design are presented in Table 1. All the experimental diets were made iso-nitrogenous and iso-caloric, for pre-starter (0-14 days), starter (15-28 days) and finisher (29-42 days) phases as per ICAR (2013) nutrient recommendations. The true metabolizable value (TME) of 3676 kcal/kg Bhamrae, 2016 for CAW was considered and palm oil was added to prepare iso-caloric experimental diets. The ingredient composition of experimental diets is presented in Table 2.

All experimental chicks were reared in deep litter system in pens up to 6 week of age. The standard management practices were followed for rearing. The incandescent bulbs were provided at 1 watt per chick till 3rd week of age. Thereafter, light was provided only during night hours. The birds were provided with feed and clean drinking water *ad libitum* throughout the experimental period. On 42nd day of experiment, 42 birds (6 birds from each group) were randomly selected, fasted for 16 hours and anaesthetized and bled to death. The different segment of intestine was separated and ligated into duodenum, jejunum (from bile duct entrance to the Meckel's diverticulum), ileum (from the Meckel's diverticulum to 40 cm proximal to the ileocecal junction) and caecum (Ravindran *et al.,*2005). The undigested content in the ileum was squeezed gently without damage the ileal tissues and collected digesta in petri-dish was deep freezed at -20ºC for further

Table1: Details of experimental diets

Treatment Groups	Composition of experimental diets
G_1	Experimental diet without CAW + no enzymes
G_2	Experimental diet with 5 % CAW + no enzymes
G_3	Experimental diet with 10 % CAW + no enzymes
G_4	Experimental with 5 % CAW + multi enzymes @ 500 g/ton
G_5	Experimental diet with 5 % CAW + multi enzymes @ 750 g/ton
G_6	Experimental diet with 10 % CAW + multi enzymes @ 500 g/ton
G_7	Experimental diet with 10 % CAW + multi enzymes @ 750 g/ton

studies. Ileal digestibility of nutrients was calculated as per equation given by Zhang *et al.* (2014).

Ileal digestibility (%) =

$$100 - \frac{\text{Diet AIA \%}}{\text{Ileal digesta AIA \%}} \times \frac{\text{Ileal digesta nutrient \%}}{\text{Diet nutrient \%}} \times 100$$

Daily feed intake and weekly live body weight of all birds in each replicate were recorded. All the data obtained in this experiment were subjected to analysis of variance using SPSS software version 24.0.

RESULTS AND DISCUSSION

The chemical composition of CAW (on dry matter) used in the experimental diets are 87.10 ± 0.19 % dry matter (DM), 20.68 ± 0.27 % crude protein (CP), 2.90 ± 0.40 % ether extract (EE), 13.90 ± 0.11 % crude fibre (CF), 03.80 ±0.09 % total ash (TA), 58.72 ± 0.47 % nitrogen free extract (NFE), 96.20 ±0.12 % organic matter (OM), 0.76 ± 0.08 % calcium, and 0.40±0.11 % of phosphorus. Contents of NDF, ADF, ADL, cell contents, hemi-cellulose and cellulose (%, DM) in CAW were 60.00±0.31, 39.00±0.7, 14.80±0.17, 40.00±0.32, 21.00±0.51 and 24.20±0.30, respectively. The chemical composition of experimental diets is presented in Table 3.

The proximate composition of CAW as observed in this study was similar to that reported by Bhamare *et*

Table 2. Ingredient composition of experimental diets (%)

Group	Maize	SBM	CAW	Oil	DCP	Shell grit	*Additives	**Enzymes	Salt	Total
Pre-starter diet										
G_1	55.00	39.0	0	2.5	1	1.2	1.05	0	0.25	100
G_2	50.50	38.5	5	2.5	1	1.2	1.05	0	0.25	100
G_3	47.00	36.4	10	3.3	1	1	1.05	0	0.25	100
G_4	50.45	38.5	5	2.5	1	1.2	1.05	0.05	0.25	100
G_5	50.43	38.5	5	2.5	1	1.2	1.05	0.075	0.25	100
G_6	46.55	36.4	10	3.3	1	1	1.05	0.05	0.25	100
G_7	46.93	36.4	10	3.3	1	1	1.05	0.075	0.25	100
Starter diet										
G_1	58.00	35.5	0	3.15	1	1	1.05	0	0.25	100
G_2	53.50	34.9	5	3.25	1	1	1.05	0	0.25	100
G_3	50.65	32.5	10	3.5	1	1	1.05	0	0.25	100
G_4	53.45	34.9	5	3.25	1	1	1.05	0.05	0.25	100
G_5	53.43	34.9	5	3.25	1	1	1.05	0.075	0.25	100
G_6	50.60	32.5	10	3.5	1	1	1.05	0.05	0.25	100
G_7	50.58	32.5	10	3.5	1	1	1.05	0.075	0.25	100
Finisher diet										
G_1	62.00	30.7	0	3.95	1	1	1.05	0	0.25	100
G_2	56.45	30.7	5	4.5	1	1	1.05	0	0.25	100
G_3	52.65	29.5	10	4.5	1	1	1.05	0	0.25	100
G_4	56.40	30.7	5	4.5	1	1	1.05	0.05	0.25	100
G_5	56.40	30.7	5	4.5	1	1	1.05	0.075	0.25	100
G_6	52.60	29.5	10	4.5	1	1	1.05	0.05	0.25	100
G_7	52.58	29.5	10	4.5	1	1	1.05	0.075	0.25	100

*Feed additives in all experimental diets contains broiler trace mineral premix @ 0.15%, choline chloride 0.15 %, toxin binder 0.05 %, Liv-52 powder 0.15 %, DL- methionine 0.225 %, L- lysine 0.225 %, broiler vitamin premix 0.10 %; **Exogenous NSP degrading multi-enzymes with chemical composition (per kg) of amylase (24,00,000 Units), hemi-cellulase (54,00,000 Units), cellulase (1,20,00,000 Units), beta-glucanase (1,06,000 Units) and protease (24,00,000 Units).

Table 3 Chemical composition of experimental diets (%, Dry Matter Basis)

Group	DM	CP	CF	EE	Total Ash	NFE	AIA	Ca	Total P
Pre-Starter Diet									
G_1	88.50	22.98	5.21	3.70	5.35	62.76	1.49	1.14	0.42
G_2	88.00	22.68	5.41	2.80	5.30	63.81	1.70	1.19	0.46
G_3	87.80	22.58	5.58	3.20	5.40	63.24	1.70	1.21	0.42
G_4	87.90	22.71	5.32	3.15	5.26	63.56	1.60	1.17	0.48
G_5	88.10	22.79	5.26	3.14	5.31	63.50	1.75	1.65	0.41
G_6	88.00	22.61	5.49	2.98	5.32	63.60	1.76	1.68	0.42
G_7	87.90	22.66	5.71	3.10	5.39	63.14	1.72	1.18	0.38
Starter Diet									
G_1	88.00	21.90	4.80	3.43	5.34	64.53	1.64	1.14	0.43
G_2	87.90	21.59	5.30	3.45	5.59	64.07	1.69	1.21	0.44
G_3	87.80	21.61	5.70	3.92	5.8	62.97	1.68	1.16	0.45
G_4	88.10	21.60	5.29	3.49	5.62	64.00	1.71	1.26	0.48
G_5	88.20	21.64	5.32	3.51	5.68	63.85	1.61	1.19	0.41
G_6	87.90	21.69	5.71	3.94	5.74	62.92	1.71	1.18	0.45
G_7	88.00	21.68	5.69	3.89	5.76	62.98	1.66	1.21	0.47
Finisher Diet									
G_1	86.20	20.23	5.18	4.10	5.63	64.86	1.16	1.25	0.44
G_2	87.40	19.63	5.20	3.90	5.56	65.71	1.20	1.32	0.41
G_3	86.70	19.92	5.42	4.01	5.52	65.13	1.40	1.35	0.45
G_4	86.00	19.84	5.59	4.10	5.55	64.92	1.25	1.34	0.49
G_5	86.00	20.00	5.04	4.19	5.60	65.16	1.24	1.30	0.41
G_6	87.30	19.92	5.67	4.20	5.98	64.23	1.42	1.37	0.45
G_7	86.80	19.96	5.65	4.16	5.66	64.57	1.49	1.32	0.47

al. (2016) and Sreekutty (2017). However, lower CP (11.5%) and CF (8.5 %) content were reported by Swain *et al.* (2007). As compared to our result, higher value of 6.67 % of AIA was reported by Bhamare *et al.* (2016). The contents of NDF, ADF, ADL, cellulose and hemi-cellulose as estimated in this study was higher than

Table 4 Effect of feeding CAW on nutrient digestibility during finisher phase

Treatments	Digestibility (%)		
	Dry matter	Crude Protein	Crude Fibre
G_1	75.93^b±0.35	73.42^b±0.44	63.43^b±0.23
G_2	67.10^d±0.15	66.40^e±0.40	52.06^e±0.23
G_3	65.10^d±0.21	64.76^f±0.15	51.16^e±0.60
G_4	75.60^b±0.31	74.00^b±0.12	64.20^b±0.15
G_5	79.00^a±0.06	77.76^a±0.15	68.60^a±0.31
G_6	67.23^d±0.15	67.90^d±0.06	54.90^d±0.49
G_7	71.30^c±0.21	69.26^c±0.32	57.30^c±0.28
P-value	<0.001	<0.001	<0.001

$^{a,b,c,d \text{ and } e}$Mean values with different superscripts within a row differ significantly

Table 5. Effect of incorporation of CAW with NSP degrading enzymes on feed intake

Age (week)	G_1	G_2	G_3	G_4	G_5	G_6	G_7	p-value
Weekly Feed Intake (g/bird)								
I	140.91^{b}±	133.72^{c}±	151.57^{a}±	144.35^{b}±	145.67^{b}±	155.66^{a}±	141.23^{b}±	<0.001**
	0.49	1.46	2.22	0.59	3.93	0.89	1.49	<0.001**
II	387.65^{c}±	285.73^{d}±	435.06^{abc}±	480.53^{ab}±	411.58^{bc}±	486.71^{a}±	427.70^{abc}±	<0.001**
	8.19	43.02	17.38	3.09	31.08	14.35	3.12	<0.001**
III	561.29^{ab}±	497.67^{b}±	553.78^{ab}±	408.24^{c}±	559.29^{ab}±	594.64^{a}±	586.11^{a}±	<0.001**
	30.13	0.40	31.67	3.85	22.75	22.13	18.77	<0.001**
IV	992.00±	1014.47±	1135.62±	1231.51±	979.59±	1138.59±	1090.75±	0.23 ^{ns}
	68.39	0.57	72.01	0.85	61.76	50.58	149.63	0.23 ^{ns}
V	1084.57±	1120.12±	1258.33±	1111.34±	1177.91±	1181.24±	1198.89±	0.88 ^{ns}
	35.89	16.31	117.44	49.41	16.82	40.024	220.81	0.88 ^{ns}
VI	1123.35^{bc}±	1160.00^{b}±	1333.33^{a}±	996.16^{bcd}±	943.33^{d}±	1141.89^{bc}±	976.27^{cd}±	<0.001**
	1.43	92.38	20.88	1.19	60.38	78.09	35.73	<0.001**
Overall	4293.11±	4211.72±	4867.71±	4372.13±	4217.45±	4698.74±	4421.02±	0.11 ^{ns}
	69.92	113.84	238.62	47.96	85.40	34.58	352.61	0.11 ^{ns}

$^{a,b,c,d,and\ e}$ Mean values with different superscripts within a row differ significantly; **Significance at p<0.01; ^{ns}non- significant

those reported by Dele *et al.* (2013), however, the values observed are quite similar to those reported by Sreekutty (2017).This variation in chemical composition among different studies may be due to the difference in variety of cashew apple processed from different location.

Ileal digestibility values of DM, CP and CF were significantly (P<0.01) higher in enzyme supplemented

Table 6. Effect of incorporation of CAW with NSP degrading enzymes on body weight gain in broilers

Age (week)	G_1	G_2	G_3	G_4	G_5	G_6	G_7	p-value
Initial B. wt	42.36±	44.72±	44.24±	44.03±	45.48±	43.99±	46.14±	0.27 ^{ns}
	0.47	2.10	0.68	0.46	1.03	0.64	0.68	0.27 ^{ns}
I	150.58^{b}±	143.39^{c}±	161.24^{a}±	154.01^{b}±	155.34^{b}±	165.33^{a}±	150.89^{b}±	<0.001**
	0.59	0.66	1.71	0.30	3.37	1.63	2.11	<0.001**
II	391.82^{a}±	319.56^{b}±	407.14^{a}±	440.00^{a}±	417.20^{a}±	421.66^{a}±	417.31^{a}±	<0.001**
	6.33	36.44	15.45	1.69	1.11	6.55	7.46	<0.001**
III	742.52^{ab}±	671.02^{c}±	731.73^{ab}±	698.02^{bc}±	715.99^{abc}±	759.50^{a}±	764.40^{a}±	<0.001**
	6.91	8.28	24.58	3.67	8.97	27.45	2.85	<0.001**
IV	1312.58^{ab}±	1268.14^{b}±	1322.00^{ab}±	1414.37^{a}±	1262.52^{b}±	1437.75^{a}±	1369.88^{ab}±	<0.05*
	54.78	1.78	41.01	35.17	35.91	59.45	26.48	<0.05*
V	1894.26^{b}±	1833.26^{b}±	1877.33^{b}±	2061.90^{a}±	1937.65^{b}±	1910.89^{b}±	1929.72^{b}±	<0.001**
	4.68	10.63	38.69	4.47	27.32	47.62	56.59	<0.001**
VI	2290.87^{abc}±	2194.99^{bc}±	2264.33^{bc}±	2395.08^{a}±	2365.93^{a}±	2268.33^{bc}±	2288.89^{abc}±	<0.02*
	35.68	56.79	35.57	5.99	9.61	53.22	20.96	<0.02*
Overall	2248.51^{abc}±	2150.27^{c}±	2220.09^{bc}±	2351.06^{a}±	2320.46^{ab}±	2224.35^{bc}±	2242.75^{abc}±	<0.02*
	36.15	56.59	35.96	6.26	9.95	53.27	20.35	<0.02*

^{a,b,c} Mean values with different superscripts within a row differ significantly; **Significance at p<0.01 *Significance at p<0.05; ^{ns}Non-significant

Table 7. Effect of incorporation of CAW with NSP degrading enzymes on cumulative feed conversion ratio in broilers

Age (week)	G_1	G_2	G_3	G_4	G_5	G_6	G_7	p-value
I	1.30±0.01	1.36±0.03	1.29±0.00	1.31±0.00	1.33±0.02	1.28±0.01	1.35±0.02	0.09 ^{ns}
II	1.52±0.04	1.54±0.04	1.62±0.03	1.58±0.01	1.50±0.08	1.70±0.03	1.54±0.03	0.06 ^{ns}
III	1.56^{bc}±0.04	1.46^{c}±0.05	1.66^{ab}±0.03	1.58^{bc}±0.01	1.67^{ab}±0.05	1.73^{a}±0.06	1.61^{ab}±0.02	<0.001**
IV	1.65±0.06	1.58±0.02	1.78±0.04	1.66±0.04	1.72±0.04	1.71±0.048	1.69±0.10	0.29 ^{ns}
V	1.71±0.04	1.71±0.00	1.92±0.10	1.67±0.03	1.73±0.02	1.91±0.03	1.82±0.15	0.12 ^{ns}
VI	1.91^{bc}±0.05	1.96^{abc}±0.02	2.19^{a}±0.08	1.86^{c}±0.02	1.82^{c}±0.04	2.11^{ab}±0.04	1.97^{abc}±0.16	<0.03*

^{a,b,c} Mean values with different superscripts within a row differ significantly; **Significance at p<0.01 *Significance at p<0.05; ^{ns}Non-significant

group with CAW (Table 4). These findings are in agreement with findings of Olukosi *et al.* (2015) who reported ileal digestibility of CP values increased by 4.2 per cent and 2.1 per cent in due to supplementation of multi-enzyme XAP-5000 and XAP-10,000, respectively. Ileal digestibility of DM, CP and CF were significantly (P<0.01) higher in birds fed G_5 (5% CAW + 750 g/ton enzymes) compared to control group and lower values were observed in birds fed 10 % CAW without any enzyme supplementation. Similarly, supplementation with either single or combined exogenous NSP enzymes improved apparent ileal digestibility of starch, CP,CF, EE, GE and phosphorus in broilers fed rations containing unconventional feed stuffs (Romero *et al.,*2014).

Data pertaining to feed intake, body weight gain and Feed conversion ratio under different dietary treatments are presented in table 5, 6 and 7. An increase in feed intake in pre-starter (1 -7 days) and starter period (8-21days) were recorded in experimental fed CAW supplemented with multi enzymes, however, overall DMI during the entire period (0-42 days) did not differ significantly. Abdel Hafez *et al.* (2018) and Alam *et al.* (2003) also observed similar trend in increased feed Intake in potato peel fed birds with multi enzymes supplementation. However, Bhamare *et al.* (2016) reported that addition of CAW at 10 and 20 % without enzymes supplementation resulted in decreased feed intake. Overall BWG in G_4 (5 % CAW with 500 g/ton) was significantly (P<0.05) higher as compared to other group of birds. The results reported by Jozefiak *et al.* (2006) was in agreement with the present study, where inclusion of 400 U/g beta-glucanase, 300 U/g xylanase and 800 U/g protease as cocktail enzyme at 1g/1 kg of diet in oat based broiler diet resulted in better body weight gain. Feed conversion ratio (FCR) was significantly (P<0.01) better in G_4 and G_5 groups birds compared to control. Similar results were recorded in broilers by Bhamare *et al.* (2016) who reported that inclusion of CAW at more than 5% without NSP enzymes shown poor FCR compared to control. Poorer FCR (P<0.01) was recorded in birds fed 10 % CAW with NSP enzymes supplemented group (G_6 and G_7) compared to G_4 and G_5.

CONCLUSION

It is concluded that CAW could be included in corn, soya bean meal based broiler ration at 10 % level with NSP enzyme at 75 0 g/ton with similar FI, BWG and FCR compared to control group.

ACKNOWLEDGMENTS

The authors would like to thanks the staff of the Department of Animal Nutrition and Poultry Farm, Instructional Livestock Farm Complex, CVAS, Pookode, Wayanad, Kerala India. The fund for this study was provided by the Kerala Veterinary and Animal Sciences University under Master degree program.

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Received on 18-06-2020 and accepted on 28-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 74-77
doi: 10.5958/2231-6744.2020.00013.4
Indian Journal of Animal Nutrition

Efficacy of Crude Soya oil and Emulsifier in Ration on Production Performance of Broilers

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ABSTRACT

This study was conducted to assess the efficacy of emulsifier in broiler ration containing crude soya oil on the production performance of broilers. A total of 90 day- old Vencobb 320 broiler chicks were randomly divided into 15 groups of six birds in each and five groups were allocated to each dieary treatment. Treatment groups were fed with basal diet contains crude soya oil as energy source (T_1), basal diet supplemented with fat emulsifier at the rate of 250 g per metric tonne of feed (T_2) and 80 kcal energy reduced from basal diet supplemented with emulsifier at the rate of 250 g per metric tonne of feed (T_3). All the chicks were reared under deep litter system for 42 days. Body weight and feed intake were recorded weekly. Body weight (6^{th} week) of T_2 birds (2622 g) was comparable with T_3 (2558 g) but was higher (P<0.05) than in T_1 (2502 g). Similarly feed conversion ratio (6^{th} week) was also similar between T_3 (1.76) and T_2 (1.80) birds, however T_1 (1.87) had lower (P<0.05) FCR than in T_3 group. Dressing percent was higher (P<0.05) in T_1 (69.44) than occurred in T_3 (65.47) and T_2 (65.55). Abdominal fat percentage, breast meat yield and drumstick percentage, serum biochemical attributes were not different among three bird groups. The present study concluded that inclusion of emulsifier at the rate of 250 g / MT of feed containing crude soya oil with 80 kcal reduced metabolic energy improved body weight and feed conversion ratio at market age

Key words: Crude soyabean oil, Feed conversion ratio, Fat emulsifier

INTRODUCTION

Several oils are used in the broiler ration as a source of energy and amount of oil in broiler ration depends on several factors such as availability, relative price and the effect on feed manufacturing process. Energy is a major cost component in diets of as broilers for higher performance and Emulsifiers can be used to improve fat digestibility and energy efficiency. Low energy diets can be formulated for birds to maintain performance, leading to lower feed cost, more economical and sustainable production. Emulsifiers facilitate the formation of emulsion droplets, which lowers the surface tension and stimulates the formation of micelles, causes high levels of monoglycerides in the intestine and facilitates the nutrient transport through the membrane allowing improved nutrient absorption and utilization (Ashraf, 2007; Melegy *et al.,* 2001). However, Emulsifier supplementation also increases nutrient digestibility but reduces growth performance and carcass characteristics (Jones *et al.,* 1992; Cooper *et al.,* 1987), which is attributed to the degree of saturation and length of fatty acids. Therefore, this study was undertaken to study the efficacy of emulsifier with crude soya oil as fat source on the metabolic energy sparing effect in the production performance of broilers.

MATERIALS AND METHODS

A total of 90 day-old Vencobb- 320 broiler chicks belonging to single hatch were purchased from a local hatchery, were wing banded, weighed and randomly distributed into 15 groups of six in each and allocated to three treatments, 5 groups in each treatment. Feed and water were provided *ad lib.* All the chicks were reared hygienically on deep litter system in separate pens under standard uniform managemental conditions for 42 days. The fat emulsifier Jubidol® used was purchased from Jubliant Life Sciences, Noida. The treatment groups were divided as basal diet containing crude soya oil (T_1), basal diet supplemented with fat emulsifier at the rate of 250 g per MT of feed (T_2) and 80 kcal energy reduced from basal diet with emulsifier supplementation (T_3). The Isonitrogenous experimental

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Table 1. Ingredients and chemical composition of broiler Pre starter, Starter and Finisher ration(%)

Ingredients (kg/100kg)	BPS			BS			BF		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
Maize	50.20	50.20	52.5	52.18	52.18	54.00	61.57	61.7	63.53
Soya	41.80	41.80	40.6	38.80	38.80	38.52	31.93	31.93	31.60
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Calcite	1.20	1.20	1.35	0.98	0.98	0.98	1.44	1.44	1.45
DCP	1.81	1.81	2.04	2.00	2.00	2.00	1.05	1.05	1.05
Soya oil	3.43	3.43	2.0	4.80	4.80	3.30	2.73	2.73	1.21
Methionine	0.32	0.32	0.30	0.23	0.23	0.20	0.17	0.17	0.16
Lysine	0.22	0.22	0.21	0.11	0.11	0.08	0.10	0.10	0.08
Vitamin premix	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Mineral premix	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nutrient composition (calculated)									
CP (%)	23.0	23.0	23.0	22	22	22	20	20	20
Crude fiber (%)	3.51	3.51	3.48	3.37	3.37	3.39	3.15	3.15	3.16
Ether extract(%)	5.78	5.78	4.47	7.14	7.14	5.74	5.45	5.45	4.04
Metabolizable energy	3000	3000	2920	3100	3100	3020	3200	3200	3120

BPS- Broiler pre starter, BS- Broiler starter and BF- Broiler finisher; Supplies per kg of diet vitamin A 16,500 IU, vitamin D_3 3200 ICU, vitamin E 12mg, vitamin K 2 mg, vitamin B_2 10 mg, vitamin B6 2.4 mg, vitamin B_{12} 12 µg, niacin 18mg, pantothenic acid 12 mg, Mn 90 mg, Zn 72 mg, Fe 60 mg, Cu 10 mg, Iodine 1.2 mg

diets were prepared (Table 1) as per Bureau of Indian Standards (BIS, 1992). Cumulative body weight and cumulative feed consumption were recorded weekly. Blood samples were collected at the end of the experiment from wing vein of birds in sterile tube and serum was separated using centrifuge for estimation of uric acid (mg/dl), creatinine (mg/dl), total protein (g/dl), albumin (g/dl), globulin (mg/L), alanine aminotransferase (ALT) (IU/L), aspartate aminotransferase (AST) (IU/L), triglycerides (mg/dl), total cholesterol (mg/dl) and high density lipoprotein (HDL). At the end of experiment, three birds from each replicate were selected randomly and slaughtered ethically by mechanical stunning followed by exsanguinities to study the dressing percentage, breast percentage, drumstick percentage and abdomen fat percentage. Data were analysed using completely randomized design with one way analysis of variance as per the procedures of Snedecor and Cochran (1989) using statistical analysis system (IBM SPSS Version 20.0 for windows).

RESULTS AND DISCUSSION

Cumulative body weight at 1st, 3rd, 5thand 6th week of age was different (P<0.05) among three groups (Table 2). During first week of age, emulsifier included treatment groups (T_2 and T_3) had shown significantly higher body weight (188.14 g and 181.44 g) as compared to body weight of 172.78 g in birds fed basal diet (T_1). There was no significant difference in body weight of chicks among three groups during 2nd of week of age. At 6th week of age highest body weight was recorded in T_2 group (2622 g), followed by T_3 (2558 g) and T_1 (2502 g) group, which agreed favourably with results of Zollistsch *et al.* (1997) who reported better body weight in birds fed soyabean oil added with emulsifier as compared to blend of vegetable oil and animal fat.

Cumulative feed intake was similar (Table 2) among the treatment groups but numerically lowered feed intake was noticed in T_3 group at 6th week of age, whereas cumulative feed conversion ratio was different (P<0.05) among the treatment groups.

Table 2. Effect of supplementation of emulsifier on production performance

Age(weeks)	Cumulative body weight (g)			Cumulative feed intake (g)			Cumulative FCR		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
Hatch weight	48.96± 0.9	48.3± 1.4	47.26± 0.4						
1	172.78^{a}± 2.3	188.14^{b} ±0.5	181.44^{c}± 0.6	138.20± 2.9	146.80± 2.7	145.60± 3.1	1.12± 0.01	1.059± 0.02	1.09± 0.02
2	447.14± 6.8	457.24± 2.3	449.96± 0.9	486.80^{b}± 5.3	476.20^{ab}± 4.5	468.80^{a}± 3.2	1.22^{b}± 0.01	1.16^{a}± 0.01	1.16^{a}± 0.01
3	765^{a}± 16.5	784^{ab}± 13.8	833.40^{b}± 28.2	1019.38± 6.9	992.54± 18.3	1027.10± 27.9	1.40^{b}± 0.01	1.30^{ab}± 0.02	1.30^{a}± 0.02
4	1270± 17.5	1277± 7.8	1276.20± 15.7	1880.78^{b}± 19.7	1813.78^{ab}± 33.7	1768.70^{a}± 20.2	1.54^{b}± 0.01	1.47^{ab}± 0.03	1.43^{a}± 0.01
5	1772^{a}± 27.7	1927^{b}± 34.8	1832^{a}± 28.8	2852.98^{a}± 43.5	3056.78^{b}± 62.9	2807.30^{a}± 39.7	1.65^{b}± 0.02	1.63^{ab}± 0.03	1.57^{a}± 0.02
6	2502^{a}± 28.9	2622^{b}± 20.5	2558^{ab}± 24.3	4574.98± 107.7	4638.78± 45.0	4422.30± 36.3	1.87^{b}± 0.02	1.80^{ab}± 0.02	1.76^{a}± 0.01

Mean with different superscript in a row differ significantly (P<0.05) between treatments

Improved feed conversion ratio may be due to effect of fat emulsifier which improved fat digestibility. Exogenous emulsifiers in broiler chicks diets have been reported to improve digestibility, body weight, FCR, weight gain and abdominal fat (Roy *et al.,* 2010) and inlcusion of soya bean oil with emulsifier imroved FCR in broiler diet (Neto *et al.,* 2011).

Dressing percentage was comparable between T_3 (65.47%) and T_2 (65.55%), which was lower (P<0.05) than occurred in T_1 (69.44%) group (Table 3). Abdominal fat percentage, breast meat yield and drumstick percent were similar among three groups. Similarly, Aguilar *et al.* (2013) reported similar carcass traits, abdominal fat and breast weight and yield when exogenous emulsifier fed with palm oil in broilers. Roy *et al.* (2010) also reported that exogenous emulsifier supplementation did not affect the carcass traits.

Serum concentrations of uric acid (mg/dl), creatinine (mg/dl), total Protein (g/dl), albumin (g/dl), globulin (mg/dl), ALT (IU/L), AST (IU/L), triglycerides (mg/dl), total cholesterol (mg/dl) and HDL cholesterol (mg/dl) and glucose (mg/dl) were similar in three groups (Table 4). The results of this study agree favourably with Neto *et al.* (2011), who reported that total cholesterol, HDL or triglycerides concentrations were not affected by dietary fat source and emulsifier addition. Response in serum biochemical parameters may be related to the type of fat source whether

Table 3. Effect of supplementation of emulsifier with crude soyabean oil on carcass studies

Parameters	Treatment 1	Treatment 2	Treatment 3
Dressing %	69.44^{b}±0.34	65.55^{a}±0.1	65.47^{a}±1.10
Breast %	25.28±1.39	23.04±0.85	21.75±0.45
Drum stick %	0.55±0.11	0.76±0.32	0.90±0.18
Abdomen fat %	9.61±0.22	9.42±0.42	8.98±0.02

Mean with different superscript in a row differ significantly (P<0.05)

Table 4. Effect of supplementation of emulsifier with crude soyabean oil on serum biochemical parameters

Parameters	Treatment 1	Treatment 2	Treatment 3
Uric acid, mg/dL	7.20±0.74	6.74±0.83	6.06±0.54
Creatinine, mg/dL	0.72±0.04	1.28±0.52	0.73±0.09
Total protein, g/dL	5.61±0.35	4.98±0.34	5.11±0.32
Albumin, g/dL	1.71±0.01	1.57±0.08	1.68±0.07
Globulin mg/L	3.90±0.34	3.41±0.29	3.43±0.26
ALT, IU/L	14.0±6.55	21.86±8.13	5.63[a]±1.66
AST, IU/L	338.89±59.69	281.33±16.94	351.50±29.91
Triglycerides, mg/dL	54.29±8.10	68.13±9.35	45.88±7.08
Total cholesterol, mg/dL	156.22±10.96	146.10±32.24	138.25±11.13
HDL-cholesterol mg/dL	53.45±3.81	44.83±9.07	48.59±4.70

vegetable oil or animal source and their inclusion level and multiple potential mechanisms were involved in the regulation of serum cholesterol (Bontempo *et al.,* 2018).

CONCLUSION

Results of this study concluded that the inclusion of emulsifier at the rate of 250 g/ T of feed containing crude soya with 80 kcal reduced metabolic energy improved body weight and feed conversion ratio in broilers at market age.

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Received on 13-02-2020 and accepted on 30-06-2020

Indian J. Anim. Nutr. 2020. 37 (1): 78-81
doi: 10.5958/2231-6744.2020.00014.6
Indian Journal of Animal Nutrition

Effect of Supplementation of Geloi (*Tinospora Cordifolia*) Stem Powder and Ascorbic Acid on Economics of Broiler Production in Arid Zone of Rajasthan

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ABSTRACT

A 42 day feeding trial was carried out to investigate the effect of dietary addition of graded levels of *Tinospora cordifolia* stem powder with or without ascorbic acid on economics of broiler production using 360 one-day-old broiler chicks in 5×2 factorial experiment within a completely randomized design and divided into ten (10) dietary treatments groups (T_1-T_{10}) in triplicate of twelve chicks per replicate. Environmental stress was observed during feeding trial as ambient temperature and THI were recorded on higher side than the threshold level during the entire experimental period. The findings of comparative economics of broiler production indicated that addition of Geloi at graded levels and ascorbic acid alone or in combinations reduced the overall cost of feed per kg gain as compared to control but maximum reduction in overall cost of feed per kg gain was obtained in T_7 treatment group containing 0.25% of Geloi supplemented with ascorbic acid *i.e.* 11.03% reduction.

Key words: Ascorbic acid, Broiler, Economics, *Tinospora cordifolia*

INTRODUCTION

Feed is a major component, affecting net return from the poultry industry, as 80% of the total expenditure in terms of cash is spent on feed purchase (Khan *et al.,* 2010). Recent trend in broiler production is to provide feed containing the feed additives to improve efficiency and get maximum returns in shortest possible time. Various types of feed additives such as antibiotics, enzymes, hormones, prebiotics, probiotics, herbal products *etc.*, are being used as growth stimulants in poultry production.*Tinospora cordifolia* (Geloi) is a herbal plant and has promising properties as plant growth promoter (Raina *et al.,* 2013), with potential benefits in poultry. *T.cordifolia* contains various phenolics, alkaloids, steroids, glycosides, diterpenoid lactones, polysaccharides and aliphatic compounds(Sharma *et al.,* 2013).Vitamin-C is a white to yellow-tinged crystalline powder. Under normal conditions, poultry can synthesize vitamin C within their body but endogenous synthesis may not be enough to provide the full need of poultry at all times, especially the need of this vitamin may increase during heat stress (Lin *et al.,* 2006). The addition of ascorbic acid to the diet of bird improves the immune response during heat stress (Zahraa, 2008).Therefore, the present investigation was planned to evaluate the comparative economy of supplementation of graded levels *Tinospora cordifolia* with or without ascorbic acid in poultry birds in arid zone of Rajasthan (India).

MATERIALS AND METHODS

A 42-days duration feeding trial was carried out at the poultry farm of College of Veterinary and Animal Science (CVAS), Bikaner, Rajasthan. Three hundred sixty (360) experimental day-old-broiler chicks were equally and randomly divided into ten (10) dietary treatments groups (T_1-T_{10}) and each dietary group was replicated to three (3) sub-groups (R_1-R_3) to make sure uniformly in various treatment groups.*Tinospora cordifolia* (Geloi) stem powder at graded levels and ascorbic acid were supplemented in basal broiler starter

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and broiler finisher ration either alone or in combinations. The T_1 *i.e.* control group was fed on basal diet while T_2, T_3, T_4 and T_5 treatment groups were supplemented with 0.25%, 0.50%, 0.75%, and 1.0% of *Tinospora cordifolia* (Geloi) stem powder in the basal broiler starter and finisher ration, respectively. The T_6 group was supplemented with Ascorbic acid @ 0.025% in the basal broiler starter and finisher ration. The T_7, T_8, T_9 and T_{10} treatment group were supplemented with 0.25%, 0.50%, 0.75% and 1.0% of *Tinospora cordifolia* (Geloi) stem powder in combination with ascorbic acid at 0.025% in the basal broiler starter and finisher ration, respectively. Good quality of *Tinospora cordifolia* (Geloi) stem was procured from reputed firm of Bikaner (Rajasthan). Thereafter, it was identified and authenticated by the Department of Botany, Government Dungar College, Bikaner (Rajasthan). The commercially available ascorbic acid (99.99% pure) was used. The broiler starter and finisher feed contained 21.37% and 20.32% crude protein (CP), respectively. Broilers were maintained under standard managemental practices regarding brooding, watering, feeding and disease control throughout the research period. Weekly growth of chicks and daily feed consumption in each group were recorded up to 42 days. Feed conversion ratio was calculated as the ratio between unit feed consumed to unit body weight gain. In the present study, the feed cost of all ten treatment groups were estimated based on feed cost of starter feed, finisher feed, Geloi and ascorbic acid. The total feed cost (in ₹) per kg weight gain in broiler chicks for various treatment groups was calculated and the reduction in feed cost per kg weight gain in terms of percentage over control was calculated. The data obtained in the research trial were analysed statistically for main effect of *Tinospora cordifolia* (Geloi) or ascorbic acid alone as well as interaction (Geloi × Ascorbic acid) in factorial design (5×2) as per Snedecor and Cochran (2004) and significance of mean differences was tested by Duncan's New Multiple Range Test (DNMRT) as modified by Kramer (1956).

RESULTS AND DISCUSSION

The mean values of temperature (ºC), relative humidity (%) and temperature humidity index (THI) recorded during different weeks have been presented in Table 1. The result of growth performance of roilers observed in various treatment groups have been presented in Table 2 as well as in Figures 1 and 2. No mortality was observed during experimental period in any groups. Overall feed cost (₹) per unit weight gain and percentage reduction in feed cost per unit weight

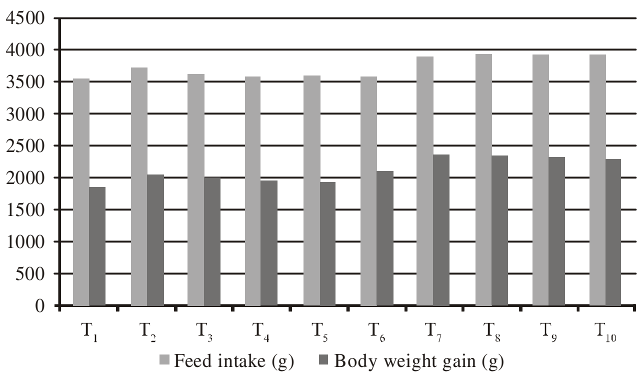

Fig. 1. Effect of Geloi and Ascorbic acid on feed intake and body weight gain of broiler chicks

Table 1. Mean temperature (ºC), relative humidity (%) and THI observed during different weeks

Period (weeks)	Mean Temperature (ºC)	Mean Relative humidity (%)	Mean THI
I	33.08	49.53	82.06
II	32.79	44.19	80.70
III	32.10	51.95	81.23
IV	29.99	61.95	80.01
V	29.05	43.90	76.01
VI	29.05	38.76	75.26
Mean	31.00	48.38	79.21

Table 2. Effect of Geloi and ascorbic acid on performance of broilers in various treatment groups

Treatment groups	Feed intake (g)	Body weight gain (g)	Average daily gain (g)	Feed conversion ratio
T_1	3566.03[a]	1861.64[a]	44.32[a]	1.96[e]
T_2	3744.22[c]	2068.03[d]	49.24[d]	1.81[c]
T_3	3656.81[b]	2004.22[c]	47.72[c]	1.82[cd]
T_4	3598.03[ab]	1954.64[b]	46.54[b]	1.84[d]
T_5	3593.11[ab]	1939.89[b]	46.19[b]	1.85[de]
T_6	3585.28[a]	2102.00[e]	50.05[e]	1.71[b]
T_7	3906.19[d]	2372.67[h]	56.49[h]	1.65[a]
T_8	3951.19[f]	2352.28[gh]	56.01[gh]	1.68[b]
T_9	3950.42[ef]	2338.72[g]	55.68[g]	1.69[b]
T_{10}	3931.42[ef]	2299.81[f]	54.76[f]	1.71[b]
SEM	6.2058	7.6910	0.1831	0.0027

Means bearing different superscripts (a, b, c, d) in a row differ significantly (P<0.01)

gain has been presented in Table 3. The overall feed cost per kg gain was calculated to be ₹ 55.54, 49.72, 50.44, 51.24, 51.89, 50.87, 49.41, 50.72, 51.31 and 52.23 in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} treatment groups, respectively. The per cent reduction in feed cost per kg gain was observed to be 10.48, 9.17, 7.74, 6.56, 8.36, 11.03, 8.67, 7.62, 5.95 in T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} treatment groups over control, respectively. The average temperature (31ºC) during the study period was higher than the recommended normothermia zone *i.e.* 22-28 ºC (Donkoh, 1989) or 18-24 ºC (Holik, 2009) established for poultry in the tropical regions, which indicated that birds were in chronic heat stress. The calculated THI for different weeks ranged from 75.26 to 82.06; a value above the THI threshold of 70, established for poultry (Bouraoui *et al.,* 2002 and Karaman*et al.,* 2007). The results obtained in the study on inclusion of Geloi are in line with the findings of earlier report (Kulkarni *et al.,* 2011 and Khobragade, 2003), who observed no mortality in Geloi supplemented group. No mortality was observed in the ascorbic acid groups are also in agreement (Ali *et al.,* 2010) who reported no mortality in ascorbic acid supplemented group. Observation of no mortality whilst Geloi (at graded levels) was fed in combination with ascorbic acid are in agreement with Biswas *et al,*(2012) who reported no mortality in birds fed herb in combination with ascorbic acid. Optimum performance in treatment groups may be explained on the basis of antioxidant property of Geloi and ascorbic acid. Better output in the form of weight gain with minimum input is always economical as well as advantageous to get maximum economic return. The findings of the present study indicated that addition of graded levels Geloi either alone or in combination with ascorbic acid reduced the overall cost of feed per kg gain as compared to control, maximum reduction in overall cost of feed per kg gain was obtained in T_7 (Basal feed + 0.25% Geloi + 0.025% ascorbic acid) *i.e.* 11.03% reduction.

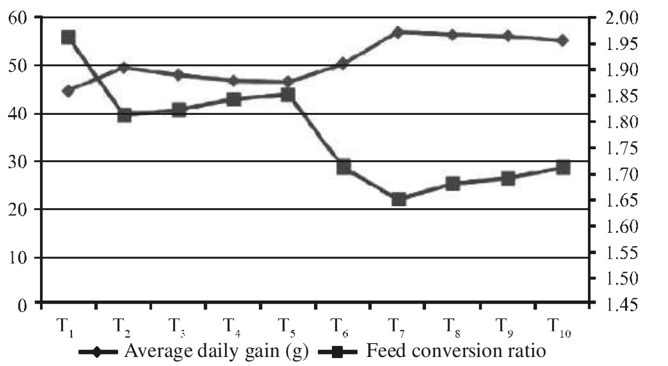

Fig. 2: Effect of Geloi and Ascorbic acid on average daily gain and feed conversion ratio of broiler chicks

Table 3. Percentage reduction in feed cost per unit weight gain in various treatment groups

Treatment groups	Total feed cost (₹)	Total gain (Kg)	Overall cost/kg gain in ₹	% Overall reduction in feed cost/kg gain
T_1	103.39	1.86	55.54	
T_2	102.82	2.07	49.72	10.48
T_3	101.10	2.00	50.44	9.17
T_4	100.15	1.95	51.24	7.74
T_5	100.66	1.94	51.89	6.56
T_6	106.94	2.10	50.87	8.39
T_7	117.24	2.37	49.41	11.03
T_8	119.31	2.35	50.72	8.67
T_9	119.99	2.34	51.31	7.62
T_{10}	120.13	2.30	52.23	5.95

CONCLUSIONS

Addition of Tinospora *cordifolia* (Geloi) stem powder either alone or in combination with ascorbic acid in broiler ration reduced the cost of feed per kg gain, the best response was obtained when basal diet was supplemented with 0.25% Geloi and 0.025% ascorbic acid. Thus, it would be beneficial to incorporate Geloi at 0.25% along with ascorbic acid at 0.025% in the diets of broilers reared under arid climatic condition.

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Received on 17-06-2020 and accepted on 02-07-2020

Indian J. Anim. Nutr. 2020. 37 (1): 82-86
doi: 10.5958/2231-6744.2020.00015.8

Indian Journal of
Animal Nutrition

SHORT COMMUNICATION

Utilization of Plant Based Attractants in *Labeo rohita* Advanced Fingerlings Diet

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ABSTRACT

Feed attractants are the substances which are added in trace amount in a diet to enhance the overall palatability and dry matter intake of feed. A 30 day experiment was conducted to study the efficacy of plant based attractants in the feed of *Labeo rohita* advanced fingerlings (average weight 17.0±0.05 g) and 10 fingerlings were stocked in duplicate for each dietary treatment. The initial body weight of the fish of each group was non-significant (P>0.05). The diet was formulated with rice bran, mustard oil cake, fish meal, vitamin and mineral mixture, binder along with 1% of different feed attractants and different feeds were named as F_1 (Control), F_2 (Ekangi, *Kaempferia galanga*), F_3 (Kharboj, *Cucumis melo*) and F_4 (Marigold, *Tagetes patula*). The net weight gain were 2.53±0.23, 4.16±0.15, 5.50±0.4 and 2.41±0.35 (g/30 days) respectively in F_1 to F_4. The water quality such as dissolved oxygen, pH and temperature ranged from 5.5-6.5 mg/l, 7.2-7.4 and 30.50-32.0°C respectively during the experimental period in treatment groups. The growth study with different attractants revealed that the final weight, net weight gain, specific growth rate, daily growth co-efficient was significantly (P<0.05) higher in F_3 having 1% kharboj. However, Feed conversion ratio was (P>0.05) lower in F_3 having kharboj as feed attractants. Thus, from the present experiment it may be concluded that F_3 having 1% kharboj performed better in terms of growth performance and feed intake in *Labeo rohita* advanced fingerlings *vis-a-vis* other feed treatments.

Key words: Ekangi, Growth, kharboj, *Labeo rohita*, Marigold

Among all animals, fish are one of the most sensitive to tastes. Feed attractants are added in trace amounts in the fish diets to enhance feed intake and to fulfill the nutrient requirement (Harpaz, 1997). The primary mode of feed detection by fish is through olfaction or sight Paul, 1996. Dietary feeding stimulants are essential to enhance feed intake by fish. Feed attractants are applied either internally or externally in the formulated feed. This approach draws the animal towards the feed and helps to initiate feed consumption. Many types of small molecular weight compounds are being investigated as potential feed attractants for various fish species used in aquaculture. These compounds include organic acids, sugars, aldehydes, alcohols, amines, hydrocarbons, nucleotides, nucleosides, betaine and free amino acids (Kasumyan and Doving, 2003). Uses of various plant-based attractants have been tried in a preliminary study in Indian Major Carps as reported earlier by Venkateshwarlu *et al.* (2009). They reported that attractant activity of different herbs is species and age specific in case of Indian Major Carps. Oliveira and Cyrino (2004) reported that attractants can improve acceptability of artificial diets by fry and fingerlings, increasing intake of unpalatable feeds and improving growth rate, while reducing feeding time and feeding wastes. Lee and Mayer (1996) reported that supplementation of artificial diets with attractants can increase acceptability and consumption of low palatable diet which ultimately enhance the growth rate and productivity. The main objective of the present study was to evaluate efficacy of different plant attractants on rohu diet, so that the economically available local materials can be utilized as feed attractants in aquaculture.

Four different diets were formulated with rice bran, mustard oil cake, fish meal, vitamin and mineral mixture along with different plant based attractants (Table 1 and 2). The control diet was named as F_1 (control diet). Three experimental diets having 1% level

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Table 1. Herbs and their plants used for attraction activity

English name	Botanical name	Family	Parts used
Ekangi	*Kaempferia galangal*	Zingiberacaea	Rhizomes
Kharboj	*Cucumis melo*	-	Roots
Marigold	*Tagetes patula*	Asteraceae	Flower

of ekangi, kharboj and marigold were designated as F_2, F_3 and F_4, respectively. The above-mentioned attractants were collected from different places of West Midnapore, West Bengal. The ingredients were finely powdered and weighed separately. The dough obtained from thorough mixing of the ingredients with water and were fortified with vitamin mineral mixture where tapioca was used as binder substances, was extruded through 1.0 mm diameter in a feed pelletizer. The pellets were sun dried, crumbled and packed in air tight plastic container for future use.

The advanced fingerlings of rohu were collected from Carp Fish Hatchery, District West Medinipur, West Bengal and were acclimatized to laboratory condition for 7 days in stocking tank. Group of 10 fish of average body weight (17±0.05 g) were randomly distributed in glass aquaria (24" × 12" × 12") of 100 L capacity. An air stone (connected with aerator) was provided to maintain the optimum dissolved oxygen in each tank. Cleaning of the tank was done by replacing 10% of aquaria with freshwater at every 5 days interval. Water quality parameters like pH, temperature and dissolved oxygen were measured at regular interval. All the fish were fed with corresponding diet in two divided meals at 2% of their body weight at 10.0 A.M and 4.0 P.M. respectively.

Proximate composition of experimental diets and carcass composition was determined according to AOAC (1990). Water parameters were monitored following the methods of APHA (2005). Weighing and mortality rate of fish was recorded at fortnight interval. At the end of the experiment individual body weight of all fish per tank was weighed. Standard procedures and formulae of Castell and Tiews (1980) were used for the calculation of NWG, PER, FCR, percent survival rate and SGR. DGC were calculated as per Cowey (1992). Another parameter used to calculate the efficiency of the attractants was the

Table 2. Ingredients and proximate composition (% DM basis) of different feeds and attractants

Particulars	F_1	F_2	F_3	F_4
Rice bran	45	44	44	44
Mustard oil cake	44	44	44	44
Fish meal	8	8	8	8
Vit+Min mix	2	2	2	2
Binder (tapioca)	1	1	1	1
Ekangi	-	1	-	-
Kharboj	-	-	1	-
Marigold	-	-	-	1
Proximate Composition of Feed				
Dry Matter	91.43±0.05	90.01±0.46	90.95±0.06	90.75±0.44
Crude Protein	25.2±0.01	25.15±0.26	25.14±0.16	24.99±0.21
Crude Fat	5.49±0.02	5.41±0.01	5.36±0.06	5.26±0.16
Crude Fibre	10.68±0.07	10.55±0.07	10.49±0.12	10.51±0.11
Total Ash	11.57±0.06	11.40±0.11	11.44±0.08	11.38±0.13

Data presented as Mean±S.E.

Table 3 Growth performance of *Labeo rohita* advanced fingerlings fed with different attractants

Particulars	F_1	F_2	F_3	F_4
Initial Weight (g)	17.0±0.5	17.0±0.5	17.0±0.5	17.0±0.5
Final Weight (g)	19.53^a±0.23	21.16^b±0.15	22.50^c±0.40	19.41^a±0.35
NWG (g/30 d)	2.53^a±0.23	4.16^b±0.15	5.50^c±0.4	2.41^a±0.35
SGR (% BW gain/d)	0.46^a±0.04	0.73^b±0.02	0.93^c±0.06	0.44^a±0.06
DGC	2.82^a±0.26	4.62^b±0.16	6.12^c±0.45	2.68^a±0.39
FCR	3.84^b±0.08	3.40^a±0.15	2.97^a±0.03	4.65^c±0.15
PER	0.10^a±0.01	0.17^b±0.01	0.22^c±0.02	0.11^a±0.02

Data presented as Mean±S.E. ^{abc} values bearing different superscripts in a row differ significantly (P<0.05); NWG: net weight gain, SGR: Specific growth Rate, DGC: Daily growth coefficient, FCR: Feed conversion ratio, PER: Protein efficiency ratio

responding time and it was calculated by stop watch. Data were subjected to statistical analysis as per Snedecor and Cochran (1994) and the least significance difference (LSD) was used for comparison of the mean values.

Table 1 listed the selected herbs and their parts used for attraction activity. Diet formulation of the present experiment is presented in Table 2 which revealed that proximate composition was similar in all the feeds. Water quality parameters *viz,* temperature, pH and dissolved oxygen ranged from 30.50-32.0°C, 7.2-7.4 and 5.5-6.5 mg/l respectively during the experiment (Table 4). The water quality parameters were within the range for carp culture as reported by Banerjee (1967). Perusal of data (Table 3) revealed the growth performance of rohu advanced fingerlings fed with different plant based feed attractants. The initial weight of each group of fish was alike. The final weight, net weight gain (NWG), specific growth rate (SGR), protein efficiency ratio (PER) and daily growth coefficient (DGC) was significantly (P<0.05) higher in F_3 having 1% Kharboj. However, Feed conversion ratio (FCR) ratio was significantly (P>0.05) lower in F_3 having 1% Kharboj. The mortality of fish was nil during the experimental period of 30 days. The survival rate (%) did not differ significantly (P<0.05) among the feed treatments. Table 5 revealed the feeding attraction time toward different attractants of rohu advanced fingerlings. The data presented in Table 6 indicated the carcass composition of *Labeo rohita* fed with different plant based feed attractants. The table revealed that carcass crude protein, crude fat and total ash was non-significant among the groups.

Incorporation of plant instead of animal protein is now the need of current aquaculture practices. But at the same time plant protein in fish feed introduces an alien taste and flavor to the feed which would reduce the feed intake (Paul *et al.,* 2012). To overcome such problem introduction and application of feed attractants in fish feed may stimulate the feeding and acclimatize fish to less palatable protein source (Venkateshwarlu *et al.,* 2009). Addition of attractant in fish feed had positive effect on prawn (Harpaz, 1997) and rohu (Paul *et al.,* 2004). Earlier report of Paul *et al.* (2014) also

Table 4. Hydro-biological parameters of experimental tank

Particulars	Range
Dissolved oxygen	5.58-5.86 mg/l
pH	7.22-7.40
Temperature	30.48-31.22°C

Table 5 Feeding attraction activities of different attractants on Rohu advanced fingerlings

Attractants	Responding time (in second)
Ekangi	575.5±17.5^b
Kharboj	422.5±12.5^a
Mari gold dust	1230.5±29.5^c
Blank	1509±11.0^d

Data presented as Mean±S.E. ^{abc}values bearing different superscripts in a row differ significantly (P<0.05)

Table 6. Carcass proximate composition (% w/w basis) of advanced rohu fingerlings fed with different attractants

Particulars	F_1	F_2	F_3	F_4
Moisture	78.64±0.3	78.28±0.46	78.53±0.06	78.49±0.14
Crude Protein	11.14±0.17	11.12±0.09	11.46±0.12	11.10±0.02
Crude Fat	2.53±0.05	2.74±0.09	2.93±0.05	2.57±0.12
Total Ash	3.19±0.04	3.23±0.06	3.47±0.09	3.43±0.04

Data presented as Mean±S.E.

reported that 1% incorporation level of awbel (*Cuscuta reflexa*) increased the growth performance of *Cirrhinus mrigala*. Similarly, 1% level of ekangi improved the growth performance of pabda and feed having 1% level of tambul had shown better performance in terms of growth in *Catla catla* fingerlings (Paul *et al.,* 2012;2013). Two distinct criteria for food preference are commonly recognized *i.e.*, attractiveness which is measured by the behavioral response of an animal while edibility is measured by intake of food (Takeda and Takii, 1999). Shankar *et al.* (2008) reported that 0.25% incorporated betaine showed higher growth performance in rohu fingerlings. Paul and Giri (2015) reported from their study that supplementation of Kharboj (*Cucumis melo*) at 1% level can be incorporated as an effective plant attractant in the feed of rohu fingerlings which is in agreement with our study. The result of the present study revealed that the improved growth performance in rohu has been observed in F_3 having 1% Kharboj, the reason behind that the growth performance of young fish in terms of protein efficiency ratio and nutrients retention has been enhanced due to supplementation of stimulants/ attractants. Harpaz (1997) reported that addition of an attractant leads to an additional thirst in food searching activity which is ultimately accompanied by increased food consumption and the report is also in agreement with our study. However, the possible mechanism responsible could be the activation of olfactory nerves or nerve associated with taste or feeding behavior (Nakajima *et al.,* 1989).

The attractiveness of different attractants was measured based on the time the animal had spent in the respective tanks. According to Venkateshwarlu *et al.* (2009) 743 seconds was the responding time for kharboz and 1150 seconds for ekangi in rohu which was higher than the our results. Venkateshwarlu *et al.* (2009) also reported that catla had shown higher attraction toward ekangi whereas kharboj showed the highest activity on mrigal and in case of rohu, kakla exhibited the highest activity. In the present study Rohu had shown the better response in Kharboz rather than the other attractants. However, in case of marigold dust responding time was significantly (P>0.05) lower than the blank. The present experimental study provided with the evidence that the feed attractants are able to increase the feed intake. The study also revealed that the most feed intake by the rohu advanced fingerlings occurred in kharboj with the minimum responding time. However, marigold was not effective as much as kharboj and ekangi.

CONCLUSION

Three of the feed attractants investigated in this study proved effective in increasing the palatability of feed with low amount of feed wastage. Based on the present study it is concluded that use of kharboj at 1% level in the diet of *Labeo rohita* advanced fingerlings could lead to their improved growth performance. Future studies should focus on the development of effective carp feed attractants so that with non-conventional fish feed resource attractants will help to increase the feed intake.

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Received on 17-06-2020 and accepted on 27-06-2020

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INCAN 2019

"Nutritional Strategies for Improving Farm Profitability and Clean Animal Production"

Report of technical sessions

1. Price of milk is less in India as compared to other countries. So, dairy business is not so remunerative to farmers. Use of innovative techniques to increase milk yield at less cost can make dairy business more ruminative.
2. Application of fermentation metabolites in dairy ration can improve the milk yield by 10-15 % along with these it also enhances immunity and decreases stress level in animals.
3. Scarcity of good quality feed is one of the primary constraints in dairy farming in India. Therefore, effort has to be made to explore the new feed resources.
4. Fodder conservation and processing technologies should be promoted in order to ensure round the year feed supply.
5. Drug residues and contaminated feed, food and milk are major public health issues. Therefore. Feed safety and quality assurance at farm and plant level is very important to reduce the contaminants in milk.
6. Considering cost and scarcity of non-ruminant feed, more emphasis should be given on reduction of pre-harvest losses and augmenting nutrient utilization through dietary approaches.
7. The dietary levels of different nutrients and functional agents need to be established for value added (designer) meat and eggs.
8. The newer non-conventional feed resources need to be identified and evaluated for feeding of pigs and backward poultry birds.
9. There is need for extensive research to validate phytogenics to improve gut health, clean meat and egg production and to improve keeping quality of meat under cold-chain preservation.
10. Addition of dried Moringa oleifera leaf powder at 10% level replacement to soyabean meal will improve semen attributes, anti-stress potential and anti-oxidant status of Barbari bucks.
11. Top foliages and region specific agro-wastes are alternative for sustainable livestock production.
12. Conventional protein and energy sources can be effectively replaced with cotton seed meal, till cake, bajra, jowar, wheat bran and rice bran at certain level with some technological intervention in both broiler and layer diets.
13. Some unconventional feeds like rice DDGS, biscuit waste, solid state fermentation biomass and bovine clostrum could be used in the ration of livestock and poultry.
14. Production of hydroponic fodder under low cost management be an alternative to traditional fodder production.
15. Plant bioactive compounds have great potential to reduce methane production and improve animal performance.
16. Silk worm pupae oil (2-3%), solid state fermentation biomass (4%), sodium sulphate (0.06%) and Emblica officinalis promace (2%) could be used in ruminant diets to reduce methane production.
17. Nutrigenomics tools can be used for economic benefit and improvement of food quality and safety in dairy and poultry sectors.
18. Urea coated with calcium salts of fatty acids and hydroxyl propyl methyl cellulose would be efficiently used in ruminant diet than uncoated urea.
19. Supplementation of *Butyrivibrio fibrisolvens* 4a along with linoleic acid rich oils may increase proportion functional fatty acids in meat of goats.
20. Impact of silage feeding on the flavor and composition of milk in dairy animal needs to be assessed.
21. Considering the importance of different kind of additives in poultry and swine nutrition, the detailed genomic study and their association needs to be explored to know the interaction of nutrient and gene and their impact on production.
22. Extensive research should be required for proper validation of phytogenic additives and their application in livestock and poultry as an additive.
23. The application of antibiotic growth promoters in poultry and swine should be reduced to check the development of resistance and it should be used an antibiotic feed additive instead of AGPs.
24. Alternative feed resources like insect meal, algae and other phytogenic feed can be used in fish diets but there is need to look into risk of food safety.
25. Mixed leaf meal replacing DORB for low cost feed in fingerlings looks to be promising. Toxic effects of leaf meal should be studied further.
26. Homemade food for dog should be balanced especially for protein and phosphorous. Nutritional studies needed regarding its nutritional values and also its safety in relation to mycotoxin infection.
27. Replacement of buffalo meat by chicken in wild animal to increase supply of carotenoids and thus to improve immunity.

Non-Ruminants

Short communication

INDIAN JOURNAL OF ANIMAL NUTRITION
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March, 2020 **Vol. 37** **#1**

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Printed and published by Dr. Asit Das, Chief Editor, Indian Journal of Animal Nutrition, on behalf of Animal Nutrition Society of India at M.M. Printing Press, 202-L, Model Town, Karnal. M : 94160-72992