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RELATIONSHIP OF RESIDUAL FEED INTAKE WITH BLOOD METABOLITES AND HORMONES IN SAHIWAL FEMALE CALVES

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SUMMARY

The study was conducted to find out relationship of residual feed intake (feed efficiency parameter) with various blood metabolites in growing Sahiwal female calves. Healthy Sahiwal female calves (n=18) were selected and fed total mixed rations consisting of wheat straw, berseem (*Trifolium alexandrinum*) and concentrate mixture (mesh, BIS type-I) according to their body requirements. Net feed intake and body weights were recorded at regular intervals. Residual feed intake (RFI) values were calculated for individual calves and they were designated low RFI group with negative (n= 9; RFI= -0.14 kg/d) and high RFI group with positive (n=9; RFI= +0.14 kg/d) RFI values. Low RFI consumed less (P<0.05) dietary DM compared to high RFI group (2.56 vs. 3.02 kg/100 kg B. wt.), while gaining similar body weights (0.48 and 0.47 kg/d) indicating higher efficiency of feed utilization in the former group. Low RFI group showed better feed conversion ratio (20.29% lower), compared to high RFI group (5.52 and 6.64 kg DM consumed/kg gain). The values of blood glucose (56.71 and 59.14 mg/dl), total plasma protein (7.32 and 7.54 g/dl) and growth hormone (4.37 and 4.29 ng/ml) were similar in both the groups. Low RFI group possessed higher (P<0.05) values for creatinine (1.52 vs. 1.26 mg/dl) and IGF-1 (140.40 vs. 122.49 ng/ml). On the contrary, the levels of aspartate aminotransferase (118.74 vs. 97.51 IU/L) and BUN (22.03 vs. 18.14 mg/dl) were higher in high RFI group compared to low RFI group.

Key words : RFI, residual feed intake, blood biomarkers, feed efficiency

India possesses a huge wealth of livestock. There are 190.9, 108.07, 135.17, 65.06 and 10.29 million cattle, buffalo, goat, sheep and pigs, respectively, in India (DAHD & F, 2012), The productivity of these animals is quite low and scarcity of feeds and fodders is the main constraint. There is deficiency to the tune of 10, 37 and 35 per cent for dry fodder, concentrates and green fodders, respectively (ICAR, 2013). Feed cost alone contributes about 60-70 per cent of total cost of livestock production. Therefore, to have more profitability selection strategies should focus on both increasing outputs and decreasing inputs like feed cost. To improve feed efficiency trait which is independent of growth rate and body weight should be used. Genetic variation in maintenance energy requirements of cattle is moderately heritable which provides an opportunity to select more efficient cattle (Carstens *et al.,* 1989). Koch *et al.* (1963) defined residual feed intake (RFI) as the difference between actual feed intake and the feed an animal is expected to consume based on its body size and growth rate. An efficient animal would have a negative RFI and vice-versa. Residual feed intake is moderately heritable and phenotypicaly independent of growth rate and body weight in growing cattle (Herd and Bishop, 2000; Arthur *et al.,* 2001a, 2001c), high genetic correlation between the trait measured in the young animal and that measured in the adult, while for other feed efficiency traits, such as feed conversion ratio, this correlation is low (Archer *et al*., 2002). This indicates that RFI probably reflects more variation in basic metabolic processes (maintenance requirements) than variation due to differences in level of production or growth rate. Systemic concentrations of key metabolites and hormones associated with feed intake, growth, fat accumulation, nutrient repartitioning, and nutrient utilization have been examined with a view to identify potential physiological markers of feed efficiency along with improving our understanding of the metabolic basis of the trait in cattle (Wood *et al*., 2004; Nkrumah *et al*., 2007b).

MATERIALS AND METHODS

Experimental Farm, Animals and their Feeding

The Livestock Research Centre at NDRI, Karnal is situated at an altitude of 250 m above mean sea level, latitude and longitude position being 29°42" N and 79°54" E, respectively. The maximum ambient temperature in summer goes up to 45°C and minimum temperature in winter goes down to about 4°C with a diurnal variation to the order of 15-20°C. The average annual rainfall is 696 mm, most of which is received from early July to mid September. Growing female Sahiwal calves (n=18; BW=77.97±2.82) of average age 9 months were selected from LRC farm and adaptation period of 22 days was given in individual pens. Proper deworming and vaccination was done to prevent occurrence of disease. All the animals were fed *ad libitum* rations in the form of total mixed ration (TMR) to meet their nutrient requirements (ICAR, 2013). Concentrate mixture, green fodder (berseem) and dry roughage (wheat straw) were fed in the ratio of 40 : 35 : 25 (on DM basis) to all the animals. Chemical composition of feed and fodders has been given in Table 1.

Feed Intake and Growth Data

Feeds offered, residue and hence net DM intake of all animals were recorded daily. Body weights were recorded at fortnight intervals in the morning hours before offering feed or water. Average daily gain (ADG) was calculated and accordingly new feed was formulated. Average DMI for the 98 days feeding period was regressed on mid-test metabolic BW ($BW^{0.75}$) and ADG (Archer *et al*., 1997). Residual feed intake was computed for each animal and was assumed to represent the residuals from a multiple regression model regressing DMI on ADG and mid-test metabolic BW ($BW^{0.75}$). The base model used was :

$$Y_j = \beta_0 + \beta_1 MBW_j + \beta_2 ADGj + e_j$$

Where, Y_j is the DMI of the j^{th} animal, β_0 is the regression intercept, β_1 is the regression coefficient on mid test metabolic BW, β_2 is the regression coefficient on ADG, e_j is the uncontrolled error of the j^{th} animal (RFI) (Fig. 1).

Blood Collection and Analysis

Computation of RFI from feeding trials is time, labour and money consuming process. So, to find out potential biomarkers of RFI, various blood parameters were examined. During experimental period, blood samples were collected twice once at the beginning and other towards the end of trial, from all the animals by jugular puncture in heparinised vaccutainer, mixed well

TABLE 1
Chemical composition of feeds (% DM basis)

Feed/fodder	DM	CP	EE	Total ash	NDF	ADF	Cellulose	Lignin
Wheat straw	90.43	2.71	0.92	11.18	77.80	51.29	41.49	7.26
Berseem	13.85	17.82	1.99	10.37	44.00	27.42	18.55	6.24
Conc. mixture	90.11	21.55	4.43	8.65	26.92	12.36	7.34	3.27
TMR	29.01	14.82	3.50	10.63	53.82	36.69	26.20	6.49

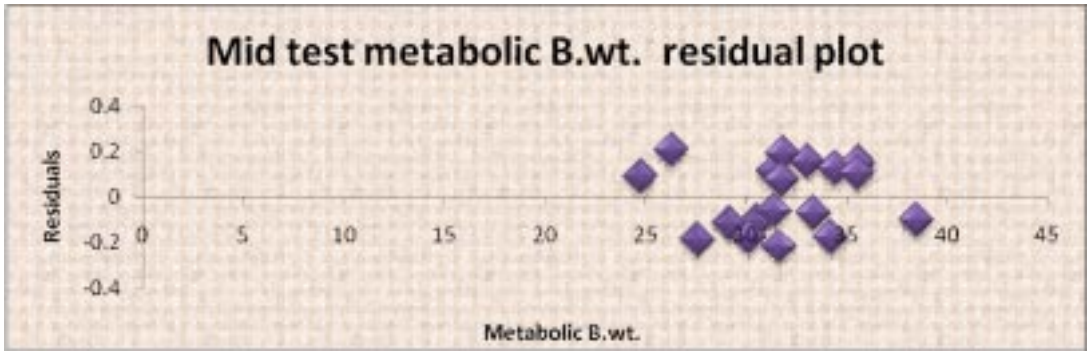

Fig. 1. Partitioning of animals in low and high RFI groups.

by rotating tubes between palms to ensure proper mixing of blood and anticoagulant and brought to the laboratory after placing in ice box. Then, the samples were centrifuged at 3000 rpm for 15 min to separate the plasma. The plasma samples were stored at -20^{0}C for estimation of aspartate aminotransferase (AST), insulin like growth factor-I (IGF-I), growth hormone (GH), glucose, blood urea nitrogen (BUN), total protein and creatinine. Plasma glucose, total protein, BUN, creatinine and AST were estimated using kit of Span Diagnostics Ltd., India. IGF-I was determined in plasma of calves by "Bovine IGF-I ELISA Test kit" (Catalog No. SEA050Bo) from Cloud-Clone Corp., Richmond Avenue Suite, Houston, USA. GH was determined in plasma of calves by "Bovine GH ELISA Test Kit" (Catalog No. ERK-B1008) from Endocrine Technologies, 35325 Fircrest Street, Newark, USA.

Feed, Urine, Faeces Sample Analysis

The samples of feeds, residues, faeces and urine were analysed for proximate principles (OM, CP, total ash and EE) and cell wall constituents (NDF, ADF, cellulose and lignin) as per AOAC (2005). The data were statistically analysed using SPSS statistics version 17.0.

RESULTS AND DISCUSSION

Across 18 animals, RFI value varied from -0.22 to +0.21 kg/d. The mean values of RFI in low and high RFI groups were found to be -0.14 and +0.14 kg/d, respectively (Table 2). The mean values of FCR obtained for low and high RFI groups were 5.52±0.11 and 6.64±0.17, respectively. FCR was significantly (P<0.05) lower in low RFI group. Low RFI calves showed 20.29 per cent lower FCR compared to high RFI Sahiwal calves. Significant (P<0.01) correlation was observed between RFI and FCR values (r= +0.77).

The DM consumption, expressed in kg/d and kg/100 kg BW, was 15.24 and 17.97 per cent higher in high RFI group than low RFI group animals. Significant (P<0.01) correlation was observed between RFI values and DM intake (kg/d and kg/100 kg B. wt.).

RFI and Blood Metabolites

The concentration of blood glucose varied from 28.80 to 71.50 mg/dl (CV = 20.90%) (Table 3). Average blood glucose levels in low and high RFI groups were found to be 56.71 and 59.14 mg/dl, respectively. These values were similar in both the groups. Kolath *et al.* (2006) observed that high RFI steers had greater concentration of glucose in their blood.

A range of 6.04-8.59 g/dl (CV = 8.69) was observed for total plasma protein in two groups of RFI. Average total protein levels in low and high RFI groups were found to be 7.32 and 7.54 (g/dl), respectively. These values were similar in two groups. Significant (P< 0.01) correlation (r=0.66) was observed between RFI value and total plasma protein concentration.

The levels of BUN showed a minimum value of 17.03 mg/dl and maximum value of 23.69 mg/dl (CV=10.91%) among all experimental animals. The mean values of blood urea nitrogen (BUN) differed significantly (P<0.05) in two groups, mean values being 18.14 and 22.03 mg/dl in low and high RFI groups, respectively. Significant (P<0.01) correlation (r= 0.95) was observed between RFI value and BUN concentration. Richardson

TABLE 2
List of animals with low and high RFI values

S. No.	Animal No.	Low RFI	Animal No.	High RFI
1.	2269	-0.07	2257	0.13
2.	2266	-0.11	2263	0.16
3.	2251	-0.06	2253	0.09
4.	2273	-0.18	2248	0.21
5.	2250	-0.18	2258	0.11
6.	2252	-0.10	2247	0.15
7.	2272	-0.19	2265	0.19
8.	2274	-0.12	2245	0.10
9.	2260	-0.22	2271	0.08
		-0.14±0.019		+0.14±0.015

TABLE 3
Levels of various blood parameters in low and high RFI groups of female Sahiwal calves with CV and correlation coefficient values

Parameter	Low RFI	High RFI	CV (%)	r
		Blood metabolites		
Glucose (mg/dl)	56.71±3.15	59.14±2.44	20.90	0.03
Total protein (g/dl)	7.32±0.27	7.54±0.14	8.69	0.66
BUN (mg/dl)	18.14^{a}±0.28	22.03^{b}±0.33	10.91	0.95
Creatinine (mg/dl)	1.52^{a}±0.08	1.26^{b}±0.05	17.81	-0.51
		Plasma enzyme		
AST (IU/L)	97.51^{a}±6.23	118.74^{b}±6.70	23.41	0.44
		Plasma hormones		
IGF-1 (ng/ml	140.46^{a}±46.38	122.49^{b}±47.17	12.52	-0.57
GH (ng/ml)	4.37±0.07	4.29±0.11	6.47	-0.07

Values bearing different superscripts in a row differ significantly (P<0.05).

et al. (1996, 2004) found greater blood concentrations of urea in less efficient genotypes. This may be credited to a greater protein intake in high-RFI animals, a greater rate of body protein degradation, or deviation in the supply of AA due in part to variation in the efficiency of microbial protein production in the rumen (Lush *et al*., 1991; Kahn *et al*., 2000). Energy costs of protein turnover accounted for 15-20 per cent of basal metabolic rate across a range of species (Waterlow, 1988). There was genetic variation in the rate of protein degradation in cattle (Oddy *et al*., 1998). There was difference in the rate of protein breakdown in cattle divergently selected for RFI (McDonagh *et al*., 2001).

The values for plasma creatinine ranged from 1.0 to 2.0 mg/dl showing a CV value of 17.79 per cent. The mean values of creatinine differed significantly (P<0.05) in two groups, mean values being 1.52 and 1.26 mg/dl in low and high RFI groups, respectively. Significant (P<0.05) negative correlation (r= -0.51) was observed between RFI value and creatinine concentration. Creatinine is proposed as a marker for muscle mass in a steady-state (Rennie and Milward, 1983; Virgili *et al*., 1994). It was also reported to be significantly associated with RFI in cattle (Fitzsimons *et al*., 2013), muscle mass and negatively associated with fat depth in sheep (Clarke *et al*., 1996) and was found to be negatively correlated with RFI in cattle (Herd and Arthur, 2009).

The variability in case of AST concentration was from 65.88 to 142.90 IU/L and reflected a large variation (CV = 23.41%). The mean values of AST activity were found to be 97.51 and 118.74 (IU/L) in low and high RFI groups, respectively, the values being lower (P<0.05) in low RFI group compared to high RFI group. RFI was positively correlated with AST (r=0.44). Concentration of AST showed a positive phenotypic correlation with steer RFI over the whole experiment though correlation did follow the stress of transport, being negative after transport and returned back to positive (Richardson *et al*., 2004).

RFI and Blood Plasma Hormones

The concentration of IGF-1 (ng/ml) varied from 92.08 to 157.09 with a CV value of 12.52 per cent. The variation in GH was recorded to be from 3.64 to 4.83 ng/ml (CV = 6.47%).The mean values of IGF-1 and GH were found to be 140.46 and 122.49 (ng/ml) and 4.37 and 4.29 (ng/ml) in low and high RFI groups, respectively. Statistically, average values of IGF-1 were found to be higher (P<0.05) in low RFI group. However, values of GH were similar in two groups. Significant (P<0.05) negative correlation was observed between RFI value and IGF-1 concentration. Results in beef cattle showed that circulating levels of IGF-1 were genetically associated with growth and finishing performance of beef cattle and might prove useful as a genetic predictor of carcass and feed efficiency traits (Johnston *et al*., 2001; 2002).

CONCLUSION

RFI is a trait related to feed efficiency in animals

and independent of growth and body weight. It has significant correlation with FCR and blood metabolites like BUN and creatinine, plasma enzymes like ALT and hormones like IGF-1. These parameters can be used as physiological biomarkers for RFI. RFI can be used as an alternative tool to meet out feed and fodder scarcity in country by selecting more efficient animals.

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