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Effect of Supplementing Graded Levels of Pulverized Jerusalem Artichoke Tuber on the Growth Performance of Pre-Weaned Calves

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ABSTRACT

The study was conducted to assess the effect of supplementation of graded levels of pulverized Jerusalem artichoke tuber on the growth performance of pre-weaned calves. Twenty-four Vrindavani calves (15 days, 23.64±0.57 kg BW) were distributed into four equal groups. The calves were fed graded levels of pulverized Jerusalem artichoke tuber (0, 1, 2 and 3 per cent of dry matter intake) mixed in milk in control, JAP-1, JAP-2 and JAP-3, respectively for a period of nine weeks. The weekly body weight, net body weight gain and average daily weight gain at the end of trial were comparable between the treatment groups. The weekly body measurements *viz* heart girth, abdomen girth, body length, wither height, chest width and hip width did not differ significantly (P>0.05) between the groups. The overall milk DMI, average concentrate intake (g/d, g/kg LW, g/kg $W^{0.75}$), average roughage intake (g/d, g/kg LW, g/kg $W^{0.75}$) and average total dry matter intake (g/d, g/kg LW, g/kg $W^{0.75}$) did not differ between the groups. The feed conversion efficiency was also similar between the groups. It is concluded that pulverized Jerusalem artichoke tuber supplementation up to 3 per cent of dry matter was not sufficient to bring about a positive impact on the growth performance of pre weaned calves.

HIGHLIGHTS

- Dietary supplementation of Jerusalem artichoke as a prebiotic has no influence on the growth and feed conversion of pre-weaned calves.
- There was no adverse effect on overall milk DMI, average concentrate intake, average roughage intake and average total dry matter intake.

Keywords: Jerusalem artichoke tuber, Growth performance, Prebiotic, Body conformation

Intensive animal production systems has led to the irrational usage of antibiotics not only to control diseases (Constable, 2003) but also to improve the growth and feed efficiency of animals (Huang *et al.*, 2010). This has paved way to the emergence of antibiotic-resistant bacteria (Manishimwe *et al*., 2017) as well as antibiotic residues in animal products, both of which are hazardous to human health. European Union in 2005 (EPC 2005) banned the usage of antibiotic as growth promoter and subsequent restrictions were imposed in The United States of America and other countries (Zaidi *et al*., 2015; Editors, 2017). These restrictions on antibiotic usage have resulted in the reduction in feed efficiency and performance of animals; an increase in morbidity and mortality rates and subsequent hike in production costs (Alsudani, 2018). Concentrated efforts from both academic researchers and the pharmaceutical industry were taken to resolve this scenario that resulted in the evaluation of products such as prebiotics, probiotics, symbiotics, postbiotics,

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enzymes, antimicrobial peptides (AMP), organic acids, bacteriophages, metal, clay, hyper immune egg yolk IgY and phytogenics as alternatives to antibiotic growth promoters.

As per Gibson *et al*. (2004) prebiotics are defined as "selectively fermented ingredients that allow specific changes, both in the composition and activity of the gastrointestinal microbiota which confers beneficial effect on host well-being and health". Prebiotics on fermentation by beneficial microbes inhabiting the hindgut of animals produces short chain fatty acids. These short chain fatty acids not only reduce luminal pH thereby making it non conducive for growth and multiplication of pathogens but also provides energy for epithelial cells of large intestine resulting in better absorption of nutrients. Additionally, prebiotic supplementation affects the synthesis of vitamins such as folic acid, nicotinic acid, B1, B_2, B_6, and B_{12} (Kannan *et al*., 2005; Pilarski *et al*., 2005). Moreover, prebiotics have also shown to lessen the negative effects of stress and boost immunity, thus enhancing efficiency of energy utilization.

Presently inulin, trans galacto-oligosaccharide, resistant starch, mannan-oligosaccharides, and lactulose fall into the category of prebiotics. Jerusalem artichoke tuber is a natural source of inulin and thus could function as a good prebiotic. Thus, we hypothesized that Jerusalem artichoke tuber could alter the gut microbial profile and create favourable conditions in enhancing growth performance of calves. To test this, we supplemented Jerusalem artichoke tuber powder to pre weaned calves at graded levels and an alysed their growth performance.

MATERIALS AND METHODS

Preparation of Jerusalem artichoke tuber powder

Jerusalem artichoke tuber**s** were procured from the local markets of Bareilly, Uttar Pradesh. They were thoroughly cleaned in running water, skin scraped and cut into small pieces. Further they were sun dried until the moisture came to less than 5 per cent. The dried samples obtained were finely powdered and stored in airtight containers.

Animal management and experimental diets

The experiment was conducted at the calf shed of Livestock Production and Management Section, Indian Veterinary Research Institute (IVRI), Izatnagar in Uttar Pradesh of India. The animal experiment was approved by the CPCSEA following recommendation by the Institute Animal Ethics Committee of ICAR-IVRI, Izatnagar. The total duration of the study was for nine weeks.

Twenty-four Vrindavani calves were separated from their dam following the completion of the colostrum feeding period and housed in hygienically maintained individual penswith adequate bedding and good ventilation. The manure was removed twice daily to keep the pens dry and visibly clean, and the pens were disinfected three times a week with a diluted phenyl solution. At 15 days of age, the animals were randomly allocated into four groups based on body weight (23.64 ± 0.57 kg average BW). The calves under investigation were fed a milk based basal diet with respective supplementation as follows: Group I (CON)- no supplementation; Group II (JAP-1)- supplemented with Jerusalem artichoke tuber powder at 1% of DMI; Group III (JAP-2)- supplemented with Jerusalem artichoke tuber powder at 2% of DMI and Group IV (JAP-3)- supplemented with Jerusalem artichoke tuber powder at 3% of DMI. The respective prebiotic supplement was mixed in milkand administered once a day to treated groups for 9 weeks.

The whole milk feeding was carried out twice a day at $1/10^{th}$ of actual BW up to 2 weeks, $1/15^{th}$ of actual BW in the third and fourth week, $1/20^{th}$ of actual BW in the fifth and sixth week, and $1/25^{th}$ in the seventh, eighth and nineth week of study. The calf starter (concentrate mixture) was formulated using quality ingredients and offered from the second week onwards. The calf starter contained maize, 50%; soyabean meal, 37%; wheat bran, 10 %; mineral mixture, 2% and salt, 1%. All the calves had 24 h free access to clean drinking water and were fed with ad libitum calf starter and freshly harvested chaffed green fodder (maize and sorghum) throughout the study.

Experimental procedure

The body weight (BW) of the animals were recorded weekly using an automated electronic weighing scale prior to feeding in the morning. By employing the techniques described by Lesmeister *et al.* (2004), weekly structural growth measurements were noted of individual calves for heart girth, abdomen girth, wither height, body length, chest width and hip width. Milk, calf starter and roughage intake and the orts left behind were measured twice weekly. The mean DMI of an individual calf was determined after assessing the dry matter (DM) content of the feed provided and the residue left.

STATISTICAL ANALYSIS

Statistical Package for the Social Sciences (SPSS for Windows, v21.0; SPSS Inc., Chicago, IL, USA) was used to analyse all data. One-way ANOVA was employed to determine dry matter intake, and body weight change. The analysis included the between-subjects main effect of diet, the within-subjects main effect of the sampling period, and the interaction between sampling periods and diet. The effects were considered, and significance was declared at $P \leq 0.05$.

RESULTS AND DISCUSSION

Chemical composition of feeds

The chemical composition of milk and the basal diet fed to calves is presented in Table 1.

Table 1: Chemical composition (on DMB) of the diet† fed to calves

Parameter	Composition (%)	
	Calf starter‡	Forage
Dry matter	97.64	96.72
Organic matter	94.26	88.18
Crude protein	24.5	8.28
Ether extract	2.96	2.03
Acid detergent fibre	4.65	48.39
Neutral detergent fibre	14.2	76.14
Ash	5.74	11.82

†Chemical composition of milk fed to calves was fat 7%, protein 4.50%, lactose 5.18%, SNF 9.12%, and ash 0.7%.

‡The calf starter contained maize, 50%; soyabean meal, 37%; wheat bran, 10 %; mineral mixture, 2% and salt, 1%.

Feed intake of calves

The data relating to average milk intake, concentrate intake, roughage intake and the total DMI by the experimental calves is presented in Table 2, and the weekly pattern of DM intake illustrated in Fig. 1. During the experimental period of 9 weeks, the milk intake, concentrate intake, roughage intake and total DMI were statistically comparable (P>0.05) between the groups.

Table 2: Feed intake and growth performance of calves fed graded levels of Jerusalem artichoke powder as a prebiotic

Attributes	Dietary groups†				SEM	P-value
	CON	JAP1	JAP2	JAP3		
Feed (DM) intake						
Milk						
g/d	270.0	274.3	269.5	283.9	13.7	0.870
g/kgLW	8.9	9.2	9.0	9.1	0.35	0.907
g/kg $W^{0.75}$	20.8	21.4	21.0	21.6	0.74	0.858
Green fodder						
g/d	53.8	56.3	52.6	57.5	2.60	0.542
g/kgLW	1.78	1.88	1.77	1.87	0.12	0.874
g/kg $W^{0.75}$	4.18	4.43	4.10	4.38	0.25	0.746
Calf starter						
g/d	317.3	321.6	313.3	323.3	11.82	0.932
g/kgLW	10.35	10.82	10.45	10.47	0.42	0.869
g/kg $W^{0.75}$	24.35	25.20	24.48	24.63	0.83	0.891
Total DMI						
g/d	641.0	652.2	635.4	664.6	22.66	0.808
g/kgLW	21.00	21.88	21.22	21.50	0.71	0.835
g/kg $W^{0.75}$	49.28	51.07	49.57	50.60	1.31	0.746
BW changes						
Initial BW, kg	24.58	23.38	23.20	23.42	1.21	0.843
Final BW, kg	39.02	37.03	38.55	39.27	1.92	0.846
Netgain, kg	14.43	13.65	15.35	15.85	1.22	0.597
ADG, g	229.1	216.7	243.7	251.6	19.3	0.596
FCR	2.89	3.12	2.73	2.65	0.21	0.441

†Dietary treatments included a basal diet supplemented with Jerusalem artichoke powder at 0 (CON), 1 (JAP-1), 2 (JAP-2) and 3 (JAP-3) percent levels, respectively.

Our findings are in line with the observations of Donovan *et al.* (2002), Roodposhti *et al.* (2012) and Toth (2019) who also reported no difference in the dry calf starter intake between calves fed prebiotic or control. On contrary to these findings Ghosh and Mehla (2012), Kara *et al.* (2015), Uzmay *et al.* (2011) and da Silva *et al.* (2012) observed an improvement in feed intake on prebiotic supplementation to calves. Thus, it is concluded that the different results of

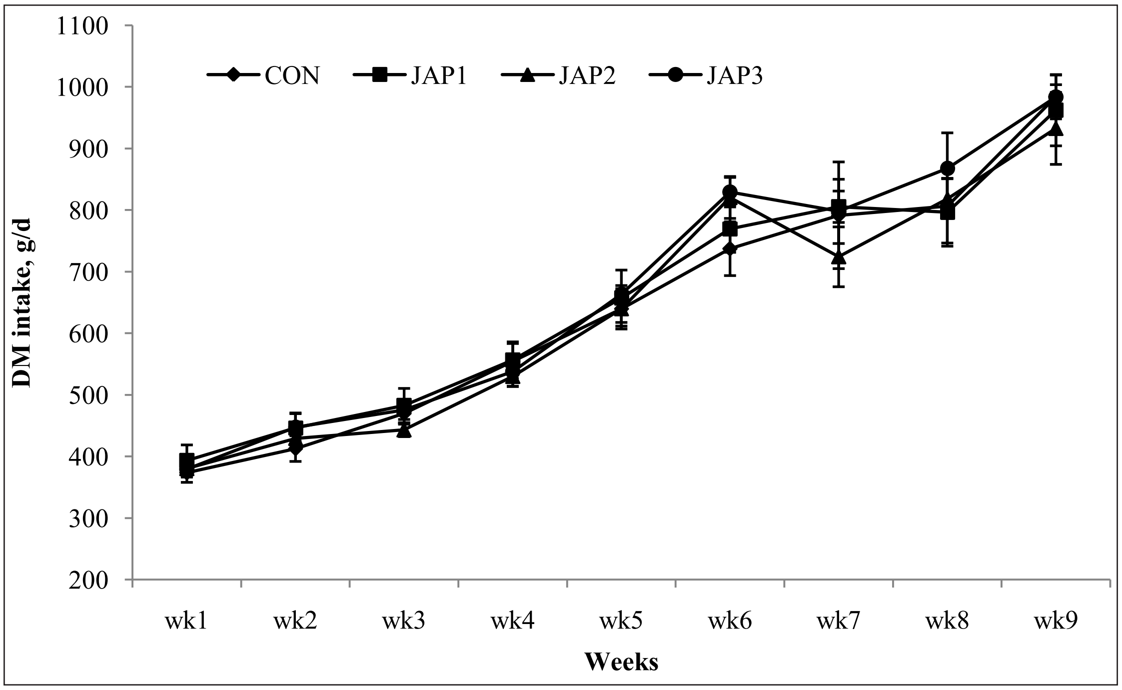

Fig. 1: Effect of graded levels of Jerusalem artichoke powder on the temporal changes in feed intake by calves

prebiotic supplementation on feed intake and subsequently the growth performance of calves could depend upon the level of supplementation, sources and manufacturers, the duration of supplementation, nutrient composition of the diet, health status of the calf, intestinal bacterial populations, adaptations of rumen microbial population to the different prebiotic sources and the environmental conditions (Demirel *et al*., 2007; Zhao *et al*., 2012; Swedzinski *et al.,* 2019).

Body weight changes and growth performance of calves

The data on BW changes and feed conversion ratio is presented in Table 3 and the weekly pattern of BW changes depicted in Fig. 2. The animals in different treatments had an initial mean body weight ranging from 23.20 to 24.58 kg which were comparable statistically (P>0.05). There was no difference evident in the weekly mean body weight, net body weight gain (kg) and average daily body weight gain (g/d) of animals during the study. The average total dry matter intake (g/d) of calves were also similar between groups ranging from 635.4 to 664.6. The feed conversion ratio was also statistically similar between the groups with JAP-1 having the highest (3.12) and JAP-3 having the lowest (2.65). These results are in accordance with previous research on pre weaned calves (Donovan *et al.* 2002; Roodposhti *et al.*, 2012; Hill *et al.,* 2008 and Toth *et al.,* 2020). Donovan *et al.* (2002) and Roodposhti *et al.* (2012) reported no difference in the dry calf starter intake between calves fed prebiotic or control. Quigley *et al.* (1997) also reported no significant difference in average daily gains between treatments when galactosyl lactose was used as a prebiotic. Hill *et al.* (2008) reported no improvement in ADG or feed efficiency in calves from birth to weaning on supplementing FOS along with milk replacer. Similar observations were made by Toth *et al.* (2020), on supplementing inulin with milk replacer to calves and observed no significant body weight gain. This experiment was conducted on pre-weaning calves who were in a transition from nursing animals to ruminants. The lack of significant impact on supplementing pulverized Jerusalem artichoke tuber as a prebiotic source could be attributed to the failure in the establishment of beneficial gut microbiota which is instrumental in bringing about positive changes in overall net body weight gain and average daily gain of calves.

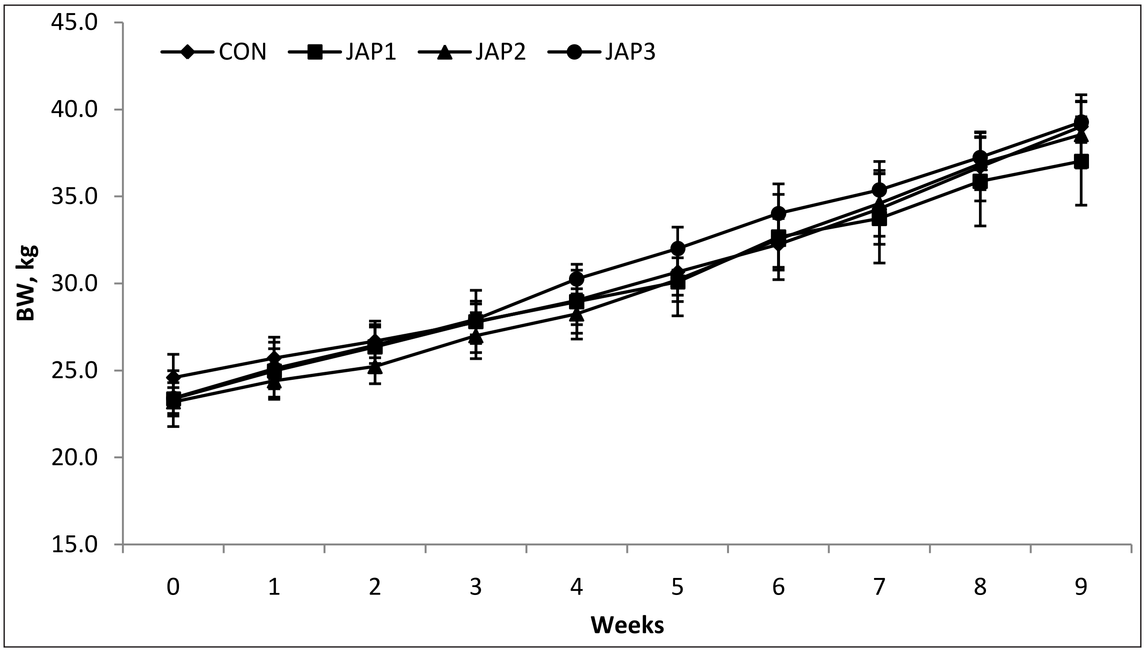

Fig. 2: Effect of graded levels of Jerusalem artichoke powder on the temporal changes in body weight of calves

Table 3: Body conformation changes of calves fed graded levels of Jerusalem artichoke powder as a prebiotic

Attribute	Dietary groups†				SEM	P value
	CON	JAP1	JAP2	JAP3		
Heart girth						
Initial, cm	67.50	68.08	67.50	67.58	1.25	0.985
Final, cm	79.17	79.50	78.33	80.17	1.52	0.859
Net gain, cm	11.67	11.42	10.83	12.58	1.39	0.844
Abdomen girth						
Initial, cm	64.75	67.17	65.50	66.42	1.26	0.561
Final, cm	79.17	80.83	81.00	81.00	1.81	0.806
Net gain, cm	14.42	13.67	15.50	14.58	1.35	0.818
Body length						
Initial, cm	64.83	64.83	64.67	65.00	1.19	0.998
Final, cm	75.33	76.33	75.83	78.67	1.14	0.202
Net gain, cm	10.50	11.50	11.17	13.67	1.05	0.201
Wither height						
Initial, cm	68.00	68.17	66.17	69.00	0.99	0.257
Final, cm	76.67	76.50	75.50	78.50	1.24	0.409
Net gain, cm	8.67	8.33	9.33	9.50	0.95	0.798
Chest width						
Initial, cm	69.42	69.92	70.25	69.75	1.24	0.971
Final, cm	84.50	87.17	86.67	87.67	2.06	0.713
Net gain, cm	15.08	17.25	16.42	17.92	1.78	0.705
Hip width						
Initial, cm	14.75	14.50	14.50	14.42	0.30	0.870
Final, cm	17.83	17.58	18.00	18.00	0.33	0.785
Net gain, cm	3.08	3.08	3.50	3.58	0.37	0.677

†Dietary treatments included a basal diet supplemented with Jerusalem artichoke powder at 0 (CON), 1 (JAP-1), 2 (JAP-2) and 3 (JAP-3) percent levels, respectively.

Body measurements

The data pertaining to the weekly body measurements *viz.* heart girth, abdomen girth, body length, wither height, chest width and hip width are presented in Table 3. The mean heart girth, abdomen girth, body length, wither height, chest width and hip width of calves at weekly intervals were statistically (P>0.05) similar in all groups throughout the experimental period of 9 weeks. There is scarcity of literature on the prebiotic influence on skeletal growth of calves. Our results were in par with the findings of Uzmay *et al.* (2011), Ratre *et al.* (2019) and Swedzinski *et al.* (2022) who observed no differences in skeletal growth of calves supplemented with prebiotics. On contrary to our findings, Sharma *et al.* (2018) and Raza *et al*. (2022) reported an improvement in body measurements on supplementing mannan oligosaccharide to calves. Feeding the yeast prebioticled to a higher DMI which resulted in availability of additional energy and nutrients required for skeletal deposition and there by the supplemented calves showed an improvement in body measurements.

CONCLUSION

It is concluded that, under the conditions of the present study, supplementing pulverized Jerusalem artichoke tuber as a prebiotic source did not bring about any improvement in growth performance of pre weaned calves.

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