JERUSALEM ARTICHOKE FLOUR FEEDING EFFECTS ON CALF DEVELOPMENT IN THE FIRST MONTHS OF LIFE

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Abstract
Studies have been conducted to find out the effect of the feeding of calves (*Bos Taurus*) with Jeruslem artichoke (*Helianthus tuberosus)* concentrate produced in Latvia containing the prebiotic – inulin. The study was performed on two groups of animals - a control group of 8 animals and test (prebiotic) group of 8 animals in summer (from June to August, 2013), and winter (from December, 2013 to February, 2014) in one of cow farm of Latvia, in the municipality of Bauska. Both groups were fed the whole milk, but the test group received additionally 12 g of Jerusalem artichoke powder (an average of 500 g kg^{-1} inulin) per day. The overall health status and physiological parameters (temperature, heartbeat and breathing frequency) of both animal groups before the study were of the normal range. After the experiment, we found out that the calves of the test group during both winter (one case) and summer seasons (seven cases), had fewer cases of diarrhea than the control (winter months four cases and summer months nine cases) group animals, the average daily weight gain (control group 0.53 g, prebiotic group 0.75 g) and the total weight gain (control group 29.42 kg, prebiotic group 42.13 kg) during 56 test days was significantly higher ($p<0.05$) than that for the control animals. We concluded that the use of Jerusalem artichoke flour concentrate when fed to the calves generally gives positive impact on the development and growth of the calves, improves the status of the gastrointestinal tract and the morphometric indicators.
Key words: calves, Jerusalem artichoke, inulin, weight growth.

Introduction

During recent years, dairy farmers worldwide have been looking for ways to improve the management techniques and find products allowing to increase the productivity of animals, at the same time improving animal welfare conditions and keeping them in a good health status. For decades antibiotics were used as feed additives to improve animal welfare and to obtain economic benefits. The European Union has introduced a ban on antibiotics as growth promoters in animal feed, from January 1, 2006 (Verdonk et al., 2005), but it is still possible to use antibiotics for the prevention of diseases. It becomes more and more obvious that the use of antibiotics in animal husbandry has to be significantly reduced because of the antimicrobial resistance. Direct animal-human contact or the contaminated food is the possible transmission route for the resistant bacteria between the animal and human populations (Mathur and Singh, 2005).

Therefore now it becomes more important than ever to find alternatives in order to keep a good animal health status, reduce illnesses, mortality, and continue to reach a high weight gain without using so many antibiotics. One of the potential alternatives for replacing antibiotics would be the supplementation of animal diets with prebiotics (Samanta et al., 2013). „Prebiotics" came into light only recently and were coined by G.R. Gibson and M.B. Roberfroid (1995). Prebiotics are carbohydrates (polysaccharides and oligosaccharides) and they may be defined as non-digestible food ingredients that stimulate the growth and/or activity of microorganisms in the digestive system and exert antagonism to *Salmonella sp.* and *Escherichia coli*, limiting their proliferation (Krol, 2011; Patel and Goyal, 2012). The possible potential positive effect of the use of prebiotics in the animal feeds was recognized already in the 1980s (Verdonk et al., 2005*)*. Since then, studies of the effects of the use of prebiotics in feed are still actual and will continue to be (Gaggìa et al., 2010; Grand et al., 2013). So J.G.M. Houdjik et al. (1998) has documented the use of prebiotics in diets for piglets, E. Flickinger et al. (2003) used prebiotics for pet animals, chicken (*Gallus gallus domesticus*), rabbits (*Oryctolagus cuniculus*) and pigs (*Sus domesticus*). With calves (*Bos Taurus*) most of the studies were carried out using prebiotics (Quezada-Mendoza et al., 2011) - mannaoligosaccharides (Krol, 2011) and fructooligosaccharides like inulin (Heinrichs et al., 2009; Masanetz et al., 2011). Inulin is a natural constituent of a wide range of plants and vegetables (Van Loo, 2007). Such plants as Jerusalem artichoke (*Helianthus tuberosus*) and chicory (*Cichorium intybus)* are rich in inulin. They have been used for industrial extraction of inulin already for a long time (Fleming et al., 1979). There are several studies performed on a single- stomach animals and birds feeding them inulin derived from Jerusalem artichoke which show the positive effect of inulin on growth and health of those animals (Kleessen et al., 2003; Valdovska et al., 2012). Nevertheless, there have been only limited studies to define the effects of the feeding of inulin to the calves. The aim of this study is to determine weather there is an effect on health condition, average daily gain and morfofunctional development of the gastrointestinal tract in calves when feeding them for the first four months after the birth with the Jerusalem artichoke concentrate (inulin 485 g kg^{-1} – 501 g kg^{-1}) produced in Latvia.

Materials and Methods

The trial was carried out in two stages in one of the cow farm of Latvia in the municipality of Bauska. The first stage was performed in summer (from June to August, 2013), the second - in winter (from December, 2013 to February, 2014).

First after the birth calves were fed 2 liters of a fresh mother's colostrum by nipple bottle for 3 consequent days (2-3 times per day). The first feeding was started not later than 30 minutes after the birth of the calves. After 3 days they were switched to the whole bulk milk up to 6 L per day depending on the calve's age.

The actual trial started when the calves were 4 weeks old and has been stopped 56 days later, and then a planned slaughter of animals was performed.

The research groups consisted of randomly selected animals. At the beginning of the study all calves were examined and fsllowing data was collected: heart rate, respiratory rate, body temperature, fecal score and *habitus*. About 23 ± 5 days old healthy male calves with the initial body weight of 50 ± 5.0 kg were grouped. During the research stage in summer calves were kept in calf houses with separated pens with natural ventilation. The total area of each pen for 4 calves was 7.5 m^2. During the second stage in winter the calves were kept in individual pens. Pens were cleaned manually one time per day.

During the entire research the calves were given up to 3 L whole milk 2 times a day and had free access to meal feed, hay and fresh water. Two weeks after the start of the trial calves additionally had free access to a fodder, made on the farm from wheat flour, which did not contain any antibiotics, prebiotics, probiotics or chemotherapeutics.

Fodder chemical composition is shown in Table 1.

Sixteen crossbreed calves were split into groups: 8 calves for summer time stage [summer control (SC), n=4; summer prebiotic (SP), n=4] and 8 - for winter time stage [winter control (WC), n=4; winter prebiotic (WP), n=4]. The whole milk, hay and fodder used to feed the experimental, as well as the control calves had the same nutrition value and quality. The only difference was that the milk feed for prebiotic group calves contained prebiotics. All SP and WP group animals were fed 12 g of Jerusalem artichoke concentrate with inulin averagely 500 g kg^{-1}, the composition of the concentrate is given in Table 1.

Daily fecal scoring was done according to Larson's scale, where 0 – normal, firm but not hard; 1- soft, does not hold form, piles but spreads slightly; 2 – runny, spreads readily to about 6 mm depth; 3 – watery, liquid consistency, splatters (Larson et al., 1977).

Body weight, heart rate, respiratory rate and temperature were measured every two weeks. The weight was determined by special measuring tape (we-Bo tape) by measuring calf heart girth behind the front legs. Body temperature was measured rectally with rectal digital thermometer, designed for veterinary use. The heartbeat was measured by placing phonendoscope at the left side of costal cavity and counted heart beats per minute.

The first stage was performed in summer from June to August, 2013, when the environmental temperatures ranged from +10 °C to + 29 °C degrees, second - in winter from December 2013 to February 2014 when environmental temperatures ranged from +7 °C to -15 °C degrees.

The animals were slaughtered after 56 days. Immediately after slaughtering, the gastrointestinal tract was removed from the carcass. The following morphometrical measurements were taken: the total weight of the gastrointestinal tract, the weight of

Table 1

Chemical composition of concentrated feed and Jerusalem artichokes flour for study animals

Flour name	Composition (g kg^{-1} Dry Matter basis)						Composition (g mg^{-1} Dry Matter basis)			
	Dry matter g kg^{-1}	CP	NDF	ADF	Strach	Inulin	Free glukouse	Free fructose	Sacch-arose	Nucleic Acids
Concen-trated feed	882	142	481	34	655	-	-	-	-	-
Jerusalem artichoke	948-956	171	-	-	628-645	485-501	8	26	106	21

CP - Crude protein
NDF - Neutral Detergent Fiber
ADF - Acid Detergent Fiber

the rumen without the feed masses, the weight of abomasum without the
feed masses, the length of the abomasum and rumen. For statistical analysis the average ± standard error was calculated and a t- test for paired samples in *Microsoft Excel* and *R-Studio* programs was used. P-values less than 0.05 were considered to be statistically significant.

Results and Discussion

In this study, we wanted to determine the feeding effect of locally produced Jerusalem artichoke concentrate on the calf's body. Generally, Jerusalem artichoke flour contain on average 10 g kg^{-1} inulin, specially designed technology allows to increase the amount of inulin to 485 g kg^{-1} - 501 g kg^{-1} (Fleming and Groot Wassink, 1979; Valdovska et al., 2012) - so it is easier to add it to the feed material in our study – whole bulk milk.

The following table (Tab.2) shows that the heart rate, respiratory rate and the temperature of both groups were within physiological reference range. In this study two of the summer stage control group animals were under 7 days long antibiotic treatment, because one calf had purulent rhinitis. In general, calve's health was good.

When the respiratory rate was analyzed for the summer group calves separately from the winter group calves, there was a difference between a 4 weeks old calf ($p<0.01$) and the one of 6 and 12 weeks ($p<0.05$). WP and SP calf respiratory rate proved to be significantly ($p<0.01$) higher in 6 and 8 weeks old calf and ($p<0.05$) in 11 weeks old calf. In this study respiratory rate was higher during summer stage.

SP and SC group calves body temperature was higher than that of the WP and WC group calves. There is no statistically significant difference in temperature measurements between calves treated with prebiotics and the control group animals. The increase of temperature and the significantly increased respiratory rate in summer stage could be explained through higher environmental temperature (+22 °C). It is well known that an increase in environmental temperature may increase the animal's body temperature.

It is possible to read in literature about an increased heart rate of a calf at an early age, which decreases when calf becomes older (Westervelt et al., 1979). In this study it was not observed. It could be explained through the constant inhibitory effect of *n. vagus* center on heart rate when the calf is 4 weeks old. Increased heart rate was detected in all animals when calves were 12 weeks old and we measured the heart rate in the slaughter house. The increase of heart rate in a stressful situation has been reported by other authors (Westervelt et al., 1979; Mohr et al., 2002).

There were no records of hard watery diarrhea (3 marks) in any group.

During the first week of the study (calves were five to six weeks of age) fecal score in SC and SP group was mostly soft or almost soft (average of 0.75 and 0.50 marks; Fig. 1). At seven weeks of age two WC group calves were detected with watery feces (averagely 1.63 marks), it might refer to a disfunction of gastrointestinal tract. At the age of seven weeks fodder was started to be fed to the calves and it could make impact on the gastrointestinal tract. Next week all the SC group animals were observed soft or watery fecal masses at an average of 1.7 marks, meanwhile

Table 2

Physiological fundamentals of the control and prebiotic groups of animals during winter and summer

Groups, old week	Respiratory rate (breaths min^{-1})		Heart rate (beats min^{-1})		Temperature (°C)	
	Summer	Winter	summer	winter	summer	Winter
Control						
4 week	36 ± 3.3	24 ± 0.01	104 ± 7.3	105 ± 5.8	38.9 ± 0.31	38.8 ± 0.27
6 week	33 ± 2.0	29 ± 1.9	111 ± 11.4	113 ± 1.6	39.1 ± 0.61	38.8 ± 0.49
8 week	31 ± 3.9	28 ± 5.6	117 ± 6.8	113 ± 1.6	39.2 ± 1.00	38.7 ± 0.36
10 week	30 ± 5.2	28 ± 3.3	117 ± 3.8	125 ± 1.6	39.1 ± 0.38	39.4 ± 0.23
12 week	33 ± 2.0	29 ± 1.9	130 ± 5.2	141 ± 3.3	38.9 ± 0.41	39.0 ± 0.67
Prebiotic						
4 week	33 ± 3.8	29 ± 4.3	113 ± 3.8	121 ± 3.7	38.5 ± 0.4	38.4 ± 0.19
6 week	32 ± 3.3	25 ± 1.6	119 ± 6.0	110 ± 6.8	39.1 ± 1.12	38.4 ± 0.22
8 week	33 ± 2.0	26 ± 1.7	123 ± 5.1	117 ± 4.9	38.8 ± 0.43	39.1 ± 0.07
10 week	32 ± 3.3	32 ± 2.8	111 ± 5.1	116 ± 6.5	38.7 ± 0.24	38.3 ± 0.22
12 week	36 ± 3.3	28 ± 2.8	136 ± 3.7	146 ± 5.0	38.7 ± 0.14	38.3 ± 0.07
Reference limits (Mohra et al., 2002)	15 – 40			86 - 125	38.0 – 39.5	

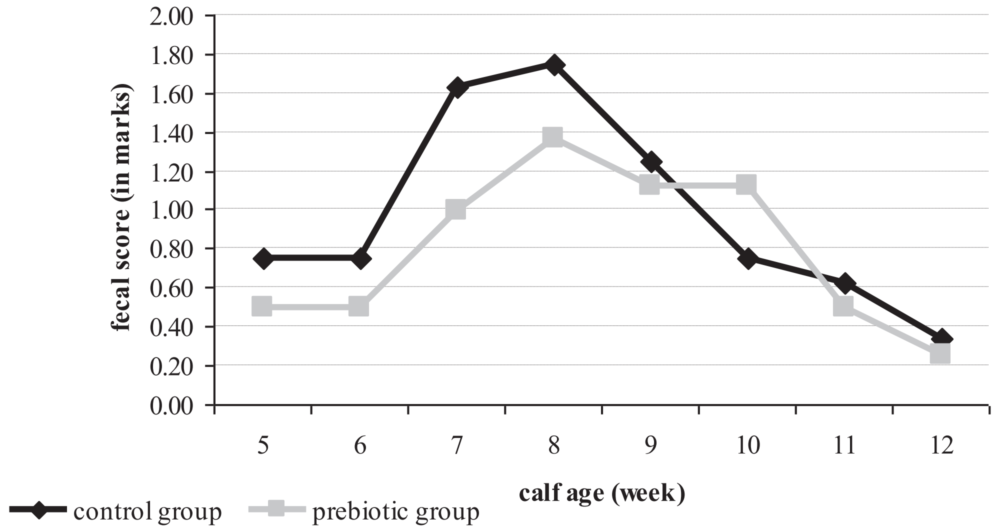

Figure 1. Calf fecal score (summer groups).

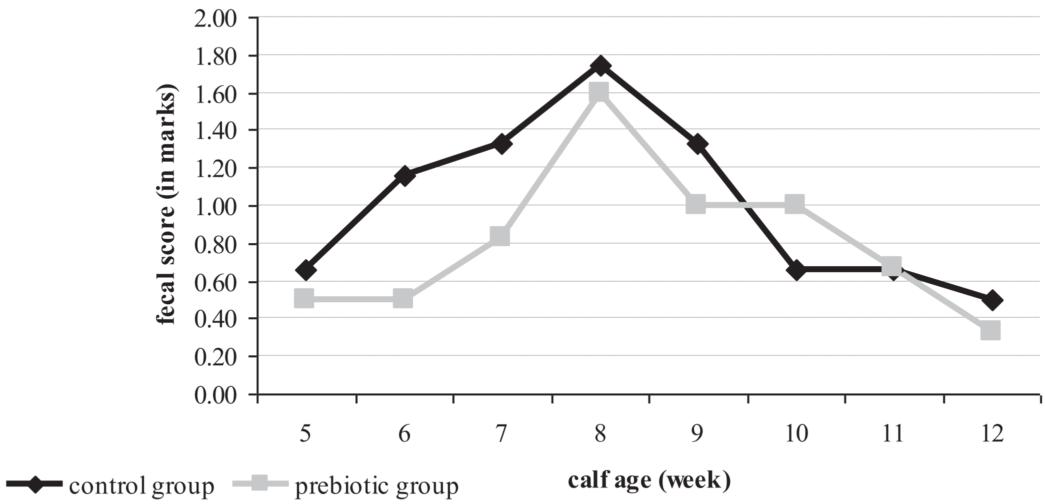

Figure 2. Calf fecal score (winter groups).

the fecal masses of the SP group animals were normal or soft at an average of 1.3 marks. Starting from the 10th week of life the consistency of feces in all animals became more rigid and at 12 weeks of age in the SC group it was 0.36 marks, but in the SP group 0.29 marks (Fig. 1). In this study we observed that at 11-12 weeks of age calves begin to eat more hay than before and this could stabilize the digestive processes.

This study shows that the SP group calves had less watery feces than those of the SC group - this could prove that feeding inulin might improve the function of gastrointestinal tract.

During the research winter stage the consistency of animal feces was normal (WP) or soft (WC), but at 6 weeks of age the fecal score of the WP group animals was on average 0.5 but of the WC group 0.67 marks (Fig. 2). The fecal score of seven and eight weeks old calf of the WC group was on average from 1.33 to 1.83, but the fecal score of the WP group animals was from 0.83 to 1.66 - it means soft. The calves of both groups at an age of 11 and 12 weeks had normal or soft fecal consistency, but at 12 weeks of age the WC group animals had 0.5 marks and the WP group animals 0.33 marks.

In summary we could conclude that the prebiotic group animals during both winter and summer stages had less watery feces than the control group animals (Fig. 1 and 2). In the middle of the study (at 7, 8 and 9 weeks of life), when animals were offered new feed materials (fodder and hay) the fecal masses became softer and the incidence of observed diarrhea increased. The calves additionally fed with

Table 3

Calf total live weight growth dynamics

Groups	Average weight of the animal (kg) at the research day			Live weight gains (kg) at the time period (day)			Average daily body weight gain (kg)
	1	28	56	1-14	1-28	1-56	
Control	53.6±5.71	71.9±10.38	83.0±11.18	7.9±5.36	18.3±4.67	29.4±5.47	0.53±0.183
Prebiotic	54.3±3.28	75.4±10.15	96.4±11.50	10.0±4.00	21.1±6.87	42.1±8.21	0.75±0.201

Table 4

Calf gastrointestinal growth performance

Groups	Average cold carcass weight (kg)	Average total mass of gastrointestinal tract (kg)	Rumen mass		Abomasum mass	
			empty (kg)	relative (%)	empty (kg)	relative (%)
Control	43.57±8.16	14.20±1.49	1.14±0.26	2.61±0.74	0.55±0.10	1.25±0.10
Prebiotic	49.14±8.07	14.44±1.57	1.29±0.32	2.62±0.80	0.62±0.11	1.27±0.15

prebiotics showed a relatively stable gastrointestinal tract organ activity at this age, especially the WP group.

Starting from the 10th week of life, fecal consistency becomes more rigid, which could be explained through the development of a stable ruminant digestive system which continues up to 11 weeks of life. Similar results were also obtained by other authors, who found the gastrointestinal tract stabilization after feeding prebiotics (Flickinger et al., 2003; Heinrichs et al., 2009; Król, 2011; Grand et al., 2013).

Hereafter we analyzed the growth rate and the development of the gastrointestinal tract organs of the control and the prebiotic group calves. Since there was no significant difference between the body weight gain at the summer and winter stages, we analyzed both stages together.

Comparing the results of the growth dynamics of the live weight of the calves from the first research day to 56 days, we found that the weight gain of the calves in 56 days additionally fed with inulin was significantly higher ($p<0.05$) than in the control group animals (Tab. 3.) The milk added inulin increased the relative cold carcass weight by 6% compared to the control group (Tab. 4).

During the first rearing period (0-28 study days) the relative body weight gain of the prebiotic group animals was by 5% higher but during the 0-56 study day period even by 23% higher than of the control group animals. N. Stolić et al., (2012), who carried out the research feeding prebiotics (mannan-oligosaccharides) to the calves, got similar results.

In all stages of the research the weight of the prebiotic group calves was higher than to the control animals.

The average daily weight gain of a prebiotic group animal was by 0.277 kg higher compared with the control group and this difference was statistically significant ($p<0.05$).

For the prebiotic group calves, all indicators show a slightly better developed gastrointestinal tract than in control animals, but these differences did not prove significant ($p>0.05$). We can conclude that the additional feeding with inulin can accelerate the development of the gastrointestinal tract.

Since the prebiotics are known to be active mainly in the intestinal canal, rather than in the stomach, it could be the main reason why the changes in gastric morphometric measurements are not significant. Research in this area should be continued.

This is only the first step of the study showing the feeding effects of the prebiotic inulin on the calf health and weight gain. The study is certainly significant and persuaded us to continue research on locally produced Jerusalem artichoke flour concentrate usage for this purpose.

Conclusions

1. The additional feeding of the Jerusalem artichoke flour containing prebiotic inulin to the calves at 4-12 weeks of age improves the gastrointestinal functional capability by reducing the incidence of diarrhea after new feed materials both in winter and summer periods.

2. The animals additionally fed with inulin at the age of 12 weeks showed significantly higher ($p<0.05$) live weight gain (control group on average 83.00 kg, prebiotic group 96.43 kg) and significantly higher average daily weight gain ($p<0.05$) the control group 0.53 g, but prebiotc group 0.75 g.The carcass weight was by 5.72% higher than of the control group animals.
3. The study shows that the Jerusalem artichoke flour concentrate feeding generally improves the gastrointestinal morphometrical indicators thereby showing the positive impact of prebiotic inulin on the gastrointestinal tract development and growth.

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