



Effect of lactose-free milk powder on lactose intolerance symptoms and nutritional status of pet dogs

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Abstract

The effects of standard cow, goat and lactose-free cow milk powder on lactose intolerance symptoms and the nutritional status of dogs was studied. Forty adult Springer Spaniels with lactose intolerance were randomly allocated into four groups with ten dogs each and fed one of the milk powders or water for 21 d. The milk powders were reconstituted daily by diluting 10 g milk powder to 60 g water and 2 g milk powder/kg body weight was provided *ad libitum* and refusals were monitored daily. Lactose intolerance was assessed by faecal composition and pH, water and lactose contents. Biochemical markers for nutritional status were analysed. Feeding intolerance and lactose in faecal samples were observed in dogs fed the standard cow and goat milk powder, but not for the lactose-free milk powder or control groups. The high- and low-density lipoprotein cholesterol increased in all milk powder groups, while there were no other differences in nutritional status measurement. The results suggested that feeding lactose-free milk powder to dogs with lactose intolerance reduced the occurrence of symptoms, thereby enhancing the health and wellbeing of dogs.

Keywords: dog, Spaniel, lactose intolerance, milk powder, faeces, cholesterol

1. Introduction

Lactose is the main carbohydrate in the milk of mammals, and comprises 4.7 to 5.0% in cow's milk (Silanikove *et al.*, 2015). When dietary lactose enters the small intestine, it is digested by the lactase enzyme to galactose and glucose, which are rapidly absorbed. In case of lactase deficiency, which is common in dogs, undigested lactose enters the colon and is metabolised by bacteria in the colon, producing gas and acidic metabolites. This results in bloating and stimulates bowel movements. Unabsorbed lactose causes isotonic water retention, which increases faecal water content, causing gastrointestinal symptoms such as diarrhoea, vomiting and abdominal pain (Brown-Esters *et al.*, 2012).

Dogs exhibit different levels of lactose intolerance, with symptoms varying from mild gastrointestinal problems to severe diarrhoea and vomiting (Grandi *et al.*, 2018; Craig, 2019). Goat milk is often recommended for dogs, as it has a slightly lower lactose content than cow's milk; on average 4.2-4.8% lactose in goat milk vs 4.7-5.0% lactose in cow's milk (Silanikove *et al.*, 2015). However, lactose-free milk could be a better option to enhance the gastrointestinal health in dogs with intolerances.

According to current published work, effects of milk powders with different lactose contents on lactose intolerance symptoms in pet dogs have not been investigated. In the following study, standard cow, goat or lactose-free cow milk powder were fed to study their effects on intolerance symptoms and nutritional status of dogs.

2. Materials and methods

The experimental protocol was approved by the Laboratory Animal Welfare and Ethics Committee of Nanjing Agricultural University, China. In total, 40 adult Springer Spaniels (mean weight 12 kg) with symptoms of lactose intolerance were used in the study. These dogs are owned by the animal facility, which continued to raise them after the experiment. For the first 7 d, 40 dogs were fed uniformly with a commercial, basal dog food to minimise differences in nutritional status. The composition of the basal dog food is shown in Table 1 below. Daily food allocation was based on the weight of the dog (Table 2).

Dogs with lactose intolerance symptoms were screened by feeding standard cow milk powder for three days. Specific immunoglobulin E (IgE) analysis was performed to exclude dogs allergic to milk protein (Table 3). In the pre-screening stage, 4 g milk powder/kg body weight (twice as much as used in the experiment) was fed for three consecutive days. If diarrhoea and vomiting occurred for two consecutive days, this was considered as lactose intolerance. A result of IgE \geq 0.19 IU/ml was considered to indicate milk allergy.

After the pre-screening period, 40 dogs were randomly divided into four groups (n=10), each group being allocated to standard cow milk powder (whole milk powder, Valio Ltd, Helsinki, Finland), goat milk powder (whole goat milk powder, Shengtang Dairy, Xi'an, China), lactose-free whole milk powder (Valio Ltd) or water (control) for 21 days. The nutritional contents of the milk powders are shown in Table 4.

Table 1. Composition of basal dog food.

Nutrient	Composition
Crude protein (Min)	24%
Crude fat (Min)	10%
Moisture (Max)	10%
Crude fibre (Max)	3%
Lysine (Min)	0.9%
Calcium (Ca) (Min)	1.2%
Phosphorus(P) (Min)	0.9%
Chondroitin (Min)	300 mg/kg
Glucosamine (Min)	800 mg/kg
Vitamin E (Min)	600 mg/kg
Vitamin C (Min)	300 mg/kg

Table 2. Feeding rates of basal dog food.

Recommended daily feeding amount	
Dog weight (kg)	Feeding quantity (g)
10-20	200-350
20-30	350-600
30-40	600-700
40-50	700-850

Each milk powder was reconstituted daily by diluting 10 g milk powder in 60 g water. An amount corresponding to 2 g milk powder/kg body weight was provided *ad libitum* to each dog. Any refused milk was weighed daily to calculate the actual amount consumed.

Faecal composition was observed daily and body weight was recorded once a week. Fasting ear or peripheral venous blood samples and fresh faeces were collected once a week. During the experiment, dogs were housed in individual kennels, which were ventilated and cleaned daily. The dogs had free access to feed and drinking water and a veterinarian monitored the dogs throughout the feeding trial and provided timely treatment where any dogs developed symptoms that were detrimental to their wellbeing.

Experimental methods

In practice, due to cool winter weather, the dogs' activity levels were low and it was difficult to assess any possible depression and inactivity related to the milk powder intake. Therefore, diarrhoea, faecal pH, lactose and water contents were the main criteria for lactose intolerance.

Faecal composition was assessed by the method of Teixeira *et al.* (2015) and two consecutive days with loose faeces was considered as diarrhoea. Faecal scores of 3 or 4 were recorded as diarrhoea (Table 5). Lactose content was determined using the lead acetate ammonium hydroxide method (Xu *et al.*, 2018).

Fasting blood was collected and analysed for biochemical indicators of nutritional status. Total protein, albumin, triglycerides, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) cholesterol, glucose, creatinine and lactate dehydrogenase were analysed by photoelectric colorimetry.

If any dog suffered from severe diarrhoea, vomiting or other severe symptoms during the study, it was removed from the feeding experiment for welfare reasons. The dog was then isolated and fed with conventional feed and received veterinary treatment and was later returned to the kennel after recovery.

Table 3. Immunoglobulin E (IgE) levels relating to milk allergy.

IgE result (IU/ml)	Milk allergy
<0.19	None
\geq 0.19	Moderate
\geq 0.90	High

Table 4. Nutritional content of milk powders (per 100 g).

Component	Whole milk powder	Lactose-free whole milk powder	Goat milk powder
Energy (kJ/kcal)	2,070/500	2,068/494	2,080/497
Protein (g)	26	32	25
Fat (g)	26	26	28
Carbohydrates (g)	39	32	37
Lactose (g)	39	<0.1	37

Table 5. Faecal scoring system used in dogs fed different milk powders.

Score	Appearance	Diagnosis
0	Formed faeces	normal
1	Formed, pasty faeces	normal
2	Formed mixed with liquid faeces	normal
3	Unformed, liquid faeces	abnormal
4	Watery faeces	abnormal

Statistical methods

Data were analysed using SPSS 25.0 software (IBM, Armonk, NY, USA). Results were expressed as mean \pm standard deviation (SD). The χ^2 test was used to study differences between groups for the faecal lactose analysis. Other statistical analyses used the T test and $P < 0.05$ was considered statistically significant.

3. Results

Animal welfare during the study

Five dogs were removed from the study. Two dogs were excluded from the standard cow milk powder group and two animals from the goat milk powder group due to chronic diarrhoea. One dog in the lactose-free milk powder group was removed due to a parasite infection.

Milk consumption, intolerance and body weight

Milk consumption was, on average, 160 ml/day (2 g milk powder/kg body weight), with no significant differences between the groups. Lactose intake from the milk powders

was 0.78 g/kg body weight and 0.74 g/kg body weight in the standard cow and goat milk powder groups, respectively.

Feeding intolerance, defined as diarrhoea and vomiting for at least two days, was seen in 40% and 60% of the dogs in the standard cow and goat milk powder groups, respectively, whereas no intolerance symptoms were seen in the dogs receiving lactose-free milk powder group or the water control ($P = 0.01$). There were no significant differences in the incidence of intolerance between dogs fed the standard cow or goat milk powder.

The weight of the dogs tended to decrease in all groups during the study, with no significant differences between groups (Table 6). This was attributed to the cool temperature (-3 to $+10$ °C) in winter when the trial was conducted.

Faecal lactose content

Lactose was detected in faecal samples from 50 and 60% of the dogs fed the standard cow milk and goat milk powder group, respectively, whereas it was not detected in the lactose-free milk powder or the control groups ($P = 0.01$; Table 6).

Biochemical indicators

Changes in biochemical indicators are shown in Table 7. Both HDL and LDL cholesterol increased in all milk powder groups, resulting in a significant difference between all milk powder groups and the control ($P < 0.01$; Table 7). No significant differences between groups were seen in other biochemical markers.

Table 6. Feeding intolerance rate, weight change (mean \pm SD) and lactose-positive faecal samples in the different groups.

Treatment	Incidence of intolerance (%)	Weight change (kg)	Lactose-positive faecal samples (%) ¹
Standard cow milk powder	60	-0.68 \pm 0.95	50 ^b
Goat milk powder	40	-0.63 \pm 0.50	60 ^b
Lactose-free milk powder	0	-0.51 \pm 0.67	0 ^a
Control (water) group	0	-0.67 \pm 0.48	0 ^a
P-value	0.01	0.95	0.01

¹ Means not sharing a letter differ significantly ($P < 0.05$).

Table 7. Changes in biochemical indicators in dogs fed different milk powders.¹

Parameter	Standard cow powder	Goat milk powder	Lactose-free milk powder	Control (water) group	P-value
	n=8	n=8	n=9	n=10	
Total protein (g/l)	4.76±2.62	-0.24±6.55	2.10±4.17	0.12±4.36	0.13
Albumin (g/l)	1.31±3.63	-0.78±2.42	-0.12±2.33	-0.13±1.69	0.43
Creatinine (µmol/l)	2.23±4.07	-1.56±3.15	-6.26±3.10	-1.00±9.41	0.61
Glucose (mmol/l)	0.89±0.82	1.08±0.70	0.83±0.55	0.54±0.48	0.36
Triglycerides (mmol/l)	0.65±1.25	0.28±0.31	0.56±0.80	0.18±0.17	0.50
HDL-cholesterol (mmol/l)	1.27 ^b ±0.52	0.92 ^b ±0.50	0.94 ^b ±0.39	0.28 ^a ±0.69	<0.01
LDL-cholesterol (mmol/l)	0.04 ^b ±0.11	0.12 ^b ±0.08	0.07 ^b ±0.13	-0.09 ^a ±0.06	<0.01
LDH (U/l)	18.0±30.0	1.13±26.12	20.78±48.28	5.70±15.90	0.53

¹ Means not sharing a letter differ significantly ($P<0.05$). HDL = high-density lipoprotein; LDH = lactate dehydrogenase; LDL = low-density lipoprotein.

Faecal pH, water and lactose

No significant changes were detected in faecal pH in any of the groups during the study (Table 9). Faecal water content differed significantly between groups in the end of the study, but changes within the milk powder groups (baseline vs end) were not significant (Table 8).

4. Discussion

The study showed that feeding intolerance symptoms and lactose-positive faecal samples were observed in dogs which consumed standard cow or goat milk powder. Dogs fed lactose-free milk powder did not show any intolerance, had a stable faecal water content and did not contain lactose and faecal pH was in the normal range.

Most puppies tolerate lactose, at least to some extent, but, with increasing age, the activity and quantity of lactase gradually decreases in most dog breeds (Craig, 2019). Hence, older dogs may have significant symptoms relating to lactose intolerance, which negatively affects their health and welfare. The analysis of faecal composition, water and lactose content as well as pH can provide a basis for diagnosing lactose intolerance.

In the current trial, four dogs manifested severe symptoms of lactose intolerance and were excluded from the study, two from the standard cow and two from the goat milk powder groups. In total, 50% of the dogs fed standard cow milk powder and 60% of animals fed goat milk powder manifested lesser symptoms of lactose intolerance. In an

earlier study, up to 2 g lactose/kg body weight was tolerated by over half (8/14) of the dogs from different breeds (Grandi *et al.*, 2018). In a study carried out with four adult Beagle dogs receiving a daily dose of 1 g lactose/kg body weight for 10 d, none of the animals displayed gastrointestinal disorders (Zentek *et al.*, 2002). In the present study in, a daily lactose intake of 0.74-0.78 g/kg body weight induced lactose intolerance symptoms in 50-60% of Springer Spaniels. The results of all these studies suggest that most adult dogs tolerate lactose to some extent, but significant differences in tolerance exist between breeds.

Compared with the control group, both HDL and LDL cholesterol increased in all milk powder-fed groups. The increase in HDL was greater than LDL. In contrast to humans, HDL is the predominant lipoprotein and the major cholesterol-carrying compound in dogs (Watson, 1996). However, although this can be associated with cardiac problems in mammals, atherosclerosis in dogs is rare (Vilahur *et al.*, 2011) and has only been achieved experimentally by administering a high-fat/high-cholesterol diet deficient in essential fatty acids (Butkus *et al.*, 1976). As the increase in this study was mainly seen in HDL, the milk powders used did not appear to pose a risk in terms of cardiovascular health. No significant differences in other biochemical markers were seen.

To conclude, various lactose intolerance symptoms were seen in over half of dogs given ordinary milk powder and goat milk powder, but not in dogs which received lactose free milk powder. Therefore, feeding lactose-free milk powder to dogs with an established intolerance reduced symptoms, avoiding health and welfare problems.

Table 8. Faecal water content in the beginning and end of the study in dogs fed different milk powders.

Experimental group	n	Baseline (%)	End (%)	P-value
Ordinary milk powder	8	62.74±4.52	65.13±4.97	0.15
Goat milk powder	8	64.27±8.45	66.18±4.88	0.37
Lactose-free milk powder	9	58.13±2.82	58.80±2.94	0.62
Control group	10	61.79±5.27	59.03±2.40	0.10
P-value		0.10	0	

Table 9. Faecal pH from dogs fed different milk powder.

Experimental group	n	Baseline	End	P-value
Ordinary milk powder	8	6.12±0.62	5.94±0.30	0.867
Goat milk powder	8	5.90±0.48	5.76±0.39	0.824
Lactose-free milk powder	9	6.84±0.46	6.75±0.61	0.636
Control group	10	6.90±0.38	7.03±0.33	0.55

Conflict of interest

Anu Turpeinen is an employee of Valio Ltd, which provided the milk powders for the study.

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