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Barley as an alternative to rice in dog food

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Abstract: In this study, 30 mixed-breed, neutered, young adult male dogs at 15–30 kg live weights were used. The foods were produced at a special facility. Dog food produced using 25% barley had a gelatinized starch content significantly greater than that of food produced using 25% rice: 18.36% vs. 17.45%, respectively. No considerable difference was observed in the dogs' preference between the two foods (50.95% vs. 49.05%). Dry matter digestibility of rice and barley food was 86.10% and 83.85% and crude protein digestibility was 80.44% and 79.24%, respectively. Based on the consumption of rice or barley, stool consistency did not change.

Key words: Barley, digestibility, dog food, palatability

1. Introduction

Grains such as wheat, barley, corn, and rice form an important part of the canine diet. Assuming that dog food contains 25% protein, 15% fat, 10% water, 3% fiber, and 7% ash, the remaining 40% is composed of carbohydrates. This carbohydrate is often derived from one or a few grains. In fact, carbohydrates are not one of the essential nutrients for dogs but they do provide a digestible energy source (1,2).

One of the common uses of grains in dry dog food is to make the diet economical. In dog diets, starch can reach 50% and grains can make up 60% of total ingredients. Most of the uncooked cereal starch is indigestible in dogs, whereas almost all the cooked cereal starch is digestible (2). Therefore, heat treatments applied during preparation have a considerable effect on the digestibility of food or diet (3). In other words, the digestibility of the dog foods is mostly related to the digestibility of starch (3). The most digestible cereals are corn and rice, followed by sorghum, barley, and wheat (4). Carciofi et al. (5) found that over 99% of rice and corn starch in dog foods is digestible.

Starch is present in plant cells as granules that are insoluble in cold water. When they are heated with water, the starch granules swell and the crystalline structure disappears. This is known as gelatinization. The degree of gelatinization of starch is very important in starch digestion (6,7). Gelatinization of starch depends on the strength, rotation speed, pressure, and pore diameter of the extruder, and the moisture level, starch content, and character of grain. Raw starch is very slowly digested by enzymes in vitro. The digestible starch, which is 27% of the barley, rises to 50% after extrusion and from 37% to 59% in corn. This rise reflects organic matter digestion (8).

Historically, dog food has been based on rice. In recent years, it has been worked on grains such as barley and oats. These grains are fiber-rich and contain β-glucan. Cereals have different glycemic indices. Corn has the highest glycemic index, followed by rice, with barley having the lowest. A low glycemic index is useful for diabetic and obese dogs (9). However, some dogs that could not tolerate β-glucans were observed to have loose or watery stools (1,9).

Oats and barley are good sources of β-glucans and water-soluble fiber, and their fat and glucose-lowering effects in humans are known. Like humans, dogs are also susceptible to chronic digestive diseases. Therefore, it is thought that the use of oats and barley may be beneficial in the control of obesity, diabetes, and dyslipidemia in dogs (9). Complex carbohydrates in barley have advantages such as having less energy than starch, lengthening satiety, increasing the viscosity in the digestive system, and slowing digestion and absorption (10).

Murray et al. (11) used 51.9% barley or 44.1% rice in dogs' diet and found digestibility and fecal consistency

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higher in a rice diet. They reported that barley should not be over 50% in dog food. Murray et al. (12) reported that loss of organic matter in vitro was higher in barley than in rice. It has been reported that barley added to dry dog food up to 40% is well tolerated by adult dogs and that complex carbohydrates protect against oxidative stress and cardiovascular disease (9).

Digestibility is as important as the nutrient composition of the dog food. Less frequent defecation and a stiff, shaped stool are signs that the animal is digesting its food well.

Another choice in the selection of food, perhaps the most important, is the animal's acceptance of the food. This can be determined by different methods. Two-pan palatability testing is a widely used method of choice for dog food (13,14). However, it is important to have enough dogs to ensure a sufficient sample size. Opinions vary as to whether 20 dogs are enough to test for 2 days (15) or whether 30 animals are necessary (16).

We can get an idea of the digestibility of the food that was fed to the dog by looking at the consistency of the stool. Well-digested products cause stiff and shaped stools. The fecal consistency may vary on a scale of 1 to 5 from watery to solid (5,17–20) or some studies rate watery as 1 whereas others rate it as 5 (14,21).

The present study was conducted to determine the effects of using barley instead of rice in dog food in terms of digestibility, gelatinized starch, fecal quality, and animal preference.

2. Materials and methods

The research was conducted at the Dog Research Unit of Veterinary Faculty at Selçuk University, Turkey, with the permission of the local ethics committee (No: 2014/53). Thirty neutered, adult male dogs were used. The animals were weighed (15–30 kg), their condition was scored on a scale of 1 to 5 (22), and they were treated for internal and external parasites using Ivomec, Guadreks, and Controline. The dogs were housed in individual kennels with an enclosed area of 3.6 m^2 and an external area of 11.7 m^2.

Food was given daily at the same time, once a day, and water was provided ad libitum. The kennels were washed once a week.

In this study, barley was included in dog food instead of the more commonly used grain, rice. Using 25% rice or barley, two different isocaloric and isonitrogenous foods were prepared as given in Table 1. These products were produced at the Bil-Yem facilities in Ankara, Turkey, by cooking in a double-screw extruder.

2.1. Nutrient analysis

The foods were milled on a laboratory mill and passed through 0.5-mm sieves (Retsch SM100, Retsch GmbH, Haan, Germany). Analysis of dry matter, ash, crude protein, ether extract, crude fiber, and starch was carried out according to the methods reported in AOAC (23). The metabolic energies of the products were calculated

Table 1. The composition of experimental foods, %.

Ingredient	Rice food	Barley food
Whey	2.00	2.00
Barley	-	25.00
Rice	25.00	-
Corn	26.00	27.00
Corn gluten meal	13.00	13.00
Corn starch	10.48	11.78
Poultry meal	16.00	14.00
Sunflower oil	3.00	3.00
Beef tallow	3.00	3.00
Vitamin/mineral*	1.52	1.22
Calculated nutrients, 100 g DM		
Crude protein, g	23.70	23.49
Energy, kcal	447	442
Crude fiber, g	1.94	2.74
Ash, g	4.40	4.13
Carbohydrate, g	62.12	62.70

*: Aminovit, minesol, K chloride, Zn proteinate, Ca iodate, Na bicarbonate

from the analysis results using NRC (24) formulations as follows:

ME, kcal/kg = $((5.7 \times CP \times 10) + (9.4 \times EE \times 10) + (4.1 \times (NFC \times 10 + CF \times 10))) \times (91.2 - (1.43 \times CF))/100 - (1.04 \times CP \times 10)$

ME: Metabolizable energy, CP: Crude protein, EE: Ether extract, NFC: Nonfiber carbohydrate, CF: Crude fiber

2.2. Gelatinized starch

Three repeated gelatinized starch measurements were taken using the Starch Damage Assay Kit (Megazyme, Wicklow, Ireland).

2.3. Preference test

The two food products, 500 g each, were given to 30 dogs, once a day, at the same time every day. At the end of 1 h, residuals were weighed and food intake was determined. The preference test lasted 4 days. According to the quantities consumed, it was determined which food was preferred. If the ratio is greater than 0.51 or less than 0.49 in the preference test, the preference is evident (14,25,26).

2.4. Nutrient digestibility

The digestibility of organic matter, crude protein, ether extract, and crude fiber was determined by the total collection method (27,26). Two animals were removed from the trial due to a kennel problem. Fourteen dogs were used per food product. For 5 days following the initial 8-day acclimation period, the stools were collected from the floor.

The dogs were divided into two groups of 14 dogs each according to their location in the Dog Unit, live weight, and body condition. Considering the consumption levels of the animals during the acclimation period, the food was provided at the same time every day, 3%–8% more than the maintenance requirement (24). The amount of food provided to dogs was between 260 and 500 g. During the last 5 days, the excrements were collected twice a day from the concrete floor with plastic scrapers and nylon bags. After being weighed, the fecal samples were stored at –20 °C. At the end of the trial, 5-day fecal samples from each dog were thawed, combined, and homogenized. Feces samples were dried in an aluminum tray at 70 °C for 60 h. Ash, crude protein, ether extract, and crude fiber were analyzed as two replicates and nutrient digestibility was calculated.

2.5. Fecal consistency

During the last 4 days of the total collection period, the stools were also scored according to the 1–5 system (17). The scoring was done by three different researchers.

2.6. Statistical analyses

Digestibility and fecal score data were compared using independent samples t-tests. In comparison of the fecal scores of the two groups, the average values of the fecal scores of 12 as a value of the fecal score (3 persons × 4 days) were used (v.22, SPSS Inc., Chicago, IL, USA).

3. Results

The nutrient composition of the two dog food products is presented in Table 2. Gelatinized starch was significantly less in dog food made with rice, at 17.45 ± 0.19% than barley, at 18.36 ± 0.05% ($P = 0.009$). Nutrient digestibility determined by total collection method for rice and barley foods is given in Table 3. Dry matter digestibility of rice

Table 2. Nutrient analysis of foods including rice or barley, % DM.

Food	DM	OM	Ash	EE	CF	CP	Starch	ME-NRC, kcal
Rice	93.25	95.91	4.09	9.77	2.07	23.73	49.55	402
Barley	93.03	96.05	3.95	9.09	3.50	22.89	46.97	390

DM: Dry matter, OM: Organic matter, EE: Ether extract, CF: Crude fiber, CP: Crude protein, ME-NRC: Metabolizable energy calculated according to NRC

Table 3. Nutrient digestibility coefficients, %.

Nutrient	Rice food		Barley food		P
	X	SEM	X	SEM	
Dry matter	86.10	1.09	83.85	0.95	0.133
Organic matter	89.11a	0.92	86.43b	0.79	0.036
Ether extract	95.24	0.71	94.43	0.29	0.296
Crude fiber	45.26	4.68	34.66	4.71	0.123
Crude protein	80.44	1.69	79.24	1.17	0.566

a,b: Means within a column with no common letters differ significantly ($P < 0.05$), n = 14

Table 4. The results of preference test (n=30)

	Rice food	Barley food
Serviced food, g/day	500.00	500.00
Consumption, g/day	216.78	229.82
Preference ratio, %	49.05	50.95
P	0.626	

and barley was 86.10 ± 1.09% and 83.85 ± 0.95% and crude protein digestibility was 80.44 ± 1.69% and 79.24 ± 1.17%, respectively. Daily consumption and preference ratios are shown in Table 4. The average stool scores determined in the last 4 days of the total collection period were 3.76 in the rice food and 3.77 in the barley food and they were not significantly different (P = 0.962).

4. Discussion

Despite being equalized in the diet formulation, the crude protein in barley food was lower. This means that barley contains less protein than was calculated. This decrease is also seen in fat and energy (Table 2). As expected, crude fiber was higher and starch was lower in barley food.

There is no difference in the digestibility of other nutrients except that the digestibility of organic matter is lower in barley food (Table 3). The lower digestibility of the organic matter may be due to the higher fiber, lower fat, and lower starch content of the barley food. β-Glucan in the barley may be effective. Corn and corn starch were also increased whereas poultry meal was reduced in barley food to equalize energy and protein in the diet formulation. A study by De Godoy (10), which used barley at 20% and 40% instead of corn, did not report differences in dry matter, fat, or fiber digestion. Dry matter, nitrogen, and fat digestion are similar in this study, but fiber digestion is higher in the study by De Godoy (10). The fiber content in formulas used in that study is three times that of the present study. It is also interesting that fiber digestion increases as the fiber increases. In contrast, Burrows et al. (28) reported that as the fiber in the diet increases, the time spent in the intestinal passage lengthens, and digestibility decreases. Fiber digestibility in dog food can be as low as 18%–31% (29). Fiber digestion was also low (45% and 35% for rice and barley, respectively) in the present study.

Barley food contained more gelatinized starch than rice food. Based on this result, the digestibility of barley food is expected to be higher. This effect could have been more apparent if barley was used at a higher percentage in the food product.

When a dog was given 500 g of each food option at feeding time and allowed to eat for 1 h, it was found that dogs consumed 216.78 g of rice food and 229.82 g of barley food (Table 4). Rice food and barley food were chosen at preference ratios of 49.05% and 50.95%, respectively. That is, the dogs showed no clear preference for either food product.

Average fecal scores of animals consuming rice and barley are close to 3.76 and 3.77, respectively. AAFCO has listed hulled barley as one of the cereals to be used in dog food. It is also stated that β-glucans contained in barley may cause loose excreta in some dogs (1). Despite the use of shelled barley in this study, barley food did not cause sticky stools. As a matter of fact, De Godoy (10) found that when the barley was used up to 40%, the fecal quality of the dogs did not deteriorate.

Barley has one of the lowest glycemic indices of all cereal grains. It is the basic ingredient used in dog food by our predecessors and shepherd dog breeders in Turkey. In this study, dog food containing 25% barley was used. Considering that the food is given 350 g per day to a dog, the daily amount of barley is equivalent to 88 g. The similarity of digestibility and preference for both rice and barley foods, and considering that barley and does not disrupt stool quality indicate that barley can be used effectively in dog food. It would be beneficial to study canine diets containing a higher barley content, as rice is an important food source for humans, while barley is mostly used to feed animals.

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