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Effects of Feeding a Dry or Fermented Restaurant Food Residue Mixture on Performance and Blood Profiles of Rats

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ABSTRACT : This study was conducted to compare the effects of feeding dry or fermented (aerobically or anaerobically with or without lactic acid bacteria) restaurant food residue mixture-containing diets on animal performance and blood profiles. Rats were used as the model animal for the simulation of laboratory rodents, rabbit or horse feeding and fed for 4 wks. The results were compared with feeding a dry diet (control) with the same ingredient composition as diets processed by aerobic and anaerobic methods. Feeding all the fermented diets tended to increase ($p>0.05$) average daily gain of rats resulting in improved ($p<0.01$) feed efficiency. Apparent digestibility of NDF was increased ($p<0.05$) by feeding the fermented diets, although digestibilities of DM, OM, CP, and NFC were not affected ($p>0.05$). Compared with the aerobically fermented diet, digestibility of ADF was increased ($p<0.05$) for the anaerobically fermented diet and for the 0.5% LAB culture plus anaerobically fermented diet. The digestibility of crude ash tended to increase ($p>0.05$) with feeding of the fermented diets. Feeding either of the fermented diets had little effects on serum nutrients, electrolytes, enzymes and blood cell profiles of rats except sodium and uric acid concentrations. These results showed that compared with feeding a dry food residue-containing diet, feeding aerobically or anaerobically fermented diets showed better animal performance as indicated by higher feed efficiency and rat growth rate. These improvements were attributed to the desirable dietary protein conservation during the food residue fermentation process and to higher total tract digestibilities of NDF and crude ash in the fermented food residue diets. (**Key Words :** Digestibility, Fermentation, Food Residue, Food Waste, Rat)

INTRODUCTION

Traditionally, processed restaurant food residue has been used as an alternative feed source for monogastic animals. Because food residues are typically wet and putricible, they need to be properly processed before feeding. The fermentation methods that have been studied include drying to less than 14% moisture (Westendorf et al., 1998; Jee et al., 2005) and aerobic and anaerobic fermentation of food residue mixed with other feeds (Kwak and Kang, 2006; Yang et al., 2006). Processing of food residue by drying has merits due to its large scale capacity and its wide use by many commercial feed mills. However, the drying of food residue has been reported to have critical disadvantages such as considerable nutrient losses resulting in depressed animal performance (Westendorf et al., 1998; Jee et al., 2005), compared to fermented feeds.

The fermentation process, with or without the addition of lactic acid bacteria (LAB) to food residue, has been used successfully to preserve food residues (Yang et al., 2006). Rather than relying on indigenous microbes, the addition of LAB helps to ensure that desirable LAB will be the predominant microflora in the feed resulting in a successful fermentation outcome. The addition of LAB inoculants to food residue also preserves the residue by inhibiting the growth of putrefactive bacteria that degrade the residue to odiferous compounds, suppresses the growth of food poisoning bacteria (Wang et al., 2001) and the LAB improve the nutritional characteristics of the food residue (Yang et al., 2006).

In a review paper by Scholten et al. (1999), fermented diets seemed to improve growth performance of monogastric animals compared with non-fermented diets. Based on this information animal diets processed by fermentation seemed to be the logical method to use for processing food residue-containing diets. However, studies are limited on the direct comparison of animal performance

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when fed dry or fermented food residue. Thus, we hypothesized that monogastric animals might perform better on fermented diets than on dry diets. Additionally the research results would be applicable in rabbit feeding.

Accordingly this study was conducted to compare the effects of feeding dry and microbially processed (aerobically or anaerobically) food residue mixtures on rat performance.

MATERIALS AND METHODS

Experimental diets

Food residues were collected from two restaurants at suburb high schools located near Seoul, Korea. The residues were composed of cooked rice, meat, vegetables and fruit residues. The analyzed chemical composition of the blended food residues was 19.9% dry matter (DM), 19.2% crude protein (CP), 24.8% neutral detergent fiber (NDF), 10.8% ether extract (EE), and 13.8% crude ash.

Restaurant food residue, bakery by-product, wheat bran, ground corn grain, barley bran and limestone (a total of 500 kg lots) were completely blended for 30 min using an electric mixer (Deplus Co., Korea) at the ingredient ratios presented in Table 1. Because usually the food residues contain high NaCl, salt was not added to the diets. The mixture was transferred in a rotary drum drier (Deplus Co., Korea) and pasteurized for 30 min at 80°C in order to meet the Korean standard treatment regulation (Korean Feed Management Regulation, KFMS, 2001) for the safe use of food residue as a monogastric animal feed. The pasteurized feed mixture was screened through a sieve (pore size, 1 cm^2) and any lumps were removed. The mixture was blended again for 30 min using an electric mixer (Atika, Italy) and then further processed into the experimental diets.

Table 1. Ingredient composition (%) of the experimental diet before processing[1]

Item	As-fed basis	Dry matter basis
Food residue	33.8	11.0
Bakery by-product	24.1	31.8
Wheat bran	5.2	7.0
Ground corn grain	11.6	15.3
Barley bran	21.2	28.7
Limestone	0.6	0.9
Soy oil	2.5	3.8
L-lysine	0.5	0.75
Vitamin-trace mineral premix[2]	0.5	0.75

[1] Bacterial culture (*Bacillus spp.*) was added at 0.5% for the aerobic fermentation of diet and LAB (*Lactobacillus salivarius*) culture was added at 0.5% for the anaerobic fermentation of diet on a wet basis.

[2] Composition within 1 kg: vitamin A 5,000,000 IU, vitamin D_3 1,000,000 IU, vitamin E 2,000 IU, vitamin C 2,000 mg, vitamin K_3 400 mg, vitamin B_2 1,000 mg, vitamin B_6 400 mg, vitamin B_{12} 4 mg, calcium pantothenate 2,000 mg, nicotine amide 500 mg, manganese sulfate 3,600 mg, ferrous sulfate 2,000 mg, copper sulfate 250 mg, zinc sulfate 160 mg, potassium iodide 80 mg, cobalt sulfate 40 mg, sodium selenite 20 mg, glucose proper level.

The dried diet was prepared by drying an 8-kg lot of the feed mixture containing food residue and feed ingredients at 105°C for 12 h to a moisture content of 8-10%. For the aerobic fermentation process the aerobic microbial culture *Bacillus spp*. was added to the food residue mixture. The culture had been used successfully in a previous study to treat food residue used in swine rations (Kwak and Kang, 2006). Forty grams (w/w) of dried culture were thoroughly blended with 8 kg of the feed mixture containing food residue and feed ingredients. To minimize chemical variations of the mixture due to sampling errors, 1 kg of the mixture was put into each of eight nylon bags (19 cm long× 20 cm wide, pore size 1 mm^2). The bags were inserted into the center of the mixture in a wooden box (90 cm long×90 cm wide×130 cm high), and fermented with the total mixture for 10 days at 55-60°C. The box had a perforated metal bottom which permitted air movement up through the food residue mixture thus facilitating growth of the *Bacillus* culture.

For the anaerobic fermentation treatment 2 kg lots of the feed mixture were put into double-lined vinyl plastic bags and ensiled for 10 days at an average temperature of 25°C. For the LAB-added and anaerobically fermented treatment, a culture of *Lactobacillus salivarius* isolated from piglet feces in our laboratory, was incubated anaerobically at 30°C for 12 h. The culture was added at a level of 0.5% (w/w) to the feed mixture and blended thoroughly. All the processed mixtures were stored at -20°C prior to the feeding trials. The raw food residue mixtures prior to the fermentative treatments had a pH of 5.98. After the 10-d process the pH of the mixtures was 6.41 for the aerobically processed mixture, 4.58 for the anaerobically fermented and 4.55 for the 0.5% LAB culture plus anaerobically fermented mixture. The reduction in pH from 6.41 to 4.58 or less implies that the food mixture had undergone a successful acid fermentation process. All the processed mixtures were stored at -20°C prior to the feeding trials.

Before feeding to rats, all the processed mixtures were thawed and thoroughly blended with soy oil, lysine, and vitamin-trace mineral premix at the ratios presented in Table 1. The experimental diet was formulated to meet the nutrient requirement of laboratory rats recommended by NRC (1995).

For the rat feeding trial, all diets were pelletized using a small-scale pelletizer (Dong-A Auska, Korea). The diameter of the pellets was 1.5 cm and the length was 1.5 to 2.0 cm. To facilitate the pelleting process water was added to the feed mixture to achieve an approximate moisture level of 30%. Moisture content was measured using a speedy moisture analyzer (ULTRA X, Laborgerate GmbH & Co., Germany).

Table 2. Chemical composition (% of dry matter) of dry and fermented diets

Item	Diet[1]			
	DR	AE	AN	ANL
Organic matter (OM)	95.7	95.4	95.6	95.5
Crude protein (CP)	12.9	13.7	13.7	14.2
Nonfibrous carbohydrates (NFC)	53.3	52.3	49.1	47.2
Neutral detergent fiber (NDF)	20.7	20.7	22.7	24.1
Acid detergent fiber (ADF)	10.4	10.4	11.4	10.8
Ether extract (EE)	8.8	8.7	10.1	10.0
Crude ash	4.3	4.6	4.4	4.5

[1] DR = Dry, AE = Aerobically fermented, AN = Anaerobically fermented, ANL = Anaerobically fermented with 0.5% LAB culture added.

Animals and diets

The study was conducted in compliance with the institutional animal care and use policies and regulations of Konkuk University. A total of 48 male outbred Sprague-Dawley white rats (four wks old, mean body weight 196.6±0.3 g) were randomly assigned to four dietary treatments, each with four cages per treatment and three rats per cage. All rats were housed in an environmentally controlled room (temperature 23±2°C, relative humidity 50±10%, programmed ventilation) under a 12-h light-dark cycle.

The four dietary treatments were i) a dry diet (DR) as a control, ii) an aerobically fermented diet (AE), iii) an anaerobically fermented diet (AN), and iv) a 0.5% LAB-added and anaerobically fermented diet (ANL). All diets were fed twice a day (08:00 and 20:00 h) during the 4-wk experimental period. Rats had access to water at all times. Water intake was determined by measuring the difference between the supplied and remaining amount of water. Prior to the study all rats were fed a commercially formulated diet with the following chemical composition: 91.5% DM, 19.7% CP, 25.8% NDF, 18.5% ADF, 4.2% crude fiber (CF), 6.0% EE, 7.6% crude ash, and 62.6% nitrogen free extract.

The experimental period consisted of a 5-d adaptation period, a 4-wk growth period, and a 5-d feces collection period. Blood samples were taken on the next day immediately after the collection period.

Sampling and chemical analysis

The unprocessed restaurant food residue was blended thoroughly prior to collecting triplicate samples for proximate analysis. Samples of experimental diets were collected for analysis on a weekly basis for 4 wk. Just prior to analysis all samples were dried and ground through a 1 mm screen using a Sample Mill grinder (Cemotec, Tecator, Sweden). Dry matter was determined by drying samples at 105°C for 24 h to constant weight. Crude protein, EE, CF and crude ash were analyzed according to the method of AOAC (2000). Ash free NDF and ADF were analyzed according to the method of Van Soest et al. (1991). Nonfibrous carbohydrate was calculated as 100-(NDF+CP +EE+crude ash). pH was measured using a pH meter (HI9321, Hanna Instrument, Portugal).

For the 5-d digestibility trial, four rats were used for each treatment with each rat housed in a separate cage. Daily fecal output during the 5-d collection period was dried at 60°C for 48 h. Feces were thoroughly mixed at the end of the collection period to obtain a composite sample which was ground through a 1 mm screen and then frozen for later analysis. Apparent digestibility was calculated by determining the difference between the supplied feed amount and fecal amount.

Six rats randomly selected within each diet for blood sampling. Blood samples were collected by heart puncture from the sacrificed rats, and an equal portion was divided into bottles with or without anti-coagulant EDTA. These samples were immediately transported to the commercial Konkuk University Research Hospital. Serum profiles were analyzed using an Automatic Biochemical Analyzer (Hitachi 7170A, Hitachi Ltd., Tokyo, Japan) based on photometry and ion selective electrode methods. Whole blood profiles were analyzed with an Automatic Blood Analyzer (Coulter STKS, Beckman Coulter Co., Miami, FL, USA) based on impedence and VCS (volume, conductivity, light scattering) methods.

Statistical analysis

Data were analyzed using one way analysis of variance with GLM procedure (SAS Institute, Inc., 1990). Orthogonal contrasts of means among treatments were DR vs. AE, AN and ANL; AE vs. AN and ANL; and AN vs. ANL (SAS Institute, Inc., 1990). Significant differences were detected at $p<0.05$.

RESULTS

Intake, growth and feed efficiency

Feed and water intake, body weight gain and feed efficiency of rats affected by the feeding of dry or fermented diets for 4 wk are presented in Table 3. Daily

Table 3. Feed and water intake, body weight change and feed efficiency of rats fed dry and fermented diets[1]

Item	Diet[2]				SE
	DR	AE	AN	ANL	
Feed DM intake (g/d)	20.3	21.0	20.7	19.2	0.6
Water intake (ml/d)	31.8	30.9	30.5	31.5	1.4
Initial body weight (g)	197.1	197.0	195.5	196.8	4.5
Final body weight (g)	318.6	335.2	333.8	326.1	9.1
Average daily gain (g)	4.34	4.94	4.94	4.62	0.25
Feed efficiency					
Feed, g/gain, g	4.69	4.28	4.20	4.16	0.13[a]

[1] Means of 12 rats (4 cages with 3 rats per cage).
[2] DR = Dry, AE = Aerobically fermented, AN = Anaerobically fermented, ANL = Anaerobically fermented with 0.5% lactic acid bacterial culture added.
[a] DR differs from AE, AN and ANL ($p<0.01$).

feed DM and water intake by the rats were not affected ($p>0.05$) by the treatments. All the fermented diets tended to increase ($p<0.13$) average daily gain of the rats by 6.5 to 13.8% compared with feeding the dry diet and this resulted in an improved ($p<0.01$) feed efficiency by 8.7 to 11.3%. Among the fermented diets, feed intake, growth and feed efficiency of the rats were not different ($p>0.05$). Weekly body weight change for rats fed the dry and fermented diets is shown in Figure 1. Although feed DM intake was not different among diets during the 4-wk feeding trial, growth rates were consistently higher for rats fed the fermented diets compared to those fed the dry diet.

Apparent nutrient digestibility

The apparent nutrient digestibility of the dry and fermented diets fed to the rats is presented in Table 4. Apparent digestibilities of DM, OM, CP, and NFC were not affected ($p>0.05$) by dietary treatments. The NDF digestibility was remarkably increased ($p<0.05$) for the fermented diets compared to the dry diet. Compared to the dry control diet the NDF digestibility was increased 38.1% for the aerobically fermented diet, 44.2% for the anaerobically fermented diet, and 78.4% for the 0.5% LAB culture plus anaerobically fermented diet. A comparison of the anaerobically fermented diets, with and without the LAB culture, to the dry diet, indicated that the ADF digestibility was increased ($p<0.05$) 46.0% for the anaerobically fermented diet and 62.6% for the 0.5% LAB anaerobically fermented diet.

Although the differences were small, the EE digestibility was lower ($p<0.05$) for the fermented diets compared to nonfermented diet. Crude ash digestibility tended to increase ($p<0.09$) for the fermented diets compared with the dry diet.

Blood parameters

Blood serum nutrients and electrolytes of rats fed dry and fermented diets are presented in Table 5. For serum nutrients, triglyceride, cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), glucose and total protein contents were not affected ($p>0.05$) by the dietary treatments.

Serum electrolytes, Ca, inorganic P, potassium (K), and chlorine (Cl) contents were not affected ($p>0.05$) by the dietary treatments. Only, the serum Na level was reduced ($p<0.05$) by feeding the fermented diets compared with feeding the dry diet. Serum Na also was reduced for rats fed the 0.5% LAB culture plus anaerobically fermented diet

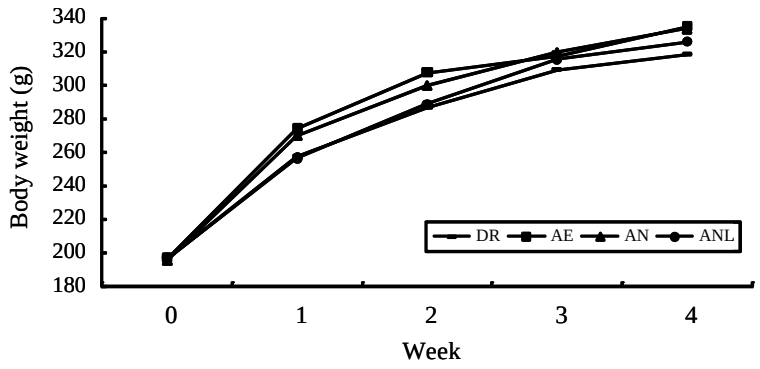

Figure 1. Weekly body weight change of rats fed dry and fermented diets. DR = Dry, AE = Aerobically fermented, AN = Anaerobically fermented, ANL = Anaerobically fermented with 0.5% lactic acid bacterial culture added. Means of 12 rats (4 cages with 3 rats per cage); means for each week were not different ($p>0.05$).

Table 4. Apparent nutrient digestibility of dry and fermented diets fed to rats[1]

Digestibility (%)	Diet[2]				SE
	DR	AE	AN	ANL	
Dry matter (DM)	74.9	75.8	75.2	75.9	1.1
Organic matter (OM)	76.1	77.0	76.4	77.0	1.0
Crude protein (CP)	70.4	72.2	72.3	74.6	1.5
Neutral detergent fiber (NDF)	23.1	31.9	34.3	41.2	3.5[a]
Acid detergent fiber (ADF)	20.2	19.5	28.5	31.7	3.4[b]
Nonfibrous carbohydrate (NFC)	94.0	93.9	93.2	93.2	0.4
Ether extract (EE)	96.5	94.9	95.7	94.1	0.4[a,c]
Crude ash	50.5	53.6	52.3	56.4	2.4

[1] Means of 4 cages with 1 rat per cage.
[2] DR = Dry, AE = Aerobically fermented, AN = Anaerobically fermented, ANL = Anaerobically fermented with 0.5% lactic acid bacterial culture added.
[a] DR differs from AE, AN and ANL ($p<0.05$). [b] AE differs from AN and ANL ($p<0.05$). [c] AN differs from ANL ($p<0.01$).

Table 5. Blood profiles of rats fed dry and fermented diets[1]

Item	Diet[2]				SE
	DR	AE	AN	ANL	
Triglyceride (mg/dl)	57.8	54.7	53.8	56.2	5.4
Cholesterol (mg/dl)	112.5	116.0	120.5	120.8	3.9
High density lipoprotein (mg/dl)	94.3	92.7	101.5	98.5	3.8
Low density lipoprotein (mg/dl)	11.3	19.7	12.0	17.8	2.6
Glucose (mg/dl)	89.7	98.8	86.2	87.3	6.9
Total protein (g/dl)	6.0	6.3	6.2	6.0	0.1
Electrolytes					
Calcium (mg/dl)	9.42	9.65	9.52	9.45	0.14
Inorganic phosphorus (mg/dl)	6.73	7.03	6.50	6.80	0.30
Potassium (mmol/L)	4.20	4.25	4.12	4.28	0.14
Sodium (mmol/L)	147.5	145.8	146.8	144.5	0.74[a,c]
Chlorine (mmol/L)	102.5	103.3	103.5	103.8	0.74
Albumin (g/dl)	2.30	2.33	2.32	2.28	0.05
Globulin (g/dl)	3.83	3.88	4.00	3.80	0.06
Albumin/globulin	0.60	0.60	0.58	0.60	0.01
Uric acid (mg/dl)	0.93	0.63	0.73	0.78	0.09[a]
Total bilirubin (mg/dl)	0.18	0.18	0.18	0.17	0.03
Alkaline phosphatase (U/L)	583	675	566	588	46
Alanine aminotransferase (U/L)	45.0	53.3	49.2	57.7	4.7
Aspartate aminotransferase (U/L)	99.0	102.7	114.8	104.2	7.2
r-glutamyltransferase (U/L)	0.5	1.0	0.7	1.0	0.2
Lactate dehydrogenase (U/L)	1,018	1,019	1,189	941	162
Amylase (U/L)	1,105	1,092	999	904	76
Urea-N (mg/dl)	17.0	19.6	17.1	19.2	1.9
Creatinine (mg/dl)	0.67	0.68	0.70	0.72	0.05
White blood cell counts ($10^3/\mu l$)	4.87	5.78	5.68	5.53	0.61
Red blood cell counts ($10^6/\mu l$)	7.65	7.64	7.84	7.75	0.13
Platelet counts ($10^3/\mu l$)	830	879	774	877	72

[1] Means of 6 rats randomly selected within each diet for analysis.
[2] DR = Dry, AE = Aerobically fermented, AN = Anaerobically fermented, ANL = Anaerobically fermented with 0.5% lactic acid bacterial culture added.
[a] DR differs from AE, AN and ANL ($p<0.06$). [b] AE differs from AN and ANL ($p<0.06$). [c] AN differs from ANL ($p<0.05$).

compared with feeding the anaerobically fermented diet. In summary, feeding either dry or fermented diets to rats did not result in remarkable differences in blood nutrients and electrolytes homeostasis of the rats except serum Na level.

Blood parameters including serum albumin, globulin, albumin/globulin ratio, total bilirubin, alkaline phosphatase, alanine aminotransferase, aspartate aminotransperase, r-glutamyltransferase and lactate dehydrogenase contents were not affected ($p>0.05$) by the dietary treatments. Serum uric acid contents were lower ($p>0.05$) for rats fed the fermented diets than those fed the dry diet. Serum urea-N and creatinine levels, as indexes of renal function, and serum amylase levels, as a diagnostic aid for pancreatic carbohydrate metabolism, were not different ($p>0.05$) among dietary treatments. Also, blood cell components, such as white blood cells, red blood cells and platelet counts, were not affected ($p>0.05$) by the treatments.

DISCUSSION

Intake, growth and feed efficiency

In spite of similar feed DM intake among diets, the consistently higher growth rates for rats fed the fermented diets compared to those fed the dry diet are supported by previous studies that compared feeding dry or non-fermented liquid diets with feeding fermented liquid compound diets. Those studies reported that with similar feed intake, there were increased daily gain and improved feed efficiency of growing-finishing pigs (Scholten et al., 1998) and weaned piglets (Jensen and Mikkelsen, 1998) fed fermented diets compared to non-fermented diets.

Apparent nutrient digestibility

The chemical composition of the experimental diets is presented in Table 2. The dried residue mixture had 1.1% less dietary protein than the aerobic and anaerobic fermented mixture indicating that the fermentation process conserved protein. The reduced NFC and increased NDF contents for the AN and ANL treatments indicate that fermentative microbes degraded NFC during the anaerobic process, resulting in the relative increase of undegradable fibrous materials. Also, this phenomenon indicates that nonfibrous carbohydrates (NFC) was more readily utilized and that fermentation was more active by anaerobic bacteria than aerobic bacteria. All the diets contained similar levels of Ca (0.73%) and P (0.58%).

The considerably improved fiber digestion for the anaerobically fermented diets might be attributed to fiber digestion by anaerobically fermentative bacteria in the rat intestinal tract or to microbial attack on fiber during the fermentation process as reported by Yang et al. (2006). Bae (1999) reported higher *in vitro* NDF digestibilities for anaerobically fermented food residue mixtures than for aerobically processed food residue mixtures. However, the reason for the significantly higher ADF digestibility for the LAB processed diet compared to the other diets is still to be explained. In case of the growing rabbits, a sufficient dietary fiber is required to prevent digestive troubles (Gidenne, 2003). Thus, responses to the dietary treatment may be expected to be great in rabbit feeding.

The EE digestibility was rather lower for the fermented diets compared to nonfermented diet. The higher initial EE contents in the anaerobic diets (Table 2) might be the reason for this outcome. In a previous study EE was observed to increase with anaerobic fermentation (Kwak et al., 2004). Lactic acid bacteria and yeasts can produce ethanol among other products during the fermentation process (Prescott et al., 1996).

The improved ash digestion in the fermented diets compared with the dry diet might have been due to an increased mineral uptake by microbes in the fermented food residue mixture or to the improved bioavailability of minerals to the animals fed the fermented diets (Kim et al., 2007). The best response of fiber (NDF and ADF) and ash digestion to the 0.5% LAB culture plus anaerobically fermented diet was also supported by the report of Shanmuganathan et al. (2004) that microbial additives improved the nutrient digestion and feeding value of rice bran rich diets for rabbits.

Blood parameters

No differences in serum nutrients such as triglyceride, cholesterol, HDL, LDL, glucose and total protein contents among treatments indicate that feeding dry, aerobically fermented or anaerobically fermented diet with or without LAB culture had little effect on lipid, carbohydrate and protein homeostasis of rats. No change in blood parameters including serum albumin, globulin, albumin/globulin ratio, total bilirubin, alkaline phosphatase, alanine aminotransferase, aspartate aminotransperase, r-glutamyltransferase and lactate dehydrogenase contents suggests that feeding dry or fermented diets did not cause any abnormal liver functions in the rats. Serum uric acid levels in humans can be affected by dietary factors such as Zn (Umeki et al., 1986) and ascorbic acid (Sutton et al., 1983). In a study with rats increased levels of serum uric acid was shown to be associated with high blood pressure and renal disease (Mazzali et al., 2001). In the present study, the lower serum uric acid for the fermented diets might be induced by more urinary excretion of uric acid although water intake was not different among treatments. The exact mechanism of this phenomenon cannot be explained by this study. Serum urea-N and creatinine levels are used as indexes of renal function, and serum amylase levels, as a diagnostic aid for pancreatic carbohydrate metabolism. Serum urea-N, creatinine, and amylase levels were not affected ($p>0.05$).

Also, blood cell components, such as white blood cells, red blood cells and platelet counts, were not affected by the treatments. These results indicate that feeding either dry or fermented diets did not have a significant effect on the normal health of the rats.

In conclusion, compared with feeding a dry food residue-containing diet, feeding aerobically or anaerobically fermented diets showed better animal performance such as higher feed efficiency and growth rate. The improved performance was attributed to the desirable dietary protein conservation during the fermentation process and higher digestibilities of fiber (NDF) and crude ash for the fermented diets. Scholten et al. (1999) hypothesized that fermented diets can positively affect the gastric pH, number of coliform bacteria in the digestive tract, pancreatic secretion, villus architecture, digestibility of dietary nutrients and sleeping/resting time of monogastric animals compared with dry or non-fermented diets. The present study supports the observation that the improved performance of rat fed fermented food residue diets compared to a dried food residue diet resulted from increased dietary fiber and mineral digestion.

CONCLUSION

The conservation of dietary protein during the food residue fermentation process and the improved animal digestibility of NDF and crude ash resulted in improved performance of animals fed the fermented food residue diets. This study indicated that the fermentation process improved the dietary nutrient availability and the utilization of nutrients by animals fed food residue-containing diets.

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