Research Note

ANAEROBIC DIGESTION AND DIRECT ACIDIFICATION OF POULTRY PROCESSING SLUDGE FOR ANIMAL DIETS[1]

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J. Agric. Univ. P.R. 87(1-2):81-86 (2003)

Waste is an inevitable consequence of the manufacturing processes of the food industry. Appropriate handling of waste has become an essential part of modern processing management. As concerns over the environment have increased, processes which generate lucrative products, but have attendant unmanageable waste problems, can become unaffordable because of prohibitive disposal costs. In Puerto Rico, sludge from broiler processing causes a management problem for the industry and environmental pollution for the island. Presently, this sludge is leaving the processing plant for land disposal. Therefore, alternatives for sludge disposal represent a major concern for the broiler industry. Preview experiments with sludge from a tuna processing plant have shown that it is possible to ferment this by-product and include it in diets for tilapia and growing pigs without affecting animal performance (Alvelo, 2001; Sánchez et al., 2001; Sanjuan, 2000). However, because of differences in the chemical and microbiological composition, those results cannot be extrapolated to this poultry by-product; thus specific research is needed on sludge from broiler processing.

Two experiments were conducted with the objective of evaluating anaerobic fermentation and direct acidification as methods to convert sludge from a broiler processing plant (SBPP) into a potential animal feed ingredient. In both experiments, SBPP was obtained from the "Industrias Avícolas de P.R." processing plant, located in Coamo, Puerto Rico, and transported to the laboratory in plastic drums. The sludge and additives corresponding to each treatment were placed in polyethylene lab scale micro-silos (1 kg capacity) fitted with release valves (Check, PP, Cole-Palmer Inst. Co.)[5] to provide gas escape, and maintained at room temperature (28 to 30°C) until opened.

In experiment 1, SBPP was mixed with cane molasses at 0, 5, 10% and 20% (w/w). The sugar source was applied to weighed portions of sludge and mixed manually. For all treatments a commercial lactic acid-producing bacterial inoculant (LAPB) was added to provide 10^6 cfu/g of fresh material. Prior to ensiling, SBPP was analyzed for contents of dry matter percentage (48°C/72 h), ash (600°C/8 h), total-N (AOAC, 1991), crude fat

[1]Manuscript submitted to Editorial Board 14 May 2002.

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[5]Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipments or materials.

(AOAC, 1991) and water-soluble carbohydrates (WSC) (Dubois, 1956). Three silos per treatment were opened after two ensiling periods (0 and 14 d) and the fermented material was analyzed for pH, chemical composition and fermentation end products [Organic acids (Dairy One Lab, Ithaca, NY) and NH_3-Nitrogen (Strickland and Parsans, 1972)]. The data were analyzed as a completely randomized design with a four (cane molasses level) by two (fermentation days) factorial arrangement of treatments (Steel and Torrie, 1992) using the General Linear Model subroutine of SAS (1990). The Bonferroni-t test was used for mean separation.

The initial SBPP had moderate crude protein, crude fat, and inorganic matter content (Table 1). When mixed with cane molasses and the LAPB inoculant and fermented for 14 days, the pH and WSC content of the resulting SBPP were lower ($P < 0.05$) than those of the control (Table 2). Fermented SBPP had a higher ($P < 0.05$) organic acid content (VFA and lactic acid) than SBBP ensiled without the sugar and bacterial sources, but lower ($P < 0.05$) NH_3-nitrogen and NH_3/Total-N ratio. Other chemical components of the mixtures (e.g., crude protein, crude fat) were similar among treatments during the fermentation process. As was found previously with sludge from a tuna processing plant (Alvelo, 2001; Sanjuan, 2000), these results indicated that it is possible to ferment SBBP with addition of a carbohydrate source and lactic acid-producing bacteria. It seems that a 10% proportion of cane molasses is the minimum addition required to obtain a stable fermentation. Fermented SBPP with cane molasses applied at 10% (w/w) has a pH value lower than five, a lactic acid content higher than 1.5% on a dry matter basis (DMB), and an acetic acid concentration lower than 0.8% (DMB), values used as criteria to define a good quality fermentation.

In experiment 2, SBPP was fermented with cane molasses applied at 0, 10, and 20% (w/w) or acidified with glacial acetic-acid applied at 15% (w/v). Triplicate samples from each treatment were opened after 14 days of fermentation or after 42 and 62 days of acidification. After opening, samples from each treatment were analyzed to determine pH, chemical composition and fermentation products as previously described. The data were analyzed as a completely randomized design (Steel and Torrie, 1978) using the General Linear Model subroutine of SAS (1990). The Bonferroni-t test was used for mean separation.

Similar to findings in experiment 1, the fermentation characteristics of SBBP improved as content of cane molasses was increased in the mixture. The pH and NH_3/Total-N ratios of SBPP fermented with 20% cane molasses were lower ($P < 0.05$) than those of

TABLE 1.—*Chemical composition and pH of sludge from a broiler processing plant.*

Item	Mean
pH	6.64
Chemical composition, (g / 100 g DM)	
Dry matter	21.01
Organic matter	88.43
Inorganic matter	11.57
Crude protein	14.52
Crude fat	16.25
NH_3 nitrogen	0.04
NH_3/ Total-N	0.28
Water soluble carbohydrates[1]	0.00

[1]Wet basis

TABLE 2.— *Fermentation characteristics of sludge from a broiler processing plant treated with different levels of cane molasses and a lactic acid-producing bacterial inoculant.*

Item	Fermentation day	Proportion SBBP: Cane molasses				SEM[1]	Probability		
		100:0	95:5	90:10	80:20		T[2]	D[3]	T*D[4]
pH	0	6.83 a[5]	5.74 b	5.78 b	5.86 c	0.13	0.01	0.01	0.01
	14	6.44 a	5.10 b	4.85 c	4.11 d				
Chemical composition (g / 100 g DM)									
Dry matter	0	20.90	21.47	25.45	30.60	0.56	0.01	0.01	0.47
	14	21.13	22.41	26.56	31.12				
Organic matter	0	88.30	88.52	87.40	88.59	0.26	0.73	0.01	0.28
	14	88.56	88.34	87.21	88.86				
Inorganic matter	0	11.69	11.47	12.63	11.40	0.26	0.84	0.01	0.38
	14	11.49	11.66	12.79	11.23				
Crude protein	0	14.25	19.17	14.61	14.51	0.16	0.94	0.79	0.22
	14	14.79	14.35	14.12	14.24				
Crude fat	0	17.72	17.07	18.45	18.25	0.55	0.11	0.22	0.50
	14	17.78	17.43	18.98	18.98				
Water soluble carbohydrates	0	0.00 a	2.05 b	5.08 c	9.93 d	0.68	0.01	0.01	0.01
	14	0.00 a	1.31 b	1.40 c	2.12 d				
Fermentation products (g / 100 g DM)									
Lactic acid	0	0.00	0.00	0.00	0.00	0.40	0.01	0.01	0.01
	14	0.00 d	0.68 c	2.07 b	4.70 a				
Acetic acid	0	0.00	0.00	0.00	0.00	0.14	0.01	0.01	0.01
	14	0.00 c	1.00 a	0.36 a	0.42 b				
Propionic acid	0	0.00	0.00	0.00	0.00	0.04	0.01	0.01	0.01
	14	0.00 c	0.69 a	0.63 a	0.17 b				
Butyric acid	0	0.00	0.00	0.00	0.00	0.04	0.01	0.01	0.01
	14	0.00 d	0.28 a	0.14 b	0.03 c				

TABLE 2.—*(Continued) Fermentation characteristics of sludge from a broiler processing plant treated with different levels of cane molasses and a lactic acid-producing bacterial inoculant.*

Item	Fermentation day	Proportion SBBP: Cane molasses				SEM[1]	Probability		
		100:0	95:5	90:10	80:20		T[2]	D[3]	T*D[4]
NH_3 nitrogen	0	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	14	0.08 a	0.03 b	0.02 b	0.02 b				
NH_3/ Total-N	0	0.77	0.65	0.57	0.49	0.20	0.01	0.01	0.01
	14	3.18 a	1.29 b	1.07 c	1.11 c				

[1]SEM = standard error of the mean
[2]T= effect of cane molasses level
[3]D= effect of fermentation day
[4]T*D= interaction T*D
[5]Means in the same row followed by different letters differ ($P < 0.05$).

TABLE 3.—*Characteristics of sludge from a broiler processing plant fermented with cane molasses and a lactic acid-producing bacterial inoculant or acidified with acetic acid.*

	Proportion SBBP: Cane molasses[1]			Acidified (acetic acid; 15%)			
Item	100:0	90:10	80:20	42 d	62 d	SEM[2]	Probability
pH	6.51 a[3]	4.80 b	4.16 c	3.65 d	3.62 d	0.04	0.01
Chemical composition (g/100 g DM)							
Dry matter	20.47 c	25.83 b	34.96 a	18.80 c	18.54 c	0.78	0.01
Organic matter	90.00	88.00	88.66	89.50	89.40	0.53	0.01
Inorganic matter	10.00	12.00	11.33	10.49	10.59	0.69	0.71
Crude protein	19.09	18.45	16.80	18.81	17.04	0.88	0.65
Crude fat	17.96	17.90	16.97	18.25	17.13	0.32	0.91
Water soluble carbohydrates	0.00	1.93	2.82	0.00	0.00	0.71	0.01
Fermentation products (g/100 g DM)							
Lactic acid	0.00 d	2.06 db	5.10 a	0.06 c	0.02 c	0.05	0.01
Acetic acid	0.31 c	1.17 b	0.78 b	12.89 a	14.70 a	0.49	0.01
Propionic acid	0.32 b	0.70 a	0.18 c	0.06 d	0.05 d	0.07	0.01
Butyric acid	0.22 a	0.15 b	0.04 c	0.02 c	0.02 c	0.07	0.01
NH_3 nitrogen	0.08 a	0.03 b	0.02 c	0.01 d	0.01 d	0.01	0.01
NH_3/ Total-N	2.69 a	1.12 b	1.07 b	0.33 c	0.36 c	0.31	0.01

[1]Fermented for 14 days

[2]SEM = standard error of the mean

[3]Means in the same row followed by different letters differ ($P < 0.05$).

SBPP with 10% molasses or without the sugar source, but the lactic acid content was higher (Table 3). Sludge from poultry processing plants acidified with glacial acetic-acid (15% v/v) had lower ($P < 0.05$) pH, lactic acid content and NH_3/ Total-N than fermented sludge, but logically, the acetic acid content was higher. No differences were observed between SBPP acidified for 42 or 62 d. These results show that direct acidification prevented the microbial activity associated with the fermentation process, thus preserving the nutrient composition of the fresh sludge.

On the basis of this study we concluded that SBPP could be fermented with a minimum of 10% cane molasses and a LAPB inoculant or acidified with acetic acid to preserve the nutrient profile. However, economic and safety considerations will determine the practical utilization of SBPP. Future research, including incorporation of fermented or acidified SBPP at different levels in animal diets, should be undertaken because of the present need to partially reduce imported protein (soybean meal) and energy (corn) supplying ingredients for use in animal diets, and to reduce the negative environmental impact of disposal of this waste.

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