Effect of Pressure and Temperature on Poultry Offal Meal Quality

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ABSTRACT In two experiments, 720 broiler strain cockerels were used to determine the effect of pressure and temperature on poultry offal meal (P.O.M.) quality. Poultry offal meals were subjected to 20, 28 and 35 pounds per square inch gauge (p.s.i.g.) steam pressure for <1 or 15 minutes (Experiment 1) and 15, 30 and 45 p.s.i.g. steam pressure for 15 or 30 minutes (Experiment 2). All pressures were allowed to reach operating level in a commercial-type pressure cooker and pressuring time started at this point. P.O.M. was added to a corn gluten meal-sesame meal basal diet at 5 and 10%, and fed to three replicates of 10 chicks each for a 4-week test period.

Maximum chick weight, feed efficiency and lysine availability were obtained by processing P.O.M. at either 20 p.s.i.g. steam pressure for <1 minute or 15 p.s.i.g. steam pressure for 15 minutes. Quantities of available lysine for the chemical method and growth assay were 2.30 and 3.28%, respectively, when P.O.M. was processed at 20 p.s.i.g. steam pressure for <1 minute and 2.47 and 3.77%, respectively, when P.O.M. was processed at 15 p.s.i.g. steam pressure for 15 minutes.

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INTRODUCTION

Poultry offal meal (P.O.M.) has been used extensively as a recycling product of the poultry industry. The meal is a valuable feed supplement in the diets of fur-bearing animals (Bassett and Wilke, 1948), household pets (Morris, 1946), hogs (Kahle and Gray, 1957) and poultry (Potter and Fuller, 1967). Potter and Fuller (1967) stated that P.O.M. had the physical characteristics that make it satisfactory for mixing into poultry diets although the final product may vary in composition as a result of variations in proportions of the starting materials.

During the manufacture of protein meals, heat and pressure are used to reduce moisture and produce a friable product. Any overheating during processing of proteins has a deleterious effect upon the feeding value of the protein (Greaves *et al.*, 1938; Clandinin *et al.*, 1946, 1947; Pader *et al.*, 1948; Clandinin and Robblee, 1951; Carpenter *et al.*, 1962; Ford and Shorrock, 1971; Varnish and Carpenter, 1975).

Binkley and Vasak (1950) suggested a method for treating feathers to produce a friable protein meal. This method is essentially a wet cooking process in which feathers are treated with saturated steam at pressures of 40 to 60 pounds per square inch gauge (p.s.i.g.) for 30 to 60 minutes with constant agitation. Bhargava and O'Neil (1975) pressured waste products from poultry processing plants, including blood, feathers, head, shanks, feet and inedible viscera, at 40 p.s.i.g. steam pressure for 30 minutes and then cooked the materials for three hours to reduce the moisture content to approximately 7 to 8%. Morris and Balloun (1971) cooked feathers at either 40 or 50 p.s.i.g. steam pressure for 30 or 60 minutes and obtained satisfactory growth rates when the material was fed to broiler chicks. Hamm and Searcy (1976) cooked raw blood at 85° C. for 10 minutes or 126° C. (20 p.s.i.g.) for 60 minutes, then dried the blood samples under various conditions at temperatures ranging from 23° C. to 193° C. and concluded that as temperature and time of exposure increased, available lysine decreased.

Clandinin *et al.* (1947) showed that heating solvent-extracted raw soybean flakes in the autoclave for over 20 minutes at 15 p.s.i.g. steam pressure resulted in a gradual decrease in nutritive value. Carpenter *et al.* (1962) recorded

decreases of up to 75% of the initial values for lysine, methionine, arginine and tryptophan when herring press cake was heated at temperatures of 85 to 145° C. Reisen *et al.* (1947) reported that the decreased nutritive value of overheated soybean meal was associated with the decreased liberation of essential amino acids. Lea *et al.* (1960) reported that when the temperature of heating was raised to 115° or 130° C., binding of lysine epsilon amino groups was greatly increased causing decreased absorption of lysine.

Because lysine may be a limiting amino acid in practical poultry diets, much attention has been focused on this particular amino acid. Eldred and Rodney (1946) and Pader *et al.* (1948) showed lysine to be unique among the essential amino acids in that the rate and, in some tests, the extent of its release from a protein is considerably less than that of other amino acids when the dried protein is heated at high temperatures or autoclaved for 20 hours. These workers found the decreased release of lysine to be due to the formation of enzyme-resistant bonds involving the epsilon amino group. Evans and Butts (1949) found that autoclaving causes two types of inactivation of lysine: (1) a reaction of lysine with sucrose to destroy lysine and (2) a reaction with proteins to render it unavailable after enzymatic digestion *in vitro*.

Many methods have been used for determining lysine availability. Netke and Scott (1970) developed a regression analysis and applied the slope-ratio techniques for estimating lysine availability. Carpenter and Ellinger (1955) reported a procedure based on dinitrofluorobenzene reagent which proved useful for testing the availability of lysine. Carpenter (1960) developed a routine method for estimating the amount of lysine with free epsilon amino groups; he used dinitrofluorobenzene as the reagent. Another reagent, 2-, 4-, 6-trinitrobenzene sulfonic acid was developed by Okuyama and Satake (1960) and Satake *et al.* (1960) to determine the free-amino groups of amino acids and peptides in column eluates. Kakade and Leiner (1969) reported a simple method involving the use of 2-, 4-, 6-trinitrobenzene sulfonic acid which was developed to determine specifically the lysine content of protein foodstuffs.

Because P.O.M. must be processed to obtain a friable product that can be used in poultry diets, an evaluation of pressures and temperatures used in these processes should be evaluated. Therefore, the following study was conducted to determine the effect of pressure and temperature on P.O.M. quality.

EXPERIMENTAL PROCEDURE

Broiler strain cockerels obtained from a commercial hatchery were used in two experiments to determine the effect of pressure and temperature on P.O.M. quality. P.O.M.'s were subjected to 20, 28 and 35 pounds per square inch gauge (p.s.i.g.) steam pressure for <1 or 15 minutes (Experiment 1) and 15, 30 and 45 p.s.i.g. steam pressure for 15 or 30 minutes (Experiment 2). All pressures were allowed to reach operating level in a commercial-type pressure cooker and pressuring time started at this point. Lower pressures were not used because a friable product could not be obtained. Corresponding temperatures for the 15, 20, 28, 30, 35 and 45 p.s.i.g. steam pressures are 121, 126, 133, 135, 138 and 145°C., respectively. All meals were processed by the method described by Bhargava and O'Neil (1975).

One-day-old chicks were wingbanded and randomly assigned to decks with raised wire floors in eleectrically heated battery brooders. Three replicates of 10 chicks each were fed each experimental diet to determine chick growth, feed efficiency and biological lysine availability when chicks were 4 weeks old. Test diets and tap water were furnished *ad libitum*.

A standard chick growth curve was established at the same time period under the same environmental conditions as those in Experiment 1 and 2 by adding 0, .1, .2, .3 and .4% L-lysine (L — lysine • HC1) to a corn-corn gluten meal-sesame meal basal diet. Compositions of basal diets are shown in Table 1. Biological lysine availability was determined by the method developed by Netke and Scott (1970).

Each test sample of P.O.M. was added to the basal diet at 5 and 10% (Table 1). All nutrients were balanced to meet or exceed the National Research Council's (N.R.C., 1971) requirement level except for lysine and sulfur amino acids. Lysine was allowed to vary with each diet.

P.O.M. chemical lysine availability was determined by the procedure described by Kakade and Leiner (1969) where the reaction of trinitrobenzene sulfonic acid with the epsilon amino group of the test proteins was used. The specificity of the technique des-

TABLE 1.—*Composition and calculated analyses of diets*

Ingredient	Composition, %		
	Basal	Added poultry offal meal, %	
		5%	10%
Yellow corn	70.70	70.91	71.12
Sesame meal, 42% protein	8.00	8.00	8.00
Corn gluten meal, 61% protein	16.85	11.91	6.96
Poultry offal meal	0	5.00	10.00
Dicalcium phosphate (19.5% P, 22% Ca)	1.81	1.53	1.26
Limestone	0.37	0.34	0.30
Salt	0.25	0.25	0.25
Fat	1.50	1.50	1.50
Fermacto-500	0.25	0.25	0.25
Methionine hydroxy analogue, Ca, 93%	0.02	0.06	0.11
Premix[1]	0.25	0.25	0.25
Total	100.00	100.00	100.00
Calculated Analysis:			
Crude protein, %	20	20	20
Metabolizable energy, kcal./kg.	3146	3146	3146
Calcium, %	.85	.85	.85
Available phosphorus, %	.45	.45	.45
Lysine, %	.50	.55	.60
Methionine, %	.90	.90	.90

[1] Furnished the following amounts of other ingredients per kilogram of feed: Vitamin A palmitate, gelatin coated 6614 I.U.; vitamin D_3, 1654 I.C.U.; vitamin E, 2.2 I.U.; riboflavin, 4.4 mg.; niacin, 27.6 mg.; d-pantothenic acid, 8.8 mg.; folic acid, 275.6 mcg.; vitamin B_{12}, 8.8 mcg.; choline chloride, 551 mg.; ethoxyquin, 55 mg.; menadione sodium bisulfite 1.7 mg.; pyridoxine, 0.55 mg.; manganese, 66.25 mg.; zinc, 44 mg.; iodine, 1.25 mg.; iron (in sulfate form), 20 mg.; copper (in sulfate form), 2 mg.

cribed in their report for the epsilon amino groups of protein is evident by the fact that subsequent to acid hydrolysis of the trinitrophenyl protein, the trinitrophenyl amino acids can be extracted with ether; whereas, epsilon trinitrophenyl lysine remains in the aqueous phase where it can be determined spectrophotometrically.

The analysis of variance (Steel and Torrie, 1960) was used to examine data statistically. Duncan's new multiple range test (1955) was used to separate means that were significantly different. All statements of significant differences refer to the 5% level of probability.

RESULTS AND DISCUSSION

The addition of lysine to a low-lysine basal diet containing 0.50% lysine resulted in increased chick growth and better feed efficiency with increasing levels of added lysine (Table 2). Chick weight was used as the criterion in testing biological lysine availability.

Chick weights were higher when chicks were fed P.O.M. processed at 20 p.s.i.g. in Experiment 1 and at 15 p.s.i.g. in Experiment 2 when

TABLE 2.—*L-lysine standard reference curve*

Added L-lysine, %[1]	Four-week results[2]	
	Mean chick weight, g.	Feed gain
0	84[e]	2.34[e]
.1	112[d]	2.10[d]
.2	136[c]	1.97[c]
.3	187[b]	1.85[b]
.4	210[a]	1.69[a]

[1] L-lysine·HCl (98%) was added to a corn gluten meal-sesame meal basal diet containing .50% lysine.

[2] Means within a column and without a common superscript are significantly different ($P<0.05$).

the meals were incorporated at both 5 and 10% of the diet (Table 3). When P.O.M. was processed at different steam pressures for <1 minute (Experiment 1) or 15 minutes (Experiment 2), composite chick weights were higher when P.O.M. was fed at 10% of the diet. Differences in body weights due to pressuring time were significant when P.O.M. was fed at 5% of the diet. Body weights were higher when 10% P.O.M. was fed than when 5% was fed in both Experiments 1 and 2 at all levels of pressures and pressuring times.

Generally, no significant differences in feed efficiency due to processing time were noted (Table 4). However, when P.O.M. was incorporated into the diet at 5%, feed efficiency was significantly better by feeding P.O.M. subjected to <1 minute of steam pressuring time than to 15 minutes steam pressuring time (Experiment 1). Generally, differences in feed efficiencies were not significant when P.O.M. was processed at either 20 or 28 p.s.i.g. (Experiment 1) and 15 or 30 p.s.i.g. (Experiment 2) steam pressures. Feed efficiencies of chicks fed P.O.M. processed at lower steam pressures in both experiments were significantly lower than those of chicks fed P.O.M. processed at either 35 (Experiment 1) or 45 (Experiment 2) p.s.i.g. pressures. In Experiment 1, when P.O.M. was fed at 5% of the diet, P.O.M. processed at 20 p.s.i.g. steam pressure resulted in a significantly lower feed efficiency than that of P.O.M. processed at either 28 or 35 p.s.i.g. steam pressures.

Because at least 30 minutes is required to maximize the steam pressure to 15 p.s.i.g., results of this study indicate that not more than 30 minutes is required to achieve maximum nutritive value. These results were similar to Clandinin *et al.* (1947) who showed that heating of solvent-extracted raw soybean flakes in the autoclave for over 20 minutes at 15 p.s.i.g. steam pressure resulted in a gradual decrease in nutritive value. Results also indicate the maximum pressures that should be used to commercially process P.O.M. to be approximately 20 p.s.i.g. steam pressures. Corresponding temperatures of 15 and 20 p.s.i.g. steam pressures are 121 and 126° C., respectively. Because Lea *et al.* (1960) and Carpenter *et al.* (1962) reported destruction or binding of amino acids occurring in overheated protein, indications are that 121 and 126° C. temperatures reported in this study are sufficient to either destroy or bind amino acids; however, the 15 and 20 p.s.i.g. (121 and 126° C. temper-

TABLE 3.—*Chick weight results showing the effect of pressure and temporary on poultry offal meal quality*

Steam pressure, p.s.i.g.	Internal temperature, °F.	Four-week chick weight, g. 5% P.O.M. Pres. time, minutes <1	15	Mean[1]	10% P.O.M. Pres. time, minutes <1	15	Mean[1]
Experiment 1							
20	126	179	176	178[a]	211	203	207[a]
28	133	168	165	166[b]	190	185	188[b]
35	138	166	168	167[b]	187	175	181[b]
		171[c]	170[c]		196[a]	188[b]	
		Pres. time, minutes 15	30	Mean[1]	Pres. time, minutes 15	30	Mean[1]
Experiment 2							
15	121	185	172	178[a]	215	203	209[a]
30	135	169	166	168[b]	199	186	192[b]
45	145	164	160	162[b]	183	182	182[c]
		173[c]	166[c]		199[a]	190[b]	

[1] Means within a column grouping or row and without a common superscript are significantly different ($P<0.05$).

TABLE 4.—*Feed efficiency results showing the effect of pressure and temperature on poultry offal meal quality*

Steam pressure p.s.i.g.	Internal temperature, ° F.	Feed/Gain					
		5% P.O.M.			10% P.O.M.		
		Pres. time, minutes			Pres. time, minutes		
		<1	15	Mean[1]	<1	15	Mean[1]
Experiment 1							
20	126	2.23	2.45	2.34[a]	2.28	2.34	2.31[a]
28	133	2.41	2.66	2.54[b]	2.39	2.42	2.40[ab]
35	138	2.73	2.76	2.74[c]	2.46	2.53	2.50[b]
		2.46[a]	2.62[b]		2.38[a]	2.43[a]	
		Pres. time, minutes			Pres. time, minutes		
		15	30	Mean[1]	15	30	Mean[1]
Experiment 2							
15	121	2.33	2.37	2.35[a]	2.20	2.25	2.22[a]
30	135	2.61	2.58	2.60[ab]	2.35	2.38	2.36[ab]
45	145	2.72	2.66	2.69[b]	2.49	2.58	2.54[b]
		2.55[c]	2.54[c]		2.35[a]	2.40[ab]	

[1] Means within a column grouping or row and without a common superscript are significantly different ($P<0.05$).

ature) steam pressures used in this study were found to be minimum to obtain a friable product.

Available lysine is one indication of binding of lysine and is used extensively to determine the quality of protein meals subjected to different pressures and temperatures (Eldred and Rodney, 1946; Reisen *et al.*, 1947; Pader *et*

TABLE 5.—*Available lysine in processed poultry offal meal obtained by chemical and biological methods*

Steam pressure, p.s.i.g.	Pressure time, mins.	Available lysine, %[1]	
		Chemical method (TNBS)	Biological method
Experiment 1			
20	< 1	2.30[a]	3.28[a]
20	15	2.15[ab]	2.88[b]
28	< 1	1.93[bc]	1.97[c]
28	15	1.76[cd]	1.66[cd]
35	< 1	1.52[de]	1.76[cd]
35	15	1.31[e]	1.56[d]
Experiment 2			
15	15	2.47[a]	3.77[a]
15	30	2.03[b]	2.62[b]
30	15	1.98[bc]	2.33[b]
30	30	1.83[c]	1.76[c]
45	15	1.67[d]	1.52[cd]
45	30	1.60[d]	1.20[d]

[1] Means within a column grouping and without a common superscript are significantly different ($P<0.05$).

al., 1948; Lea *et al.*, 1960; Carpenter *et al.*, 1962; Netke and Scott, 1970; Varnish and Carpenter, 1975). Results of biologically and chemically available lysine analyses are shown in Table 5.

As steam pressure increased in both Experiments 1 and 2, both biological and available lysine decreased. These results were similar to those of Hamm and Searcy (1976) who cooked raw blood at 85° C. for 10 minutes or at 126° C. (20 p.s.i.g.) for 60 minutes and concluded that as temperature and time of exposure increased, available lysine decreased. Quantities of available lysine were 2.30% for the chemical method and 3.28% for the biological method when P.O.M. was processed at 20 p.s.i.g. for <1 minute and 2.47 and 3.77%, respectively, when P.O.M. was processed at 15 p.s.i.g. for 15 minutes. Although the 15 p.s.i.g. (121° C.) and 20 p.s.i.g. (126° C.) steam pressures are sufficient to either destroy or inactivate amino acids (Lea *et al.*, 1960; Carpenter *et al.*, 1962; Hamm and Searcy, 1976), pressures and temperatures used were found to be minimum to obtain a friable P.O.M. At least some of the lysine in this study was rendered unavailable when P.O.M.'s were subjected to pressure and temperature treatments. Similar results were reported by Evans and Butts (1949). Although higher available lysine values were obtained with the biological method when compared to the chemical method, available lysine decreased as pressures and temperatures increased.

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