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## NUTRITIONAL VALUE OF FEATHER AS AFFECTED BY STEAM PROCESSING

(With 5 Tables)

By

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(Received at 30/9/1992)

### تأثير درجة معاملة الريش بالبخار على قيمته الغذائية

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تم جمع الريش الطازج من مجزر محلى و عومل تحت 3 مستويات من الضغط ( 2، 2.5، 3، 4، 5 كجم / سم ) لأربعة أزمنة مختلفة ( صفر ، 60 ، 75 ، 90 دقيقة ) باستخدام اتوكلاف المعمل. تم تحليل كل من الريش الغير معاملى والريش المعاملى لمعرفة التركيب الكيماوى لها. أجرى تقدير الهضم الخارجى باستخدام الببسين فى حامض الهيدروكلوريك لكل من المادة الجافه والبروتين الخام فى الريش المعاملى وغير المعاملى. استخدم ريش عومل بثلاث طرق مختلفة ليحل محل كسب فول الصويا فى علائق الأغنام لدراسة تأثير المعاملات على هضم العلائق لذلك اجريت أربعة تجارب هضم على حملان تم تغذيتها على اربعة علائق مضاف اليها الريش المعاملى بطرق مختلفه. وقد أوضحت النتائج ان معاملة الريش لم تؤثر معنوياً على تركيبه الكيماوى. وقد أوضحت نتائج الهضم بالببسين أنه لا يوجد تأثير مشترك بين الضغط وزمن المعاملات على معدل هضم كل من المادة الجافه وكذلك البروتين. زيادة زمن المعاملات وكذلك الضغط المستخدم أدى الى زيادة هضم الببسين لكل من المادة الجافه والبروتين الخام. احلال الريش محل كسب فول الصويا لم يؤثر معنوياً فى معاملات هضم المركبات الغذائيه للعلائق. لوحظت فروق عدديه موجبه عند احلال الريش المعاملى تحت ضغط 3 كجم / سم مربع لمدته 90 دقيقه محل كسب فول الصويا ( البروتين الخام 1.8 ٪ مستخلص الأثير 2.1 ٪ والألياف الخام 9.6 ٪ ) وكان هناك نقص عددى عند احلال الريش المعاملى عند 3 كجم / سم ضغط عند الزمن صفر محل كسب فول الصويا ( البروتين الخام 5.4 ٪ والمستخلص الخالى من الأوت 3 ٪ ) ويستنتج من هذا البحث ان الريش المعاملى تحت 3 كجم / سم مربع لمدته 90 دقيقه يمكن استخدامه كمصدر جيد للبروتين فى علائق المجترات .

## SUMMARY

Fresh feather was collected from local slaughter-house and processed at 3 pressures (2, 2.5 and 3 Kg/cm) for 4 different times (0, 60, 75 and 90 min.) using laboratory autoclave. Nonprocessed feather (NPF) as well as processed feather (PF) were analyzed for approximate analysis. In vitro pepsin-HCl digestibility of dry matter (DM) and crude protein (CP) was calculated for both of NPF and PF. Three different PF were used to replace soybean meal (SBM) in three diets to test the effect of processing on digestibility. Four in vivo digestibility trails were conducted using the previous diets. The results indicated that the processing has no effect on chemical composition of feather. The in vitro study indicated that there was no interaction effect of pressure and time of processing on the digestibility of both DM and CP. Increasing time and/or pressure increased the pepsine-HCl digestibility for both DM and CP. Replacement of SBM by any of the three processed FM had no effect on digestibility of diet nutrients. Positive numerical differences were observed in digestibility of CP (1.8%), EE (2.1%) and CF (9.6%) when feather processed at 3 Kg/cm for 90 min replaced SBM. However, negative numerical differences were observed when feather processed at 3 Kg/cm for 0 min. time replaced SBM (4.5 and 3% for CP and NFE resp.). The conclusion of the present study is that feather processed at 3 Kg/cm for 90 min could be used as a good source of CP for ruminants.

## INTRODUCTION

Recent trends in livestock feeding is directed to increase the use of animal byproducts and wastes as substitutes for the more conventional energy and protein sources. Hydrolyzed feather meal (FM) which contain from 85 to 99% protein, is promising animal byproduct from the industry (DAUGHERTY and CHURCH, 1982). Different studies indicated that FM, when processed properly, is an excellent protein supplement comparable to cottonseed meal (CSM) or soybean meal (SBM) per unit of N in ruminant diets (ADERIBIGBE, 1981 and CHURCH *et al.*, 1982). However, there is a lack of specific relationship between the way of processing and utilization of this N source by ruminant (ADERIBIGBE, 1981).



Current processing of feather meal or similar protein sources involves steam cooking under pressure, usually with constant agitation (MORAN *et al.*, 1967 and THOMAS & BEESON, 1977). The standard definition adapted for FM by the Association of American Feed Control Officials (AAFCO) specified that FM should contain not less than 70% digestible crude protein (DAVIS *et al.*, 1961) as measured with pepsin-HCl (AOAC, 1975).

Objectives of the present study were: (a) to study the effect of FM processing on its chemical composition; (b) to determine the minimum amount of processing needed for optimum pepsin-HCl digestibility; (c) to compare the digestibility of diets containing SBM and FM processed under different pressures for different times.

## MATERIAL and METHODS

Chemical analysis and *in vitro* pepsin-HCl digestibility beside four *in vivo* digestion trials were conducted to achieve the objectives of this study.

### Feather processing:

Fresh chicken feather collected from a local slaughter house were washed thoroughly with water and 250 g portions were steam cooked in a laboratory autoclave. Cooking time and pressure were designed at 3x4 factorial, three pressures 2, 2.5 and 3 Kg/cm and four cooking times, 0, 60, 75 and 90 min were used. Timing starts when the desired pressure was reached. Feathers of zero treatments was cooked until the proper pressure was reached. Feathers were then dried at 50 C and ground in a willy mill with 20 mesh screen (ADERIBIGBE and CHURCH, 1983). Triplicate portions of each FM were analyzed for CP, CF, ash, and EE using the AOAC (1975) procedure.

### In vitro pepsine-HCl dry matter and CP digestibility:

Each feather either processed or not were used in the *in vitro* pepsin-HCl digestibility for DM and CP. Triplicate samples of each feather were used. Pure casein was tested to measure the recovery of the *in vitro* study. Pepsin-HCl digestibility of casein averaged 93% for DM and 91.2% for CP. The results of tested feathers were then corrected. The pepsine-HCl digestibility was calculated using the AOAC (1975) procedure.

### In vivo digestion studies with wether lambs:

Four digestion trials were conducted with Ossimi wether lambs. Eight wether lambs were used in the study. About 35% of CP in the tested diets was supplied by either SBM (control) or one of three processed feathers. The processed feathers were chosen according to the definition adapted for FM.



by the AAFCO (DAVIS *et al.*, 1961) except for that processed at 3 Kg/cm<sup>2</sup> for zero time which had been chosen in a trial to decrease the cost of processing. According to this definition feathers processed at 2, and 3 Kg/cm<sup>2</sup> for 90 min were chosen. Pepsin-HCl digestibility of the chosen FM in trails 2, 3 and 4 were 74.2, 62.9 and 90.6% respectively. Diets ingredients and chemical analysis are shown in table 1.

Experimental feeds, feces and feathers were analyzed for proximate component as described by AOAC (1975).

Statistical analysis. data for the effect of processing on chemical composition, in vitro pepsin-HCl digestibility and in vivo digestibility results were analyzed by use of one-way analysis of variance (COCHRAN and COX, 1957). Treatments means were compared by use of LSD as outlined by STEEL and TORRIE (1980).

## RESULTS

Data obtained from the laboratory hydrolyzed chicken feather (at different times and different pressures) are shown in table 2. There was no interaction effect of processing time and pressure on all components except for CF and EE content. The processing (time or pressure) has no effect on DM, CP, CF and NFE content of processed feather, while it affects EE and Ash content.

Data in table 3 represent the effect of processing on the in vitro DM and CP digestibilities. Statistical analysis indicated that there was no interaction effect of processing time and pressure on DM or CP digestibility. Increasing time of processing or pressure increased significantly ( $P < .05$ ) the CP digestibility. The same results were observed for DM digestibility, this because feather is almost all protein. The correlation coefficient between CP and DM digestibility is .78 ( $P < .01$ ).

Data of the effect of processing on the in vivo digestibility is present in table 4. Digestibility of almost all nutrients was the lowest for diet contain feather processed at 3 Kg/cm<sup>2</sup> for zero time except for the CF which was the lowest for the control diet. On the other hand, digestibility of almost all nutrients was the highest for diet contain feather processed at 3 Kg/cm<sup>2</sup> for 90 min but all these differences were not significant.



Data of N metabolism for the experimental lambs are shown in table 5. Although, there were no significant differences among diets in all items, there were numerical differences exist among diets. Fecal N excretion was about 33.6% higher in diet 3 than both control diet and diet 4. This was probably due either to the higher level of N in that diet or to the insufficient treatment of the used feather (3 Kg/cm<sup>2</sup> for zero time). The higher urine N was excreted by lambs fed the experimental diets than for those fed the control diet. The N retention expressed as g/Kg of metabolic weight (g/Kg BW), was higher for the supplemented diets than the control diet. The value obtained for diet 3 (.305) was lower than those obtained for diets 2 and 4 (.327 and .325 respectively). This further illustrates the high potential utilization of well processed FM. Biological value (percentage of absorbed N that was retained) was higher for the supplemented diets than the control diet.

## DISCUSSION

The average CP content of the FM found by CHURCH *et al.* (1982) was higher than that obtained in the present study (94 vs 90%). On the other hand, the CP content of FM reported by ALLEN (1991) was lower than that found in the present study. CHURCH *et al.* (1982) in their study reported that CP content of FM was higher than others because it has been derived from chicken, turkeys and other species. In addition some meals may contain more nonfeather materials (head and skin). It is likely that these factors could account for some of the differences in CP concentration that have been reported.

THOMAS and BEESON (1977) found 5.8% EE in FM and attributed the higher values to modern mechanical feather pickers that beats off a large number of head into the feathers. CHURCH *et al.* (1982) reported that EE of FM is 3.1% which is the same as that reported in the present study. ALLEN (1991) reported that the true crude fat content of FM is 2.5%. Ash content reported by CHURCH *et al.* (1982) was lower (2.5%) while the value reported by ALLEN (1991) was higher (3.9) than that found in the present study. These differences may be due to the level of feather protein content reported in their studies.

Treated feather did not differ significantly from nontreated one. Increasing pressure and/or time of processing did not affect CP content of



treated feather. These results are in agreement with that obtained by STEINER *et al.* (1983).

*In vitro*: Pepsin-HCl digestibility is an accepted mean of evaluating digestibility of proteins for monogastric species. For ruminant it could be used to evaluate the low degradable protein sources. Different studies indicated that FM is very low degradable in the rumen (ADERIBIGBE & CHURCH, 1983 and MOUSA, 1988).

The obtained results for DMD and CPD are in agreement with that presented by DAVIS *et al.* (1961), they observed an increase in CPD with increasing hydrolysis time at a constant pressure of 2.46 Kg/cm. ADERIBIGBE and CHURCH (1983) found that increasing the cooking time from zero to 90 min increased the CPD from low of 7 to 62.9% respectively. They also added that increasing the cooking time to 105 or 120 min decreased the CPD to 55.6 or 49.2% respectively.

Pepsin-HCl digestibility (percentage) of the CP content of FM reported in the present study as an average was lower (73 vs 80.3%) than that of CHURCH *et al.* (1982). They reported that the CPD was 80.3% while in the present study it was 73% for FM cooked at 3 Kg/cm<sup>2</sup> and 75.5% for that cooked for 90 min. On the other hand, their value is lower than that obtained when feather was cooked at 3 Kg/cm<sup>2</sup> for 90 min in the present study. This conformed the idea that increasing the extent of hydrolysis during processing increases CPD (CHURCH *et al.*, 1982).

*In vivo*: GOEDEKEN *et al.* (1990) found that DM and total tract N digestibility did not differ significantly when lambs were fed SBM supplemented diet. On the other hand, these results do not agree with the previous data. THOMAS and BEESON (1977) reported that DM digestion values were unchanged but N digestion was reduced by 9% units when FM replaced SBM in the diets. CHURCH *et al.* (1982) reported that protein digestibility was reduced 5.7 and 8.5 percentage units in two digestion studies when FM replaced 70% of the SBM protein in the ration. In these studies, the replacement of SBM by FM may reduce the amount of protein degraded in the rumen and thus ruminal ammonia concentration may have been reduced below optimal level for maximal ruminal digestion. This could have increased the amount of digestion that occurred in the hind gut and thus, increased the amount of fecal microbial N which in turn reduced the apparent N digestibility for any ration (GOEDEKEN *et al.*, 1990).

The results of the N metabolism obtained in the present study are in agreement with that obtained by ADERIBIGBE and CHURCH (1983). Increasing



processing time and/or pressure of feathers cooking improved the utilization of FM produced. These results confirmed by the results of MORRIS and BALLOUN (1973 a,b) when they observed, in two experiments, that more intensive processing of FM (time and pressure) resulted in higher availability of amino acids and higher biological values for growing chicks.

Previous studies by (WARY *et al.*, 1979; DAUGHERTY & CHURCH, 1982; ADERIBIGBE & CHURCH, 1983; GOEDEKEN *et al.*, 1990) indicated that FM was comparable to CSM and SBM on a per unit N basis in ruminants diets. In the present study DCP was about 1% unit over in FM diet than that of the SBM diet (control). While the TDN value for the SBM diet was better than diet 2 and 3 and was equal to that of diet 4.

It could be concluded that FM processed at 3 Kg/cm for 90 min could be used as a source of protein in ruminant diets. Also, the effect of FM content in the dairy ration, growing animals and reproductive effect must be studied.

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Tabl 1. Diet composition, chemical analysis and feeding values

Items	Diet			
	1	2	3	4
Corn	% 40			
Nontraditional feed mix.	% 49	44.7	44.7	44.7
Soybean meal	% 10	49	49	49
Feather meal*	% —	—	—	—
Salt	% 1	5.3	5.3	5.3
		1	1	1
Chemical analysis				
DM	% 89.2			
CP	% 14.8	88.5	88.4	88.5
EE	% 3.1	16.1	16.6	16.1
CF	% 5.5	3.2	3.1	3.0
NFE	% 61.4	4.5	5.5	4.5
Ash	% 4.4	59.4	58.7	60.4
Feeding value		5.3	4.5	4.5
DCP	% 11.4			
TDN	% 74.1	12.3	12.0	12.7
		72.9	70.8	74.9

\*Feather processed for 90 min at 2 Kg/Cm<sup>2</sup> was used in diet 2.  
 Feather processed for 0 min at 3 Kg/Cm<sup>2</sup> was used in diet 3.  
 Feather processed for 90 min at 3 Kg/Cm<sup>2</sup> was used in diet 4.

Table 2. Chemical composition of feather as affected by processing.

Item	DM%	Analysis % of DM				
		CP	CF	EE	Ash	NFE
Nontreated	91.8	90.3	0.84	2.95 <sup>b</sup>	2.92 <sup>b</sup>	2.99
2Kg/Cm <sup>2</sup>						
0 min	93.0	90.0	0.52	3.25	2.65	3.28
60 min	95.0	90.6	0.61	3.30	2.84	2.69
75 min	93.0	87.0	0.75	3.90	3.30	5.05
90 min	94.0	89.3	0.69	3.30	3.60	2.16
Average	93.6	89.2	0.64	3.44 <sup>a</sup>	3.09 <sup>ab</sup>	3.55
2.5 Kg/Cm <sup>2</sup>						
0 min	95.0	90.0	0.80	3.00	3.40	2.83
60 min	93.0	91.0	0.60	3.30	2.70	2.40
75 min	94.0	90.4	0.65	3.60	3.40	1.95
90 min	93.0	90.1	0.55	4.10	2.35	2.86
Average	93.5	90.4	0.65	3.50 <sup>a</sup>	2.96 <sup>a</sup>	2.51
3.0Kg/Cm <sup>2</sup>						
0 min	94.0	90.7	0.32	3.25	3.55	2.20
60 min	93.0	90.5	0.71	2.55	3.30	2.94
75 min	93.0	90.3	0.45	3.50	2.60	3.15
90 min	93.0	90.5	0.80	2.45	3.85	2.40
Average	93.1	90.5	0.57	2.94 <sup>b</sup>	3.33 <sup>a</sup>	2.67
SEM	0.342	0.280	0.0239	0.075	0.075	0.21
Time average						
0 min	92.7	90.3	0.70	3.06 <sup>b</sup>	3.06	2.88
60 min	93.5	90.7	0.64	3.05 <sup>b</sup>	2.93	2.68
75 min	93.3	89.2	0.62	3.67 <sup>a</sup>	3.10	2.81
90 min	93.3	90.0	0.68	3.28 <sup>b</sup>	3.27	3.38

ab Means in the same column with different superscripts are different (P<.05)



Table 3. In vitro dry matter and protein digestibility of feather processed for different times and pressures.

Pressure	Time of processing min				Average
	0	60	75	90	
	CPD				
0					23.5c
2	15.9	28.6	23.2	74.2	33.4b
2.5	17.0	19.0	30.4	61.6	32.0b
3.0	62.9	67.2	71.4	90.6	73.0a
Average	27.7c	30.3b	41.6b	75.5a	42.2
SEM1					1.727
	DMD				
0					23.0c
2	42.8	31.8	14.35	62.8	37.9b
2.5	19.9	19.1	48.7	54.0	35.4bc
3.0	60.1	62.8	60.7	72.4	64.0a
Average	32.0b	37.9b	41.2b	63.1a	41.2
SEM					2.910

abc Means in the same row or in the same column with different superscripts are different (P<.05).

SEM= Standard error of mean.

Table 4. Effect of feather processing on the digestibility of rations

Item	Chemical composition					
	DM	OM	CP	EE	CF	NFE
	Diet 1					
Daily intake g.	986.6	927.2	140.2	29.5	132.5	623.9
Daily output g	210.3	170.9	32.2	3.6	55.3	80.2
Digested	776.3	756.3	108.0	25.9	77.2	543.7
Digestion Coeff. %	78.7	81.7	77.0	87.8	58.3	87.2
	Diet 2					
Daily intake g	980.5	912.8	151.9	30.8	123.5	606.4
Daily output g	201.0	166.4	36.0	3.6	43.9	82.9
Digested	779.5	746.4	115.9	27.2	79.6	523.5
Digestion Coeff. %	79.5	81.8	76.4	88.4	64.5	86.3
	Diet 3					
Daily intake g	979.6	919.1	156.2	29.6	132.5	600.2
Daily output g	233.3	193.1	43.0	3.6	49.9	96.5
Digested	746.3	726.0	113.2	26.0	82.6	503.7
Digestion Coeff. %	76.2	79.0	72.5	87.8	62.3	84.0
	Diet 4					
Daily intake g	980.5	920.0	151.9	29.0	123.5	615.4
Daily output g	181.6	151.3	32.2	2.6	39.7	75.9
Digested	798.9	768.7	119.7	26.4	83.8	539.5
Digestion Coeff. %	81.5	83.6	78.8	90.9	67.9	87.7
SEM1	1.115	1.033	1.663	0.670	1.781	0.892

Daily feed was divided into two equal parts and fed at 0800 and 1600h.

1. SEM = Standard error of mean.

Diet 1 contains SBM as source of protein.

Diet 2 contains feather processed for 90 min at 2 Kg/Cm2.

Diet 3 contains feather processed for 0 min at 3 Kg/Cm2.

Diet 4 contains feather processed for 90 min at 3 Kg/Cm2.