Table II. Analysis of Variance of Results in Table I

Source of Variance	Degrees of Freedom	Mean Squares: Feed samples	Mean Squares: Bone samples
Total	59	...	...
Subgroup	11	3.0535	7.73190
Sample	5	6.71606[a]	16.93349[a]
Method	1	0.00670[b]	0.11625
Sample × method	5	0.00029	0.05343
Within sample	48	0.00004	0.00265

[a] Significant at $P = 0.001$.
[b] Significant at $P = 0.01$.

Table III. Recovery of Calcium Added to Feed and Bone Solutions

Feed Sample	% Recovery ± Std. Error: Oxalate method	% Recovery ± Std. Error: Back titration method
1	99.63 ± 0.16	99.44 ± 0.04
3	100.04 ± 0.04	99.33 ± 0.03
5	99.80 ± 0.06	98.90 ± 0.03
Bone Sample		
1	100.22 ± 0.08	100.11 ± 0.07
2	100.07 ± 0.10	100.08 ± 0.04
3	99.63 ± 0.08	99.90 ± 0.05

Table IV. Effect of Added Phosphate on the Determination of Calcium in Feed by the Back Titration Method

Feed Sample	Calcium Present, Mmoles	Phosphate Added, Mmoles	% Recovery ± Std. Error
1	0.02116	0.080	99.99 ± 0.09
1	0.02116	0.160	99.95 ± 0.09
1	0.02116	0.320	100.12 ± 0.04
3	0.04036	0.080	99.92 ± 0.03
5	0.03100	0.080	100.07 ± 0.05

curve) of volume of back titrant to known concentrations of calcium phosphate solution for each set of samples. This was checked by obtaining standard curves with both the oxalate and back titration methods. The respective equations of the standard curves for the oxalate and back titration methods were $\hat{Y} = 0.9780x - 0.0023$, and $\hat{Y} = 0.9902x - 0.0011$, while the respective standard deviations from regression (*7*) were 0.947×10^{-4} and 0.155×10^{-3}.

Statistical tests showed no significant differences between the two regression equations.

Recovery of known amounts of calcium added to the feed and bone solutions are presented in Table III. As in the feed analysis data of Table I, the standard error was lower with the back titration than with the oxalate method for both the feed and bone samples, which is contrary to the standard curve results. Recoveries with both methods were good and within the working range of our laboratory.

The effect of phosphate on the back titration method is presented in Table IV. The presence of a 15-fold concentration of phosphate did not influence the results provided the EDTA was added before the solution was made basic. Reversing this order of adding reagents resulted in varying results.

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TOMATO BY-PRODUCTS AS FEEDSTUFFS

Nutritive Value of Dried Tomato Pulp for Ruminants

C. B. AMMERMAN, L. R. ARRINGTON, P. E. LOGGINS, J. T. McCALL,[1] and G. K. DAVIS

Department of Animal Science, Florida Agricultural Experiment Station, Gainesville, Fla.

Dried tomato pulp, unlike dried tomato pomace and certain other tomato feed by-products, consists of the whole cull fruit. The fruit has been cut and pressed, with the resulting juice concentrated by evaporation and remixed with the press cake for further dehydration. Tomato pomace has been shown useful in feeding fur-bearing animals (*10*), and both tomato pomace and pulp have been found useful for chickens (*7, 8*), but only limited data are available to indicate the nutritive value of tomato by-products for ruminants. Chapman *et al.* (*4*) reported satisfactory gains of yearling steers grazing pasture and consuming 16 to 19 pounds daily of a concentrate containing 10 to 30% tomato pulp. Tomato pulp replaced citrus pulp at 10 to 30% of the concentrate, and the steers fed tomato pulp yielded carcasses equal in grade and acceptability to those fed citrus pulp.

The present study was conducted to determine the nutrient composition and nutrient utilization of dried tomato pulp by steers and lambs.

Experimental Procedure

The first experiment was a conventional digestibility trial conducted with three 2-year-old steers. A 21-day preliminary feeding period was followed by a 7-day total fecal collection period. Nutrient digestibility of the tomato pulp was determined by difference by feeding both Alyce clover hay alone and a mixture of 30% Alyce clover hay and 70% tomato pulp. In the second experiment conducted with the same animals, the tomato pulp was gradually increased in the ration until 100% pulp was fed for 17 days. Total fecal collections were taken during the last 7 days of this period for obtaining digestibility coefficients. Twelve to 14 pounds of the rations were fed daily in two equal feedings which maintained animal body weight. In addition, 25 grams of defluorinated phosphate (4.25 grams P, 8.75 grams Ca) and 25 grams of trace mineralized salt (Table I) were fed daily. Water was provided *ad libitum* during the preliminary period but was supplied twice daily when the steers were in the metabolism stalls.

Ten native lambs averaging 72 pounds in body weight were used to obtain

[1] Present address: Department of Animal Husbandry, Iowa State University, Ames, Iowa.

The disposal of cull tomatoes is a serious problem in certain tomato-growing regions. As a means of sanitary and practical disposal, the culls have been dehydrated and prepared in a form suitable for animal feeding. The chemical composition, nutrient digestibility by mature steers, and protein utilization by lambs indicate that dried tomato pulp (dehydrated whole cull tomatoes) is a potential feedstuff. The average proximate composition in per cent on the dry matter basis was as follows: ash, 10.6; ether extract, 4.2; protein, 24.0; crude fiber, 17.8; and nitrogen-free extract, 43.4. Average coefficients of digestibility obtained with steers for protein, ether extract, crude fiber, and nitrogen-free extract were 56.3, 90.2, 46.2, and 79.0, respectively. When supplying 58% of the total protein in the ration for lambs, nitrogen in tomato pulp had a lower digestibility coefficient ($P < 0.01$) and a lower biological value ($P < 0.05$) than nitrogen from soybean meal.

nitrogen balance data for the dried tomato pulp. Lambs were randomly assigned to either the tomato pulp or soybean meal ration shown in Table I. A 21-day preliminary feeding period was followed by a 7-day total fecal and urine collection period. The lambs were fed equal amounts twice daily, and water was provided *ad libitum*. The tomato pulp ration was somewhat unpalatable to the lambs, and daily feed intakes were maintained at only 700 grams for both rations. This level of feeding, however, allowed slight body weight gains by all lambs during the experiment. Because of the higher fiber content of the tomato pulp ration, 5% Solka floc was added to the soybean meal ration. The tomato pulp and soybean meal rations contained 12.7 and 13.1% protein, respectively, with approximately 58% of the total protein supplied by the test material in both rations.

Proximate analyses of the rations and feces and calcium and phosphorus determinations were made as outlined by A.O.A.C. (*1*). Magnesium and potassium were determined with the flame photometer as described by Breland (*3*), and pectic materials were determined according to the procedures of Rouse and Atkins (*13*). Iron and copper were determined by the methods of Sideris (*14*) and Cheng and Bray (*5*), respectively. Gross energy was measured with an adiabatic oxygen bomb calorimeter. The data were analyzed statistically by analysis of variance as described by Snedecor (*15*).

Results and Discussion

Tomato pulp used in these experiments was received with the flakes and screenings or fines bagged separately. The flakes were largely peel with some attached rag and were hygroscopic, requiring storage in a dry area to prevent molding. All of the fines passed through a No. 10 sieve, 86% through No. 20, 61% through No. 30, and 41% through a No. 40 sieve. The experimental material yielded 59% flakes and 41% fines at the time of processing and was mixed in this proportion for feeding. The composited material, referred to as tomato pulp, was bulky in nature having a density of 12.9 pounds per cubic foot and containing 17.8% crude fiber.

Table I. Per Cent Composition of Lamb Rations

Ingredients	Ration: Soybean meal	Tomato pulp
Snapped corn (ground)	42.0	42.0
Bahiagrass hay (ground)	20.0	20.0
Corn starch	15.5	1.0
Soybean meal (50% protein)	13.5	...
Tomato pulp	...	33.0
Solka floc[a]	5.0	...
Corn oil	2.0	2.0
Salt[b]	1.0	1.0
Defluorinated phosphate	1.0	1.0
	100.0	100.0

[a] Brown Co., 500 Fifth Ave., New York 36, N. Y.
[b] The Carey Salt Co., Hutchinson, Kan. Listed minimum analysis in per cent: Fe 0.27, Mn 0.25, Cu 0.033, Co 0.01, Zn 0.005, I 0.007, and NaCl 95.9.

The chemical composition of the tomato pulp and its component parts is shown in Table II. The proximate composition of the whole pulp was considerably different from that of tomato pomace as reported by Morrison (*11*). Expressed on a dry matter basis, the average percentages of ash, ether extract, crude fiber, and nitrogen-free extract in eight tomato pomace samples were approximately 3.5, 15.3, 32.2, and 25.1, respectively. Tomato pulp in the present study contained 10.6, 4.2, 17.8, and 43.4% of the corresponding nutrients, respectively. Both tomato pomace and the tomato pulp contained approximately 24% protein. In the preparation of the tomato pulp, approximately one half of the pressed juice was concentrated by evaporation and remixed with the pomace or press cake prior to dehydration. Since the juice portion is removed when making tomato pomace, this may explain a major part of the difference in composition between the two tomato by-products. As shown in Table II, the nutrient composition of the fines and flakes was similar. There was an indication, however, that the flakes were lower in ether extract and higher in potassium. Similar data were obtained by Dennison and Celmer (*6*). The values of 0.37 to 0.48% iron are con-

Table II. Chemical Composition of Tomato Pulp

	Fines	Flakes	Pulp
Proportion, %	41	59	100
Dry matter, %[a]	90.9	89.6	89.1
Energy, therms/pound	2.01	2.07	2.00
Proximate composition, %			
Ash	8.5	9.9	10.6
Ether extract	4.5	2.7	4.2
Protein	22.0	23.4	24.0
Crude fiber	17.4	18.8	17.8
Nitrogen-free extract	47.6	45.2	43.4
Mineral composition			
Calcium, %	0.56	0.42	0.58
Phosphorus, %	0.51	0.56	0.56
Magnesium, %[b]	0.20	0.18	0.20
Potassium, %[b]	2.50	3.45	3.63
Iron, %	0.48	0.37	0.46
Copper, p.p.m.	26.5	23.7	32.6
Pectic substances, %[c]			
H_2O soluble	5.29	6.08	8.90
NH_4 oxalate soluble	8.74	8.71	9.18
HCl soluble	4.24	3.85	4.45
Total	18.27	18.64	22.53

[a] Other than dry matter content, all values expressed on the moisture-free basis.
[b] Values were obtained by J. NeSmith, Soils Specialist, Agricultural Extension Service, University of Florida.
[c] Values were obtained by C. B. Hall, Dept. Food Technology and Nutrition, University of Florida.

Table III. Average Digestion Coefficients and Total Digestible Nutrients for Tomato Pulp, Steers[a]

	Per Cent				Total Digestible Nutrients[b]
	Protein	Ether extract	Crude fiber	Nitrogen-free extract	
Tomato pulp, fed with hay	58.0	94.6[c]	50.1	79.5	66.6
Tomato pulp, fed alone	54.6	85.8	42.2	78.4	63.1
Av.	56.3	90.2	46.2	79.0	64.8

[a] Each figure represents an average of three determinations.
[b] Expressed on the moisture-free basis.
[c] Significant at the 5% level.

Table IV. Nitrogen Balance Data for Lambs[a]

	Ration	
	Soybean meal	Tomato pulp
N intake, grams/day	14.71	14.27
N in feces, grams/day	4.56	7.04
N in urine, grams/day	5.94	5.57
N retained, grams/day	4.21	1.66
N retained, %	28.6[b]	11.6
Apparent digestibility of N, %	69[b]	51
Biological value of N	64[c]	57
Net apparent value of N	44	29

[a] Each figure represents an average of five determinations.
[b] Significant at the 1% level.
[c] Significant at the 5% level.

siderably higher than those reported by Albritton (*2*) for whole tomatoes and may be due in part to contamination from machinery during processing. Spectrographic examination indicated that no molybdenum was present.

The data obtained with steers indicated that the digestibility of each nutrient in the tomato pulp was slightly higher when determined by feeding with clover hay than when determined by feeding the tomato pulp alone (Table III). Only with ether extract, however, was there a significant difference in digestibility ($P < 0.05$). The average digestibility coefficients of 56.3 obtained for protein and 46.2 for crude fiber are lower than those for most concentrates, while the coefficients of 90.2 for ether extract and 79.0 for nitrogen-free extract are more nearly comparable with coefficients obtained with many concentrates.

Although no signs of digestive disturbances became evident, steers consuming tomato pulp alone appeared rather gaunt, presumably from lack of bulk. This condition might have been overcome to some extent had the pulp been offered free-choice. Feces from the steers consuming tomato pulp alone were of a rather sticky or waxy consistency and had a water content similar to that of feces from steers receiving only clover hay (71.6 compared with 73.3%). McCay and Smith (*10*) and Morrison (*12*) reported that tomato pomace in the diet of dogs, foxes, mink, and humans had an antidiarrheal effect.

Nitrogen balance data obtained with lambs are summarized in Table IV. Biological values were calculated by assuming a metabolic fecal nitrogen output of 0.55 gram per 100 grams of dry matter consumed and an endogenous urinary nitrogen output of 0.033 gram per kilogram of body weight (*9*). The nitrogen in the dried tomato pulp ration was less digestible ($P < 0.01$) and had a lower biological value ($P < 0.05$) than the nitrogen in the soybean meal ration. The values of 51 for the apparent digestibility coefficient and 29 for the net apparent value

$$\frac{(\text{apparent digestibility coefficient} \times \text{biological value})}{100}$$

obtained with the tomato pulp ration were applied to the tomato pulp itself. On a dry matter basis, tomato pulp contained 12.2% apparent digestible protein and 7.0% apparent net available protein. Based on the steer data, the apparent digestible protein was 13.5%. Average coefficients of digestibility for energy and organic matter were 69 and 70 for the tomato pulp ration, and 74 and 77 for the soybean meal ration. These coefficients were significantly different between rations ($P < 0.01$).

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