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Effects of Various Settings and Speeds of the Beehive Machine on the Composition of Mechanically Deboned Beef and Pork[1]

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Mechanical deboning is the only economical method for final removal of meat from bones, and the use of mechanical deboners can result in an additional annual production of over 700 million pounds of beef and over 300 million pounds of pork for human consumption, American Meat Institute (1975).

A mechanical deboning system was developed by the Japanese 25 years ago to remove meat from fish bones; this system has been used for deboning all types of raw and cooked meat, *Food Engineering* (1970). The poultry industry is using this system very successfully for deboning chicken necks and backs as well as turkey racks and spent laying hens, Noble (1973).

Grunden *et al.* (1972) reported that mechanically deboned meat produced different physical and chemical characteristics. The ash and calcium content of mechanically deboned meat was always higher than for hand-deboned meat because some fine bone particles were passed through the holes of the deboner, Field *et al.* (1974). Grunden and MacNeil (1973) reported that the bone content of mechanically deboned poultry meat can be determined by ethylenediaminetetraacetic acid or atomic absorption spectrophotometric methods; both give similar results. (Factors used for converting percent calcium to percent bone were 6.25 for broilers and 4.55 for mature poultry. A factor of 0.015 was allowed for calcium naturally occurring in meat.) Hand-boned lamb breast had a higher hydroxyproline content than machine-boned lamb breast because much of the connective tissue was eliminated by the mechanical deboner, Field (1974).

Field (1974) analyzed yields and the fat, protein, moisture, ash, and calcium content of mechanically deboned meat from trimmed pork necks andback bones; he obtained a yield of about 30 to 40% meat by weight from trimmed neck bones. The temperature of the deboned product increased approximately 10-15°C during grinding and deboning; it follows that any delay in processing could cause an increased growth of psychrotrophic and psychroduric organisms, Ostovar *et al.* (1971).

Field *et al.* (1974) stated that when the ring valve of the Beehive deboner was tightened to increase yields, the calcium content of the meats was increased, with an increase in bone content of over 1% at the maximum level. They stated that the following factors affect the amount of calcium in mechanically deboned meat: size of grinder plate; size of the holes in the deboner; amount of meat left on bones; whether the product was raw or cooked; and whether the product was deboned on the killing floor while warm or after chilling.

High calcium content in mechanically deboned meat may not be harmful; it may help to prevent calcium deficiencies when the calcium content of meat is low, Watt and Merrill (1963) and the human diet is low in calcium, Walker (1972) and Lutwak (1974).

Field (1974) and over 40 meat companies did studies on mechanically deboned, partly trimmed, trimmed, and mixtures of partly trimmed beef and pork bones. The American Meat Institute (AMI) committee made the following conclusions and

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recommendations based on this work:

1) The mechanically deboned meat should be considered a meat ingredient, not an end product. The calcium level should be controlled in the finished product. Mechanically deboned meat with a calcium content of 0.75% or under should be permitted in processed meat up to a maximum of 30% of the total product.
2) The mechanically deboned meat was equal or superior in quality to hand-deboned meat, so protein and fat restriction should be eliminated.

On November 6, 1974, the United States Department of Agriculture (USDA) approved the use of mechanically deboned red meat in meat products provided it met the following requirements, Meat Processors' Institute, (1974):

1) Content	*Beef %*	*Pork%*
(a) Minimum protein	15	14
(b) Maximum fat	30	30
(c) Maximum calcium	0.5	0.5
(d) Minimum essential amino acid	33	33

2) Maximum Temperature Limit:
(a) Ground raw products, 55°F
(b) Deboned products, 75°F
(c) Chilled products, 40°F or below

Approval was suspended in September, 1976, until further data could be obtained concerning safety for human consumption of products made from deboned meat. USDA has since deemed the use of deboned meat safe. It has proposed new regulations for manufacture and use of these products.

Little has been published on yield and composition of mechanically deboned beef and pork as related to back pressure setting and speed of the Beehive deboning machine. The objective of this research was to determine the effects of different deboner speeds and back pressure settings of the Beehive machine on yield and on calcium, fat, protein, moisture, and ash levels of mechanically deboned pork and beef.

Table 1. Percent yield of mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means for Settings
6K	Pork	18.25	15.50	15.25	16.33	20.10
	Beef	19.97	23.33	28.33	23.88	
7.5J	Pork	27.75	22.75	20.50	23.67	27.63
	Beef	30.50	31.34	32.92	31.59	
8.5H	Pork	27.75	28.25	26.00	27.33	38.60
	Beef	41.25	53.35	55.00	49.87	
Means for Speeds						
	Pork	24.58	22.17	20.58		
	Beef	30.57	36.01	38.75		

Overall yield: Beef 35.11%

Pork 22.44%

Table 2. Percent calcium content of mechanically deboned beef and pork as affected by settings and speeds of Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means for Settings
6K	Pork	0.152	0.192	0.208	0.184	0.376
	Beef	0.467	0.570	0.664	0.567	
7.5J	Pork	0.188	0.196	0.192	0.192	0.362
	Beef	0.505	0.594	0.498	0.532	
8.5H	Pork	0.168	0.204	0.200	0.191	0.435
	Beef	0.566	0.780	0.688	0.678	
Means for Speeds		0.341	0.423	0.408		

Overall average calcium: Beef 0.59%

Pork 0.19%

PROCEDURE

Three hundred pounds of mixed, mmed beef ribs, plates, and neck nes were obtained from a local cking company. These products ere machine deboned using a ehive Model AU-6173 deboner. bout 15% of the meat was left on e trimmed bones, to meet USDA quirements of not less than 15% otein and not more than 0.5% lcium, Meat Processors' Institute 974). The trimmed beef bones ere then passed through a bone inder equipped with plates hav- g 3/8-inch-diameter holes before mechanical deboning. Whole pork picnic bones were obtained from the same sources and treated in the same way.

Meat was forced through 0.018-inch-diameter holes in the Beehive cylinder while bones were eliminated through the cylinder end. This cylinder was used throughout the experiment at three speeds and three back pressure settings.

The mechanically deboned beef was mixed thoroughly before sampling. Protein, moisture, fat, ash, and calcium were measured by the Association of Official Agricultural Chemists methods, and duplicate values were determined for each sample, Horwitz (1970). Pork was mixed and measured in the same way.

The experimental design was a completely randomized 3 x 3 x 2 factorial experiment with three settings for back pressure, three machine speeds, and two kinds of meat. Each treatment was replicated twice.

RESULTS

elds

The yield of deboned products of ef and of pork differed gnificantly ($P < .01$). Yield for ef was higher than for pork---.11% compared to 22.4% (Table 1). Yields of both meats increased as ttings for back pressure in- eased, with average percent of .10, 27.63, and 38.60 for Beehive achine settings of 6K, 7.5J, and 5H, respectively (Table 1). The fference in the yield between pork ıd beef was not the same at each tting (significant at $P < .01$). eans tested by Duncan's multiple nge test indicated that the pork eld increased when the setting as increased to 8.5H (Table 1).

A significant difference between e effect of speed on beef yield and pork yield was indicated. Means sted by Duncan's multiple range st showed the yield of beef was gnificantly higher ($P < .01$) when speed of 24 RPM was used instead f 10 RPM. Conversely, the pork ended towards a greater ($P < .05$) ield at the lower speed of 10 RPM; e differences for pork, however, ere not statistically significant.

alcium

The beef contained significantly ore ($P < .01$) calcium than the ork, 0.59% compared to 0.19% for ork (Table 2). There was no significant difference in the calcium content of deboned meat when the setting was increased from 6K to 7.5J, but there was a significant rise ($P < .05$) when the setting was increased from 7.5J to 8.5H.

The calcium content also rose ($P < 0.5$) when the speed of the machine was increased to 18 RPM (Table 2). The speed and setting showed no significantly different effects on either meat.

Protein

The beef contained significantly more protein than the pork---an average of 15.89% compared to 13.13% (Table 3). There was a highly significant effect ($P < .01$) on protein content due to the setting of the machine. The content rose when the machine setting was increased from 6K to 7.5J but showed no further rise when the setting was increased to 8.5H (Table 3).

Table 3. Percent protein in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means for Settings
6K	Pork	12.32	13.14	13.35	13.00	14.19
	Beef	15.00	15.38	15.76	15.38	
7.5J	Pork	13.46	13.46	13.68	13.53	14.93
	Beef	15.82	16.86	16.31	16.33	
8.5H	Pork	13.03	13.52	13.85	13.47	14.73
	Beef	15.93	15.82	16.20	15.98	
Means for Speeds		14.26	14.70	14.89		

Overall average protein: Beef 15.89%
Pork 13.13%

Speed significantly affected the protein content ($P < .05$). Meat ground at 24 RPM had a significantly ($P < .05$) higher percentage of protein than samples ground at 10 RPM. The protein content of meat ground at 18 RPM was not different from meat ground either at 10 RPM or at 24 RPM (Table 3). There was no significant differences between the two meats.

Fats

There was a significant difference in the fat content of the deboned product according to the type of meat. Pork was significantly higher ($P < .01$) in fat, with an average of 29.26%, compared to 18.16% for beef (Table 4).

Machine setting significantly affected fat content ($P < .05$). The 6K and 8.5H settings produced higher fat content ($P < .05$) for deboned meat than a setting of 7.5J (Table 4). There were no significant differences in fat content due to speed or between the two meats.

Ash

The beef was significantly higher in ash content than pork---on average 2.44% to 1.25% (Table 5). The ash content of beef increased at setting 8.5H ($P < .05$), but no difference was found in the pork at any setting (Table 5).

Moisture

There was a highly significant ($P < .01$) difference in the moisture content of deboned product between the two meats: beef had a significantly higher moisture content---averaging 63.17%, than pork, which averaged 55.80% (Table 6).

Moisture content was not significantly affected by setting or speed, and there were no differences between the two meats for these variables.

Table 4. Percent fat content in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means for Settings
6K	Pork	33.43	29.95	30.20	31.19	25.42
	Beef	19.77	19.43	19.74	19.65	
7.5J	Pork	27.17	29.16	29.73	28.69	22.82
	Beef	19.42	16.45	14.94	16.94	
8.5H	Pork	30.22	28.60	28.52	29.11	24.19
	Beef	17.84	21.41	18.52	19.26	
Means for Speeds		24.64	24.17	23.61		

Overall average fat: Beef 18.16%

Pork 29.26%

Table 5. Percent ash content in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

		SPEED (RPM)				
Setting	Meat	10	18	24	Average	Means for Settings
6K	Pork	1.16	1.28	1.27	1.24	1.78
	Beef	2.03	2.29	2.62	2.31	
7.5J	Pork	1.28	1.29	1.23	1.27	1.78
	Beef	2.12	2.53	2.19	2.28	
8.5H	Pork	1.18	1.24	1.30	1.24	1.98
	Beef	2.50	3.09	2.57	2.72	
Means for Speeds		1.71	1.95	1.86		

Overall average ash: Beef 2.44%

Pork 1.25%

DISCUSSION

Removal of meat from beef bones was best achieved with a Beehive machine setting of 7.5J and a speed of 24 RPM; this resulted in a yield of 32.92%, an average calcium content of 0.498%, and an average fat content of 14.94%. These values are less than the USDA-approved levels, which were set to prohibit too much calcium in meat as the result of too much pulverized bo[illegible] Meat Processors' Institute (197[illegible] The protein content of meat deb[illegible] ed at the 7.5J setting and 24 R[illegible] was 16.31%, well above the USI[illegible] minimum, Meat Processors' [illegible] stitute (1974).

The best machine back press[illegible]

tting and speed for pork produc-on were 8.5H and 24 RPM, respec-vely. The yield for these settings as 26%, which was 4% lower than .e value reported by Field (1974). ne calcium content was 0.20%, otein 13.85%, and fat 28.52%. alcium and fat were below USDA-pproved values, as was the pro-in content.

SUMMARY

An evaluation was made of the fects of three settings of back ressure and three speeds of the eehive machine on yield of beef nd pork and on the calcium, rotein, fat, ash and moisture ontent of these meats. The verage yield of beef was 35.11% nd of pork, 22.44%.

Results indicated that the eehive machine should be set on .5J and operated at a speed of 24 PM for preparation of deboned eef with maximum protein content. The best setting and speed for preparation of deboned pork were 8.5H and 24 RPM, respectively. However, none of the settings or speeds tried resulted in meat with the minimum 14% protein presently recommended for pork obtained by mechanical deboning.

Table 6. Percent moisture content in mechanically deboned beef and pork as affected by settings and speeds of the Beehive deboner.

Setting	Meat	SPEED (RPM) 10	18	24	Average	Means for Settings
6K	Pork	53.39	55.60	55.41	54.80	58.69
	Beef	62.86	63.09	61.76	62.57	
7.5J	Pork	57.87	55.95	55.31	56.38	60.55
	Beef	62.69	64.42	67.06	64.72	
8.5H	Pork	55.63	56.52	56.52	56.22	59.22
	Beef	64.27	59.97	62.42	62.22	
Means for Speeds		59.45	59.26	59.75		

Overall average moisture for: Beef 63.17%

Pork 55.80%

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