MEAT AND MEAT PRODUCTS

Comparative Analysis of Meat Samples Prepared with Food Chopper and Bowl Cutter

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Analyses of meat samples after preparation with either a bowl cutter or by the official procedure with a food chopper were compared for homogeneity of comminution and for differences in fat, moisture, and protein content. Cutting time in the bowl cutter was limited to minimize temperature rise in samples. Beef chuck, pork shoulder, and beef shank, cheek, and tongue were used in the study. Variances of replicate analysis data for the 5 meat types were pooled for either cutter or chopper treatment and for each analyzed component. Sample portions cut and mixed by using the bowl cutter were more homogeneous than those ground with a food chopper. Comparative accuracy was indicated by fat and moisture means: 5 were in good agreement and 5 differed significantly; 3 of 5 paired protein means differed significantly but were within 0.3% protein. Results on precision and accuracy as well as the simplicity and convenience of the bowl cutter procedure favor its use as an alternative to a food chopper for preparing meat samples for analysis.

Preparation of meat samples for analysis by AOAC procedure **24.001** (1) involves passing the sample rapidly through a food chopper 3 times, using a plate with openings of ≤1/8 in., with thorough mixing after each grinding. The same procedure is specified in the laboratory manual of the American Meat Institute (2) except that a plate with approximately 1/8 in. holes is specified. The USDA laboratory manual (3) for regulatory analysis directs use of the AOAC procedure except that a plate with 5/64 in. holes is specified. Ockerman (4), in an Ohio State University laboratory manual, omits specification of plate hole size in a procedure similar to that of AOAC, but recommends regrinding 5 times for any product that mixes poorly. This reference demonstrates the importance of regrinding in the variation of apparent fat content in a beef lot after each of 3 grinding and mixing operations, and allows 2 alternative methods of sample preparation (ground 3 times in a food chopper using a plate with 1/8 in. holes, or reduction of meat to a very fine particle size with a bowl cutter) for determination of fat by using the modified Babcock method.

Although not currently specified as an alternative AOAC procedure, bowl cutters are commonly used for preliminary preparation of samples for analysis. Experience in this laboratory with using a bowl cutter for preparing meat emulsions indicated its utility for routine cutting and mixing of meat samples before proximate analysis. Apparent advantages are the fineness of particles and the uniformity of sample constituents. Use of a food chopper with a worn feed screw may result in sinews separating from meat tissue and wrapping around the screw or behind the cutter bar. Adipose tissue particles also may adhere to the inner surface of the barrel. The time required for preparation of a sample with either cutter or chopper is about the same (2–4 min) but the methods of action differ, with the bowl cutter knives the more efficient in dispersion and mixing.

Wijlhuizen and Paardekooper (5), using model systems, studied the parameters involved in both particle size reduction and mixing of meat in bowl cutters of different sizes. Parameters included geometry of the cutter, speed of knives and bowl, amount and initial size of meat pieces, length of time of cutting action, number of knives, and distance between knives and bowl. From their preliminary results, the investigators concluded that further study may lead to the ability to preselect conditions to achieve optimum efficiency of cutting and mixing action when the parameters are fitted in a mathematical equation. Assurance of optimum homogeneity of samples prepared for analysis would complement results reported here.

Our objective was to compare samples prepared with a bowl cutter and a food chopper, and to determine if the alternative procedure yielded a more uniform and representative product than procedure **24.001.** Both the food chopper and

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bowl cutter were benchtop models. Comparative analyses were used so that precision of proximate analysis indicated sample homogeneity within treatment procedures, and accuracy of the compared data indicated any treatment effect between procedures measured as a difference of fat, moisture, or protein content.

METHOD

Principle

Combined action of the knives and bowl cutter reduce the size and mix the particles of fat and lean tissue of a meat with high efficiency. Test portions of a cut and mixed sample may be taken for proximate analysis without manual mixing and quartering. As with other particle size reduction procedures, samples must be firmed by prechilling before cutter treatment. The sample and any cutter parts that may contact it must be precooled to −1.5 to −2.0°C to reduce melting of fatty constituents and dripping of meat juice from the shearing friction of cutter knives. The ideal sample size and length of cutting time necessary to obtain a small particle size and good mixing must be predetermined from trials for each model of bowl cutter to be used. Kilogram samples of coarse (½ in. plate) ground meat require 4 min treatment for beef and 2 min for pork. Over-treatment produces a glossy appearance on the sample surface indicating a temperature rise of between 0.5 and 5.0°C.

Apparatus

(**a**) *Bowl cutter.*—Benchtop model, ½ HP; 14 in. bowl, 22 rpm; two 3.5 in. knives, 1725 rpm; Model 84145, Hobart Corp., Troy, OH, or equivalent.

(**b**) *Food chopper.*—Benchtop model, ½ HP; 2.75 in. D plate with ⅛ in. D holes; Model 5126, Toledo Scale Co., Columbus, OH, or equivalent.

Preparation of Samples

Boneless beef chuck, pork shoulder, and 3 meats with high connective tissue content—beef cheek, shank, and tongue—were used in the study. Beef chuck (5.7% fat, 20.8% protein) and beef fat trimmings (78.7% fat, 3.3% protein) were coarse-ground individually through a ½ in. plate by using a floor model food chopper and were used to formulate 6 samples that ranged from 10 to 30% fat. Pork shoulder meat (18.0% fat, 17.5% protein) and back fat (91.3% fat, 1.8% protein) were similarly ground and used to prepare 4 samples that ranged from 20 to 50% fat. Two lots of each of the 3 high connective meats were ground in the same manner and used without added fat.

Each coarse ground sample of meat mixture or type was packaged in plastic freezer bags in 1 kg amounts for storage. Duplicate bags of each sample were flattened to a thickness of about ⅓ in. and stored at −34°C. All frozen meat samples along with contact parts of the food chopper and bowl cutter were tempered in a −1.5 to −2°C cold room overnight before cutter or chopper treatment.

Bowl cutter treatment of prechilled samples required 4 min for beef and 2 min for pork in preliminary trials. The cutter was stopped halfway through the cutting procedure to recover and to return any particles that adhered to the cover and knife-comb.

Operating time required to pass a 1 kg sample 3 times through the food chopper and to mix the ground meat between passes was approximately 4 min.

A sampling procedure for analysis of the prepared meat samples was devised to permit comparison of data within and between treatment procedures. To determine homogeneity of meat treated in the bowl cutter, one 100 g sample was taken from each quadrant for analysis because the entire quantity in the bowl was not manually mixed. Meat ground in the food chopper was sampled randomly and mixed thoroughly as is commonly done to obtain 200 g of a composite analytical sample.

Determinations

Fat, moisture, and protein content were determined by using methods **24.005(a), 24.003(a),** and **24.027,** respectively (1), on all analytical samples of formulated and of unmodified meats. Single or duplicate determinations were made on each of the bowl cutter quadrant samples and replicate determinations (2–8 for beef and 4 for the other meat samples) were made on food chopper composites.

Statistical Treatment

Data from the comparative analysis of beef chuck (Table 1), pork shoulder (Table 2), and high connective tissue meat samples (Table 3) were analyzed statistically for variations within (Table 4) and differences between (Table 5) bowl cutter and food chopper treatments. A 95% probability confidence level was selected. Variance of replicate analyses (precision) indicated homogeneity within a prepared sample.

Table 1. Proximate analysis of beef chuck samples [a]

Fat level, %	Cutter			Chopper		
	Fat	Moisture	Protein	Fat	Moisture	Protein
30	30.6	53.6	15.0	30.6	53.9	15.0
	30.2	53.7	14.9	30.2	54.0	15.1
	30.7	53.8	15.2	32.0		15.1
	30.6	53.8	15.4	30.8		15.3
		54.0				
		54.0				
		54.1				
26	26.8	53.8	16.3	27.0	56.5	16.1
	27.5	56.6	15.8	26.0	55.9	15.9
	27.1	56.0	15.8	27.3		16.0
	26.9	56.3	15.9	26.4		16.0
		55.8				
		56.8				
		56.2				
		56.3				
22	22.7	56.2	17.0	22.3	59.8	17.0
	22.6	59.8	16.8	22.3	60.4	17.2
	23.2	59.8	16.9	22.7	60.4	17.0
	23.0	59.8	16.7	23.0		16.9
		59.9				
		59.7				
		59.8				
		59.9				
		59.9				
		59.7				
		59.8				
		60.0				
18	18.5	59.9	17.9	18.3	63.0	18.0
	18.4	63.2	18.0	18.6	63.0	18.0
	18.9	63.1	18.1	18.4	62.8	18.1
	18.7	63.0	18.0	18.8		18.0
		63.0				
		62.9				
		63.2				
		63.0				
14	15.5	63.0	18.8	14.7	65.7	18.8
	14.8	65.8	18.8	14.0	66.0	19.0
	15.4	65.8	19.0	14.5	66.6	18.8
	15.0	65.8	18.8	13.9	66.0	18.7
		65.5		15.0	66.2	18.7
		65.8		14.3	66.3	18.9
		65.7		15.6		18.8
		65.9		14.6		18.7
10	10.8	65.8	19.8	10.7	68.8	19.9
	11.2	68.7	19.8	11.3	68.5	19.7
	10.6	68.6	20.2	10.6		19.6
	10.9	69.0	19.7	12.1		19.5
		68.7				
		68.7				
		68.6				
		68.8				
		68.8				

[a] Results (%) of replicate determinations.

Paired variances from chopper and cutter treatments were compared for significant difference before and after pooling data according to 3 experimental variables: treatment (cutter or chopper), analyzed component, and fat level or sample type. Analysis of variance compared means of replicate data for each sample group and each component analysis (accuracy). This comparison of means could be viewed as a strong indication of when loss of tissue components occurred (treatment effect) in either the bowl cutter or food chopper except that a difference between results is compounded by inseparable formulating and sampling errors.

Table 2. Proximate analysis of pork shoulder samples [a]

Fat level, %	Cutter			Chopper		
	Fat	Moisture	Protein	Fat	Moisture	Protein
50	48.8	39.7	10.8	50.5	39.5	11.0
	49.0	39.8	10.9	51.2	38.1	10.8
	49.5	39.6	10.7	48.8	37.6	10.7
	49.3	39.5	10.9	49.7	38.2	11.0
40	39.4	47.1	13.4	38.4	47.8	13.4
	39.2	47.5	13.2	38.6	47.1	12.9
	39.2	47.3	13.1	38.8	47.7	13.1
	39.4	47.6	13.1	38.4	47.7	13.0
30	29.6	54.8	15.0	30.2	54.9	14.8
	29.6	54.7	15.0	29.8	53.8	14.9
	29.5	54.9	15.3	29.4	54.3	15.1
	29.4	54.9	15.0	29.8	54.7	14.9
20	19.5	62.8	17.0	19.4	62.5	17.2
	19.5	62.6	17.1	19.4	62.8	17.5
	19.8	62.5	17.0	19.9	62.2	17.3
	19.4	62.6	17.2	19.9	62.7	17.1

[a] Results (%) of replicate determinations.

Results and Discussion

Variance of Replicate Analysis

Fat Determinations.—Variances of replicate determinations (Table 4) were random with only slight indication of proportionality to fat content. The 16 values ranged from 0.001 to 0.104 on cutter-treated meats and 0.041–1.120 on chopper-treated meats. Variances of replicates of chopper composite samples were higher than those of cutter quadrant samples in 15 of the 16 paired comparisons of which 7 were significantly higher. When variances were pooled across fat content for chopper and cutter paired groups (5 meat types), values for each of the 5 chopped meats were higher than the paired cutter value and 4 of the 5 were significantly higher.

Moisture Determinations.—Variances of repli-

Table 3. Proximate analysis of beef meats with high connective tissue content—shank, cheek, and tongue [a]

Sample type	Cutter			Chopper		
	Fat	Moisture	Protein	Fat	Moisture	Protein
Shank 1	3.9	74.1	21.2	4.1	74.1	21.1
	4.0	74.1	21.0	4.1	74.0	21.0
	4.0	74.1	20.9	4.4	74.4	21.1
	4.0	74.3	20.9	3.9	74.4	21.3
2	3.7	74.2	21.3	3.7	73.6	22.0
	3.8	74.2	21.1	3.8	74.1	22.1
	3.8	74.3	21.3	4.3	73.6	21.7
	3.8	74.3	21.5	4.2	73.9	21.9
Cheek 1	12.0	67.9	19.3	11.4	68.5	19.7
	12.7	67.9	19.1	12.0	68.9	20.0
	12.2	67.9	19.1	11.4	68.8	19.6
	12.2	67.8	19.4	11.2	68.7	19.9
2	14.2	66.4	18.9	13.2	66.7	18.4
	14.3	66.1	19.2	13.0	66.3	19.4
	14.4	66.3	19.1	13.0	66.6	19.3
	14.4	66.3	19.2	13.8	67.1	18.9
Tongue 1	19.0	64.2	15.9	19.9	63.7	15.8
	19.0	64.4	15.8	19.3	64.0	15.8
	18.9	64.2	16.0	19.9	64.5	15.7
	18.9	64.1	15.9	18.9	63.9	15.5
2	15.7	66.8	17.0	16.0	66.7	16.9
	15.4	66.9	17.1	16.0	67.0	17.1
	15.3	66.8	17.2	15.7	66.6	16.7
	15.5	66.6	17.0	16.6	67.1	17.0

[a] Results (%) of replicate determinations.

Table 4. Variance and homogeneity test of preparation procedure

Fat level (%) or sample type	Fat			Moisture			Protein		
	Cutter	Chopper	*F*-value	Cutter	Chopper	*F*-value	Cutter	Chopper	*F*-value
Beef Chuck									
30	0.056	0.599	10.8[a]	0.023	0.009	2.8	0.036	0.013	2.7
26	0.090	0.312	3.5	0.109	0.205	1.9	0.054	0.003	20.7[a]
22	0.079	0.112	1.4	0.008	0.127	15.9[a]	0.012	0.009	1.4
18	0.060	0.055	1.1	0.011	0.019	1.8	0.013	0.003	4.6
14	0.104	0.305	2.9	0.010	0.087	8.8[a]	0.014	0.011	1.3
10	0.059	0.488	8.2	0.014	0.061	4.3	0.048	0.027	1.8
Sum of degrees of freedom	18	22		46	12		18	22	
Pooled variance	0.075	0.311	4.2[a]	0.03	0.08	3.1[a]	0.029	0.011	2.7[a]
Pork Shoulder									
50	0.087	1.120	12.9[a]	0.015	0.627	43.3[a]	0.008	0.014	1.7
40	0.016	0.041	2.5	0.044	0.079	1.8	0.015	0.038	2.6
30	0.007	0.105	14.6[a]	0.010	0.219	22.4[a]	0.024	0.022	1.1
20	0.039	0.084	2.2	0.018	0.060	3.3	0.013	0.019	1.5
Sum of degrees of freedom	12	12		12	12		12	12	
Pooled variance	0.037	0.337	9.1[a]	0.022	0.246	11.4[a]	0.015	0.023	1.6
Beef Shank, Cheek, and Tongue									
Shank 1	0.003	0.047	15.8[a]	0.007	0.040	6.2	0.023	0.022	1.0
2	0.001	0.089	63.9[a]	0.003	0.057	19.0[a]	0.029	0.029	1.0
Sum of degrees of freedom	6	6		6	6		6	6	
Pooled variance	0.002	0.068	31.1[a]	0.005	0.049	10.1[a]	0.026	0.026	1.0
Cheek 1	0.088	0.135	1.5	0.001	0.031	38.6[a]	0.015	0.035	2.3
2	0.007	0.127	17.3[a]	0.015	0.114	7.6	0.012	0.070	6.1
Sum of degrees of freedom	6	6		6	6		6	6	
Pooled variance	0.048	0.131	2.8	0.008	0.072	9.2[a]	0.014	0.052	3.9
Tongue 1	0.001	0.241	185.7[a]	0.008	0.106	12.7[a]	0.006	0.022	3.9
2	0.025	0.128	5.1	0.015	0.051	3.3	0.011	0.029	2.6
Sum of degrees of freedom	6	6		6	6		6	6	
Pooled variance	0.013	0.185	13.9[a]	0.012	0.079	6.7[a]	0.008	0.025	3.1

[a]Exceeds tabular *F*-value at $P = 0.05$.

cate determinations (Table 4) were random with slight indication of an inverse relation to moisture level. The 16 values ranged from 0.001 to 0.109 for cutter-treated meats and 0.009–0.627 for chopper-treated meats. Variances of replicates of chopper composite samples were higher than those of cutter quadrant samples in 15 of the 16 paired comparisons of which 7 were significantly higher. When variances were pooled across moisture content for chopper and cutter paired groups, values of all 5 chopper-treated meats were significantly higher than the paired cutter value.

Protein Determinations.—Variances of replicate Kjeldahl determinations (Table 4) were random and varied independent of protein content. The 16 values ranged from 0.006 to 0.054 for cutter-treated meats and 0.003–0.070 for chopper-treated meats. Variances of replicates of chopper composite samples were higher than those of cutter quadrant samples in 8 of the 16 paired comparisons and 1 was significantly lower. When variances were pooled across protein content for chopper and cutter paired groups, the values for 3 of the 5 meats treated with chopper were higher and 1 was significantly lower than their paired cutter values. The latter low variance (chopper-treated beef chuck) contrasts with the comparisons of pooled variances of fat and moisture determinations, but may result from the generally low variances associated with the Kjeldahl method.

Analysis of Variance of Means

Analysis of variance of fat determinations (Table 5) indicated no treatment effect on the fat content of beef chuck, pork, and shank meat samples. Fat in chopper-treated portions of cheek meat, however, was determined 0.9% high and in tongue 0.6% low, both significant. The

Table 5. Means (%) of replicate determinations and tests of treatment effects by analysis of variance on paired data

Fat level (%) or sample type	Fat			Moisture			Protein		
	Cutter	Chopper	*F*-value	Cutter	Chopper	*F*-value	Cutter	Chopper	*F*-value
Beef Chuck									
30	30.5	30.9	0.8	53.8	53.9	0.5	15.1	15.1	0.1
26	27.1	26.7	1.7	56.3	56.2	0.1	16.0	16.0	0.2
22	22.9	22.6	1.9	59.8	60.2	11.5[a]	16.8	17.0	7.5[a]
18	18.6	18.5	0.6	63.0	62.9	2.5	18.0	18.0	0.7
14	15.2	14.6	4.2	65.8	66.1	10.9[a]	18.8	18.8	0.3
10	10.9	11.2	0.6	68.7	68.6	0.7	19.9	19.7	2.5
Overall mean	20.9	20.7	1.6	61.2	61.3	5.9	17.4	17.4	0.0
Pork Shoulder									
50	49.1	50.1	2.8	39.6	38.3	10.6[a]	10.8	10.9	1.0
40	39.3	38.6	40.1[a]	47.4	47.6	1.1	13.2	13.1	0.8
30	29.5	29.8	2.8	54.8	54.4	2.5	15.0	14.9	1.3
20	19.5	19.7	0.6	62.6	62.5	0.5	17.1	17.3	4.4
Overall mean	34.4	34.5	0.9	51.1	50.7	9.4[a]	14.0	14.0	0.0
Beef Shank, Cheek, and Tongue									
Shank 1	4.0	4.1	1.7	74.1	74.2	0.5	21.0	21.0	1.1
2	3.8	4.0	2.0	74.2	73.8	12.3[a]	21.3	22.0	28.8[a]
Overall mean	3.9	4.1	3.7	74.2	74.0	4.8[a]	21.2	21.5	22.0[a]
Cheek 1	12.3	11.5	10.6[a]	67.9	68.7	97.2[a]	19.2	19.8	28.1[a]
2	14.3	13.3	34.2[a]	66.3	66.7	5.2	19.1	19.1	0.0
Overall mean	13.3	12.4	38.0[a]	67.1	67.7	41.2[a]	19.2	19.5	11.8[a]
Tongue 1	18.9	19.5	6.0	64.2	64.0	1.3	15.9	15.7	6.7[a]
2	15.5	16.1	9.2[a]	66.8	66.9	0.2	17.1	16.9	1.6
Overall mean	17.2	17.8	14.4[a]	65.5	65.5	0.4	16.5	16.3	6.9[a]

[a] Exceeds tabular *F*-value at $P = 0.05$.

high and low differences for these 2 meats suggest an inconsistent or random variation in the data rather than a constant difference resulting from a treatment effect. A large between-means difference is considered to be >1.2% fat [3 σ value of repeatability established in a collaborative study of **24.005(a)** (6)].

Analysis of variance of moisture determinations (Table 5) indicated that 3 paired means of the 5 meat types differed significantly but not all in the same direction, suggesting an inconsistent variation in the data rather than a treatment effect. The largest difference between means, 0.6% (cheek meat), was considered to be an acceptable level of difference. A large between-means difference would be >0.9% moisture [3 σ value of repeatability established in a collaborative study of **24.003** (7)].

Analysis of variance of protein determinations (Table 5) indicated that 3 paired means of the 5 meat types differed significantly, again not all in the same direction, suggesting an inconsistent variation rather than a treatment effect. Mean differences are all within 0.3% protein and this is considered an acceptable level of difference. A large between-means difference would be >0.6% protein [3 σ value of repeatability established in a collaborative study of **24.027** (8)].

Conclusion

Examination of variance of replicate determinations of fat, moisture, and protein determinations on 5 types of meat, with preparation treatment as the principal variable, showed that precision of determination was higher for samples prepared with a bowl cutter than with a food chopper. This observation suggested that samples prepared with a cutter were more homogeneous than those ground with a chopper. Complete and reproducible homogeneity would involve more elaborate conditions than those used here. Prechilling, essential to a meat sample preparation procedure, provided firmness of fat and minimized loss of sinewy tissues and meat juices during cutting or grinding operations.

Analysis of variance of replicate determinations of samples treated with either bowl cutter or chopper procedures indicated that accuracy between the 2 procedures was equivalent for fat,

moisture, and protein content. Differences between the means were random without an indication of treatment effect and were within acceptable tolerance for each method of proximate analysis.

Overall analyses on meat samples indicated the bowl cutter to be an adequate alternative to a food chopper. Advantages include convenience, simplicity, analysis of a prepared sample without an additional mixing step, and homogeneity of a prepared sample for good analytical precision. It is recommended that the procedure be adopted as an alternative to **24.001** for meat analysis.

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