JOURNAL OF ANIMAL SCIENCE
The Premier Journal and Leading Source of New Knowledge and Perspective in Animal Science

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J ANIM SCI 1966, 25:809-813.

STUDY OF BACKFAT LAYERS OF SWINE [1]

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ULTRASOUND has been shown to be influenced by the kind of transducer employed (Goldman and Hueter, 1956) and the temperature (Goldman and Hueter, 1956; Davis, 1963), composition (Ludwig, 1950; Goldman and Hueter, 1956; Claus, 1957; Stouffer and Wellington, 1960; Price *et al.*, 1960) and location of the tissue within the animal's body (Kliesch *et al.*, 1957; Dumont, 1959). Price *et al.* (1960) further postulated that differences in thickness, as well as chemical and physical properties of the tissues, may affect the reliability of ultrasonic results.

Published reports document the differences in iodine value (Callow, 1935; Lush *et al.*, 1936; Shorland *et al.*, 1944; Johns, 1941), fatty acid composition (Hilditch, 1956; Sink *et al.*, 1964) and pattern of fat deposition (McMeekan, 1940; Sink *et al.*, 1964) of the outer and inner backfat layers. A distinct partition between the backfat layers of live hogs was observed on an ultrasonic oscilloscope by East *et al.* (1959). Two fat layers were subsequently observed in the carcass backfat.

Information to characterize three individual backfat layers in swine has not been published, notwithstanding the report by Thomsen (1965) that an innermost third fat layer was present to some extent in all hogs.

This paper presents the results of an experiment to determine the differences in three component backfat layers of swine as depicted by ultrasonic and carcass measurements as well as fat and moisture determinations. Also, the relationship of these measurements to some indices of carcass quality was examined.

Materials and Methods

Data from 169 Poland China hogs approximately equally divided between barrows and gilts were analyzed in two separate experiments. Hogs in experiment I ranged in live weight from 95.9 to 194.5 kg., whereas those in experiment II ranged from 90.0 to 156.3 kg. The first experiment was further subdivided on a backfat thickness basis into four groups of 25 hogs each (table 1).

Approximately 24 hr. antemortem the hogs in experiment II were measured with an ultrasonic instrument [4] coupled to a 1-Mc. transducer. The hogs were restrained in a modified holding crate, and the hair was clipped over the site to be measured on the right side. Recordings were made of the sound reflections from the connective tissue partitions between the backfat layers over the 10th thoracic vertebra 5 cm. laterally from the midline. A scalpel was used to incise the skin at the exact site measured for subsequent identification on the untrimmed loin. In addition, metal probe backfat measurements were taken 5 cm. laterally from the midline over the 10th thoracic vertebra, rump and shoulder as described by Zobrisky *et al.* (1954, 1959a).

After the packer style carcasses were chilled 24 hr. at 4° C., backfat thickness measurements were taken opposite the first and last thoracic and last lumbar vertebrae. The carcasses were processed as outlined by Cole (1951). Special care was taken to make a similar cut between the belly and loin in each fat thickness group. The rough loin was separated from the rough belly by dividing along a straight line made by snuggling the tenderloin muscle at the posterior end of the loin and just missing the ventral portion of the backbone at the anterior end of the loin. In addition, each pork side was tilted slightly to permit the skin surface at the junction of the belly and loin to lie flat against the cutting table before making the knife cut. While the side was held in this position, the angle of the cut was made perpendicular to the skin. The untrimmed loin was cut perpendicular to the cut surface of the vertebrae between the 10th and 11th thoracic vertebrae. Subjective scores based on a 1 to 10 scale (Wellington and Stouffer, 1959) were used to evaluate the marbling in the cut surface of the *l. dorsi* muscle posterior to the 10th thoracic vertebra. The total thickness of the three fat layers over the

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[3] The authors express appreciation to Branson Instruments, Inc., Stamford, Conn., for use of ultrasonic equipment.

[4] Branson Sonoray Model 5, Branson Instrument Co., Stamford, Conn.

TABLE 1. AVERAGE THICKNESS OF INDIVIDUAL FAT LAYERS ASSOCIATED WITH EQUAL INCREMENTS IN BACKFAT THICKNESS

	Backfat thickness groups, cm.[a, b, c]			
Fat layers	A	B	C	D
First	1.55	1.47	1.32	1.19
Second	2.08	1.57	1.37	1.07
Third	1.07	0.84	0.81	0.69
Total fat	4.3 to 4.6	3.8 to 4.1	3.3 to 3.6	2.8 to 3.1

[a] N=25 in each group.
[b] Any two means on the same line not underscored by the same line are significantly (P<.01) different.
[c] Average of carcass backfat thickness measurements was taken at the first and the last thoracic and the last lumbar vertebrae.

10th thoracic vertebra also was measured. Subsequently a 7.6-cm. section of the untrimmed loin, posterior to the 10th thoracic vertebra, was removed and weighed. From this loin section the skin and the three fat layers were carefully dissected by following the connective tissue partitions. The first layer consisted of the outermost fat layer exclusive of the skin, whereas the second layer was in the center, and the third was nearest the *l. dorsi* muscle. Each fat layer was weighed, wrapped in aluminum foil and stored at approximately −24° C. At a later date individual fat layers were placed in dry ice and finely ground. Each sample was thoroughly mixed prior to the removal of a 2-gm. sample for fat and moisture determinations (A.O.A.C., 1960).

Results and Discussion

Experiment I. The thickness of each of the three backfat layers illustrated in figure 1 and presented in table 1 was greater in the carcasses with thicker total backfat. The increase in thickness of the second fat layer was greater (P<.01) than the third, which in turn was greater than the first fat layer in all fat thickness groups. As the average backfat thickness increased from Group B (3.8 to 4.1 cm.) to Group A (4.3 to 4.6 cm.), the thickness of the second fat layer increased 6.4 times as much as the first fat layer and 2.2 times as much as the third fat layer. However, the difference in thickness between the first and second fat layers was rather small on carcasses with average backfat from 2.8 to 4.1 cm. thick (represented in groups A, B and C). A significant difference was observed in the thickness of the first fat layer between groups B and C (1.47 *vs.* 1.32 cm.), but not between groups A and B (1.55 *vs.* 1.47) nor between C and D (1.32 *vs.* 1.19 cm.). Regarding the second fat layer, groups A and D were each significantly different from groups B and C. The second fat layer of groups B and C was significantly different in thickness. The thickness of the third fat layer did not

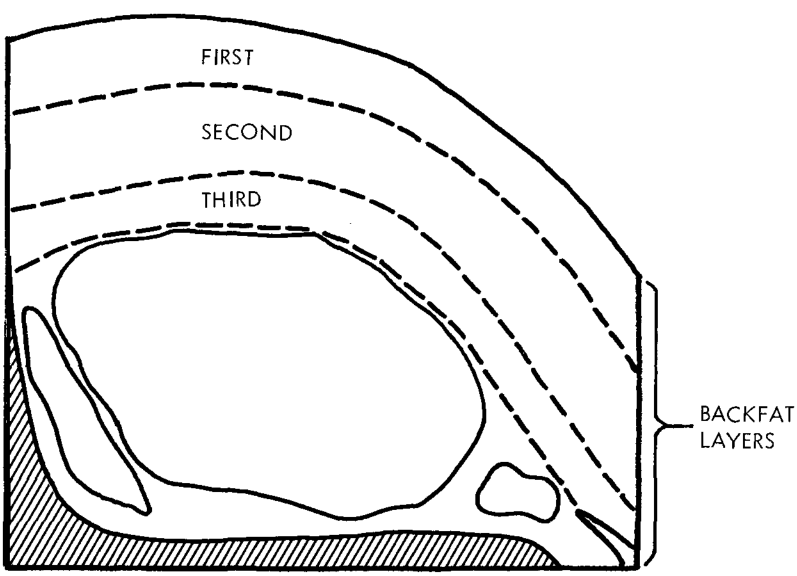

Figure 1. Diagram of pork loin cross section between 10th and 11th ribs showing location of backfat layers. Lined area represents bone.

TABLE 2. PERCENT OF BACKFAT WEIGHT REPRESENTED BY EACH FAT LAYER

Fat layers	Backfat thickness groups[a, b, c] A	B	C	D
First	38.52	42.82	44.12	47.56
Second	41.96	40.36	38.48	35.68
Third	18.12	15.44	16.52	16.88

[a] N=25 in each group.
[b] Average percent each fat layer represented of the total separable backfat weight from a 7.6-cm. untrimmed loin section cut posterior to the 10th thoracic vertebra.
[c] Any two means on the same line not underscored by the same line are significantly (P<.01) different.

differ significantly as the hogs fattened, until the backfat surpassed 4.1 cm. in thickness. These results agree with those of McMeekan (1940), Sink and Miller (1962) and Sink *et al.* (1964), who reported that the inner (second) layer increased faster and to a greater thickness than the outer (first) layer as total backfat increased.

The backfat developmental pattern is further emphasized in table 2, where the percent of total separable backfat weight represented by each fat layer is presented. The first fat layer represented a significantly smaller and the second a significantly larger percent of total backfat weight in all five fat thickness groups (A to D). Conversely, the third fat layer did not differ significantly in percent of total backfat in any of the fat thickness groups.

Backfat thickness groups and fat layers were associated with significant differences in percent ether extractable fat, moisture and residue,[5] as indicated in table 3. Results of the multiple range test (Duncan, 1955) indicated that the third layer contained a greater

[5] Residue=100—(percent moisture+percent fat).

TABLE 3. ANALYSIS OF VARIANCE OF PERCENT ETHER EXTRACTABLE FAT, MOISTURE AND RESIDUE IN BACKFAT LAYERS OF SWINE

Source of variation	d.f.	Mean squares Fat	Moisture	Residue
Layer	2	1513.87**	688.30**	153.72**
Group	3	160.91**	84.67**	13.66**
Error	66	221.70	10.70	2.74

** P<.01.

percent of moisture and residue and a smaller percent of fat than either the first or the second fat layers. These latter two fat layers were not significantly different in percent moisture, residue or fat. Although not significant, the second fat layer had a greater percent of fat and a smaller percent of moisture and residue than the first layer. The percent of moisture and residue decreased and the percent of ether extractable fat increased as total backfat thickness increased. These differences were significant between the 2.8- to 3.1-cm. and the 3.3- to 3.6-cm. backfat thickness groups. For a backfat thickness of 3.3 to 4.6 cm. the percent of moisture, fat and residue did not differ significantly among fat layers.

Experiment II. Correlations between the thickness of individual backfat layers and several indices of carcass merit are presented in table 4. The magnitude of the correlations closely parallels those reported by Hetzer *et al.* (1956) and Zobrisky *et al.* (1959a, b) between backfat probes and similar measurements of carcass merit. The relationships observed between ultrasonic measurements and indices of carcass merit are also in agreement with those reported by Claus (1957), Panier

TABLE 4. CORRELATION COEFFICIENTS BETWEEN BACKFAT MEASUREMENTS AND SEVERAL INDICES OF CARCASS MERIT

Indices	Correlation coefficient[a] First fat layer Ultrasonic[b]	Carcass[b]	Second fat layer Ultrasonic	Carcass	Third fat layer Ultrasonic	Carcass
One metal probe, cm.[c]	0.61	0.43	0.57	0.58	0.36	0.62
Av. metal probe, cm.[d]	0.48	0.40	0.61	0.65	0.14	0.50
Av. carcass backfat, cm.	0.47	0.34	0.52	0.67	0.18	0.58
Ham, %	—.32	—.31	—.30	—.51	—.37	—.37
Four lean cuts, %	—.48	—.47	—.50	—.57	—.12	—.57
Total trim fat, %	0.58	0.41	0.59	0.67	0.26	0.67
Backfat wt.	....	0.41	....	0.77	....	0.30
Marbling score	....	0.03	....	0.07	....	0.29

[a] Correlation of 0.23, P=.05; 0.30, P=.01.
[b] Ultrasonic and carcass backfat thickness measurements were taken 5 cm. laterally from midline at 10th thoracic vertebra.
[c] Measurement taken 3.8 cm. laterally from midline.
[d] Average of three probe and three carcass backfat measurements, respectively.

(1957), Stouffer *et al.* (1959), Price *et al.* (1958, 1960) and Hiner and Thornton (1962). With the exception of the ultrasonic measurement of the third fat layer, the correlations were of the same approximate magnitude, i.e., not significantly different between a specific carcass index and the ultrasonic or carcass measurements.

These results imply that the first and second backfat layer, as measured on the live hog or subsequent carcass, and the third layer as measured on the carcass were approximately equivalent in accounting for variation in the characteristics studied. However, correlations were significantly ($P<.05$) smaller among the ultrasonic measurement of the third fat layer and the other carcass indices, exclusive of percent ham. Furthermore, the correlations which included ultrasonic measurements of the third layer were also significantly ($P<.05$ or $P<.01$) smaller than those which included carcass measurements of the third layer. The discrepancy between ultrasonic *vs.* carcass in respect to the third fat layer may be explained partially by the smaller relative thickness and greater variation in ultrasonic thickness measurements, as compared with the variation in carcass measurements of the same layer. This variation was also greater than similar comparisons between these measurements of the first and second fat layer. The third fat layer was susceptible to more postmortem distortion than the first or second fat layer. Postmortem change in thickness appeared to parallel directly the greater quantity of moisture and residue present within the third fat layer.

The magnitude of the correlations in table 4, the greater change in thickness per unit increase in total fat thickness (table 1) and ease in ultrasonic measurement indicate that the second layer was the most practical and reliable of the three fat layers as an index of carcass meatiness.

Correlations of individual backfat layer thickness with weight of backfat and subjective intramuscular fat (marbling) scores of the *l. dorsi* are also presented in table 4. The thickness of the second fat layer accounted for approximately 42 and 51% more ($P<.05$) of the variation in backfat weight than the first and third fat layers, respectively. The correlations between backfat layer thickness and marbling scores were small but increased from the first to the third layers. Thickness of the third fat layer was significantly ($P<.05$) correlated with marbling scores. Subjective marbling scores of the *l. dorsi* decreased ($P<.01$) as percent loin or percent four lean cuts increased. There was also a tendency for the larger *l. dorsi* muscle areas to be scored lower ($P<.01$) for marbling than the smaller *l. dorsi* muscle areas. The magnitude of the correlations between marbling scores and meatiness indices was rather low. However, there was a significant trend toward a negative association between these variables and intramuscular fat.

Summary

Data from 169 hogs were used to characterize the three backfat layers by live ultrasonic and carcass measurements as well as fat and moisture determinations. The intermediate (second) fat layer increased faster and to a greater thickness than the outer (first) or inner (third) layer in carcasses with thicker total backfat. The third fat layer contained a greater ($P<.01$) percent of moisture and residue than the first layer, which contained a greater proportion of these two constituents than the second layer. The second fat layer contained a greater ($P<.01$) percent of extractable fat than the third layer, whereas the first layer was intermediate.

These results indicate that the first and second backfat layers, as measured ultrasonically or on the carcass, and the third layer as measured on the carcass, are approximately equal in accounting for variation in indices of carcass merit.

The thickness of the third fat layer appeared to change more postmortem than the first and second fat layer. Thickness of the third layer was significantly ($P<.05$) correlated with marbling scores. Marbling scores were negatively associated with *l. dorsi* area and yield of lean cuts.

Literature Cited

A.O.A.C.1960. Official Methods of Analysis (9th ed.). Association of Official Agricultural Chemists. Washington, D. C.

Callow, E. H. 1935. Carcass quality of the pig in relation to growth and diet. Empire J. Exp. Agr. 3:80.

Claus, A. 1957. The measurement of natural interfaces in the pig's body with ultrasound. Fleischwirtschaft 9:552.

Cole, J. W. 1951. Slaughtering, chilling and cutting methods for pork carcass evaluation. Proc. Recip. Meat Conf. 4:111.

Davis, J. K. 1963. Ultrasonic instruments for live animal evaluation. Proc. Recip. Meat Conf. 16:230.
Dumont, B. L. 1959. Measurement of fatness in pigs by the ultrasonic method. Compt. Rend. Acad. Sci. Agr. 12:628.
Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.
East, E., J. Taylor, I. T. Miller and R. W. Widdowson. 1959. Measurements of backfat thickness on live pigs by ultrasonics. An. Prod. 1:129.
Goldman, D. E. and T. F. Hueter. 1956. Tabular data of the velocity and absorption of high frequency sound in mammalian tissue. J. Acoust. Soc. Am. 28:35.
Hetzer, H. O., J. H. Zeller and O. G. Hankins. 1956. Carcass yields as related to live hog probes at various weights and locations. J. Animal Sci. 15:257.
Hilditch, T. P. 1956. The Chemical Constitution of Natural Fats. John Wiley and Sons, Inc., N. Y.
Hiner, R. L. and J. W. Thornton. 1962. Ultrasonic evaluation of composition in hogs slaughtered at 75, 125, 175, 225 and 275 pounds. Proc. Recip. Meat Conf. 15:49.
Johns, A. T. 1941. The influence of sex upon the composition of the fat of the pig. New Zealand J. Sci. Technol. 22:248.
Kliesch, J. U., U. Newhaus, E. Silber and E. Kostzewske. 1957. Studies of the measurement of fat thickness of live animals with the help of ultrasound. Zeitschrift Tierzucht. Züchtbiol. 70:29.
Ludwig, G. D. 1950. The velocity of sound through tissues and the acoustic impedance of tissues. J. Acoust. Soc. Am. 22:862.
Lush, J. L., B. G. Thomas, C. C. Culbertson and F. J. Beard. 1936. Variation in the softness of lard produced in the record performance testing. Proc. Am. Soc. An. Prod. 29:258.
McMeekan, C. P. 1940. Growth and development in the pig with special reference to carcass quality characters. J. Agr. Sci. 30:569.
Panier, C. 1957. Ultrasonics in the determination of the state of fatness of hogs. Revue Agr. France 10:482.
Price, J. F., A. M. Pearson, H. B. Pfost and R. J. Deans. 1960. Application of ultrasonic reflection techniques in evaluating fatness and leanness in pigs. J. Animal Sci. 19:381.
Price, J. F., A. B. Pfost, A. M. Pearson and C. W. Hall. 1958. Some observations on the use of ultrasonic measurements for determining fatness and leanness in live animals. J. Animal Sci. 17:156.
Shorland, F. B., R. Hansen and K. L. Hogan. 1944. Studies on the fats of the bacon pig with reference to carcass quality. Empire J. Exp. Agr. 12:103.
Sink, J. D. and R. C. Miller. 1962.. Fat deposition in swine. J. Animal Sci. 21:985. (Abstr.).
Sink, J. D., J. L. Watkins, J. H. Ziegler and R. C. Miller. 1964. Analysis of fat deposition in swine by gas-liquid chromatography. J. Animal Sci. 23: 121.
Stouffer, J. R., M. V. Vallentine and G. H. Wellington. 1959. Ultrasonic measurement of fat thickness and loin-eye area on live cattle and hogs. J. Animal Sci. 18:1483.
Stouffer, J. R. and G. H. Wellington. 1960. Ultrasonics for evaluation of live animal and carcass composition. Proc. Am. Meat Inst. Found. 13:18.
Thomsen, R. N. 1965. Report of the work of the sub-commission on pig progeny testing of the European Association for Animal Production during the period 1959/1964. World Rev. An. Prod. 1:129.
Wellington, G. H. and J. R. Stouffer. 1959. Beef marbling: its estimation and influence on tenderness and juiciness. Cornell Agr. Exp. Sta. Bul. 941.
Zobrisky, S. E., D. E. Brady, J. F. Lasley and L. A. Weaver. 1954. Pork carcass evaluation. Mo. Agr. Exp. Sta. Res. Bul. 554.
Zobrisky, S. E., D. E. Brady, J. F. Lasley and L. A. Weaver. 1959a. Significant relationships in pork carcass evaluation. I. Lean cuts as criteria for live hog value. J. Animal Sci. 18:420.
Zobrisky, S. E., D. E. Brady, J. F. Lasley and L. A. Weaver. 1959b. Significant relationships in pork carcass evaluation. II. Measurements and cuts of fat as criteria for live hog value. J. Animal Sci. 18: 583.