IS INTERMUSCULAR FAT RESPONSIBLE FOR PROPORTIONAL FAT GROWTH IN FEMALE AND SURGICAL CASTRATE FINISHER PIGS?

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Abstract – A move towards value-added products with more discerning purchasers has resulted in greater feedback on pig carcass quality, with excess subcutaneous and intermuscular fat in some cuts observed. Carcasses (72) across three carcass weight groups (80, 90 and 100 kg) and two sexes (female and surgical castrate) were broken into four distinct primals; ham, shoulder, loin and belly. These primals were further broken down to a 'retail' level, by dissection, removing the rind, bone and subcutaneous fat. The remaining tissue then underwent chemical analysis to determine the intermuscular and intramuscular fat content and muscle by subtraction.

The proportional distribution of tissues within primals and the half-carcass did not, generally, show significant change as the carcass got larger. There was a trend in most depots for the intermuscular fat content to increase with size, with a significantly higher proportion of this tissue in the belly and half-carcass when comparing the heaviest and lightest groups. Unlike most other studies, the intermuscular fat depot grew faster than the other depots.

This study shows we are unlikely to see significant changes in tissue distribution within the pig as we move to heavier carcasses, but attention should be paid to potential issues with intermuscular fat in particular primals.

Key Words – Allometric growth, intramuscular fat, subcutaneous fat.

I. INTRODUCTION

Historically the Australian pig industry has focused on the domestic market with opportunistic exporting. With the maturation of the market, a move to value-added products and the exporting of carcasses to more discerning buyers in Singapore, greater feedback on carcass quality is being received. One such issue is increased variation and excessive fat, subcutaneous and intermuscular, within the belly; a high value cut within the Singapore market. Excess intermuscular fat is also likely to be an issue in larger value-added cuts, as whilst subcutaneous fat can be trimmed, intermuscular fat is often integral to the cut, with excess fat reducing consumer acceptability.

The aim of this experiment was to describe the change in the carcass as it grows from the domestic trade weight with particular attention on the development of intermuscular fat.

II. MATERIALS AND METHODS

Seventy-two carcasses (Hybrid slaughter generation, 50 % Large White, 12.5 % Landrace, 37.5 % Duroc) were investigated. The study was based on a 2 x 3 factorial design with two sexes; female and surgically castrated male, and three carcass weights; 80, 90 and 100 kg. The weight groups reflected the current domestic trade weight in Australia at the time of the experiment, a heavy weight suitable for export and value-adding and an intermediate group.

Carcasses were sourced from commercial slaughter pigs grown under normal husbandry conditions on a single site. Pigs had *ad libitum* access to standard mash diets with wheat and sorghum as the base cereals, with soybean, canola, fish and meat meals as the main protein sources. Finisher diets contained 13.5 MJ DE/kg and 0.58 g available lysine / MJ DE. At slaughter, after approximately 15 hours off feed, the animals were electrically stunned and bled. Scalding, dehairing and evisceration were conducted according to standard commercial practices. Carcasses were chilled overnight at 4°C prior to transportation to the research facility.

All carcasses were prepared in an identical manner. The head was removed at the atlas joint with all fat, muscle and other tissues in this plane being removed. The carcasses were split along the sagittal line and the right side was selected for dissection into tissue types. To allow for a greater description of tissue distribution the half-carcass was broken down into 4 distinct primal regions. The ham was separated by a straight cut perpendicular to the longitudinal axis between the last lumbar and the first sacral vertebrae. The shoulder was created by separation at the junction of the third and fourth thoracic vertebrae and cutting along the caudal edge of the third rib. The remaining middle was then split along the line from the base of the scapula to the head of the pelvis (ilium) resulting in an upper loin and a lower belly. The ham primal was 30 % of the half-carcass weight, shoulder 30 %, loin 22 % and belly 18%.

Six distinct tissue types were identified as being significant with each primal undergoing a similar dissection. Initial dissection was to a 'retail' level with the removal of defatted rind, the removal of all bones and the separation of subcutaneous fat. Whilst this depot is well defined in a primal such as the ham, in other primals it is less well defined, therefore the subcutaneous fat was defined as any fat between the rind and the first layer of muscle, and in that plane when muscles were not adjacent. The remaining tissue was further differentiated into its component parts by chemical analysis. A sub-sample of fat free muscle was taken for the determination of intramuscular fat by Soxhlet extraction [1]. The remaining tissues were minced and were analysed for fat by Soxhlet extraction, with the intramuscular fat content subtracted to determine an intermuscular fat content, and were converted to a dissected value based on Smith *et al.* [2]. The mass of muscle was thus determined from the subtraction of these two fat depots. The converted mass values of subcutaneous, intermuscular and intramuscular fat were added to give a total fat content within the primal.

Differences between sexes were not significant nor were there interactions between sex and weight groups, these results are not shown. To take account of minor variations within weight groups and to allow for comparisons between weight groups, raw values were converted to the proportion of the primal. Analysis of variance was used to determine differences between groups.

Allometric analyses of fat depot growth within each primal over this weight range was conducted through the linear regressions of natural log transformations of fat depot weights on log transformed primal weight, muscle or total fat within that primal. Values less than 1 indicated slower growth and values greater than 1 indicated faster growth in comparison to the muscle, total fat or weight of that primal. Analysis of variance was used to assess differences in fat depot allometric growth rates within each primal.

III. RESULTS AND DISCUSSION

Actual carcass weights (mean ± sem) of the three weight groups differed significantly ($P<0.001$), 79.0 ± 0.7, 90.9 ± 0.5 and 101.5 ± 0.9 kg. Weight groups did not differ significantly in P2 fat depth (65 mm from the midline at the head of the last rib), 17.9 ± 1.6, 19.8 ± 1.5 and 18.0 ± 1.2 mm respectively; however muscle depth at the P2 site in the two heavier weights was significantly greater ($P<0.05$) than that of the lightest group, 52.6 ± 0.9, 57.1 ± 1.8 and 59.7 ± 0.9 mm.

Generally there were no significant differences in the proportional distribution of body tissues within primals, or half-carcass, across the weight groups (Table 1). Muscle accounted for half of the tissues within the ham, with no differences being seen for muscle, subcutaneous or intramuscular fat as carcass weight increased. There was a minor trend ($P=0.10$) for intermuscular fat to increase as weight increased, however this did not affect total fat content. Differences were not seen in the distribution of most tissues within the shoulder. The lower proportion of intramuscular fat in the 90 kg group compared to the 100 kg group was significant ($P<0.05$) but not biologically different.

There were no significant differences or trends in the proportional distribution of tissues in the loin. Within the belly the content of intermuscular fat increased significantly ($P<0.05$) as the carcass got heavier, whilst there was no trend in other tissues.

Within the half-carcass the distribution of muscle, total fat, subcutaneous or intramuscular fat did not change as the weight of the carcass increased. However, the intermuscular fat content of the half-carcass increased significantly ($P<0.05$) as the weight of the carcass increased, with the 100 kg weight group having a greater proportional content of intermuscular fat than the 80 kg weight group.

Table 1 Mean proportional distribution of body tissues within carcass primals and the half-carcass. Values within a row with different superscripts are significantly different (P<0.05)

Tissue	80 kg	90 kg	100 kg
Ham			
Muscle	0.50	0.51	0.49
Total fat	0.31	0.30	0.31
Subcutaneous	0.17	0.16	0.17
Intermuscular	0.10	0.10	0.11
Intramuscular	0.04	0.03	0.03
Shoulder			
Muscle	0.37	0.38	0.35
Total fat	0.39	0.37	0.40
Subcutaneous	0.15	0.14	0.15
Intermuscular	0.19	0.19	0.21
Intramuscular	0.04^{ab}	0.04^{a}	0.04^{b}
Loin			
Muscle	0.33	0.35	0.32
Total fat	0.44	0.44	0.47
Subcutaneous	0.28	0.27	0.29
Intermuscular	0.14	0.15	0.15
Intramuscular	0.03	0.02	0.03
Belly			
Muscle	0.23	0.25	0.22
Total fat	0.58	0.57	0.56
Subcutaneous	0.36	0.33	0.32
Intermuscular	0.19^{a}	0.20^{ab}	0.21^{b}
Intramuscular	0.03	0.03	0.03
Half-carcass			
Muscle	0.38	0.39	0.36
Total fat	0.41	0.40	0.42
Subcutaneous	0.22	0.21	0.22
Intermuscular	0.15^{a}	0.16^{ab}	0.17^{b}
Intramuscular	0.03	0.03	0.04

Increasing the weight of the carcass is unlikely to result in significant changes to the proportional distribution of tissues within the pig carcass. The proportion of muscle, subcutaneous and intramuscular fat remained fairly constant across weight groups. The intermuscular fat depot, particularly in the belly but observable in other primals appears to be influenced by carcass weight. The higher proportion of intermuscular fat seen in the belly, compared with the ham is consistent with precious studies [3]

This variation in fat growth is expected [4] but it has been further influenced by the direct selection of leanness in pigs by measurement of the subcutaneous layer [5]. The lack of phenotypic correlation between the subcutaneous and intermuscular depots is well described [6] and indicates different physiological control.

There were significant differences in the allometric growth of the three fat depots investigated (Table 2). Subcutaneous fat within the ham grew comparatively slower than the muscle and total fat depots within the ham, and slower than the growth rate of the whole primal. In comparison, the intermuscular and intramuscular fat depots within the ham grew at a faster rate than the other tissues, with intermuscular fat growing significantly faster than the subcutaneous depot.

Within the shoulder the subcutaneous fat depot grew at a significantly different rate than the intermuscular fat depot when compared with the growth of the primal and the weight of muscle and total fat within the shoulder. Whilst intermuscular fat grew at a faster rate than other tissues within

Table 2 Allometric development of subcutaneous (sub), intermuscular (inter) and intramuscular (intra) fat depots relative to primal, muscle or total fat weight within carcass primals and the half-carcass. Values within a row with different superscripts are significantly different (P<0.05)

	Fat depot		
Allometry relative to item	Sub	Inter	Intra
Ham			
Primal	0.78^{a}	1.62^{b}	1.27^{ab}
Muscle	0.80^{a}	1.76^{b}	1.37^{ab}
Total fat	0.75^{a}	1.43^{b}	1.13^{ab}
Shoulder			
Primal	0.89^{a}	1.32^{b}	1.13^{ab}
Muscle	0.91^{a}	1.38^{b}	1.00^{ab}
Total fat	0.79^{a}	1.14^{b}	1.07^{ab}
Loin			
Primal	1.25	1.24	1.06
Muscle	1.24^{ab}	1.39^{b}	0.93^{a}
Total fat	1.02	0.97	0.91
Belly			
Primal	0.71^{a}	1.27^{b}	1.36^{b}
Muscle	0.61^{a}	1.22^{b}	1.27^{b}
Total fat	0.74^{a}	1.29^{b}	1.39^{b}
Half-carcass			
Half-carcass	0.94^{a}	1.38^{b}	1.21^{a}
Muscle	0.97^{a}	1.51^{b}	1.20^{a}
Total fat	0.85^{a}	1.20^{b}	1.11^{ab}

the shoulder, its rate relative to total fat reflects its greater proportion in the shoulder.

Fat tissues within the loin grew close to or faster than the relative weights. Within the loin differences between fat depots only occurred when compared with muscle, where intermuscular fat grew significantly faster than intramuscular fat. In the belly, subcutaneous fat grew significantly slower than the other depots when compared relative to the weight of muscle or primal, or to the total fat content.

In the half-carcass, fat depots grew at or relatively faster to the growth of muscle or the half-carcass, with intermuscular fat growing significantly faster than the other fat depots. When compared with the total fat in the half-carcass the intermuscular depot grew at a significantly faster rate than the subcutaneous depot.

The increased growth of intermuscular fat relative to other fat depots seen in this study is not reflected in other studies. Early classical studies [4, 7] found intermuscular fat growth was slower than the growth of subcutaneous fat (0.97 v 1.01 and 0.87 v 1.01), although more modern studies show similar growth rates (1.47 v 1.42) [8]. Regional differences have been seen [9] with faster intramuscular growth in the forequarter, but similar in the hindquarter.

This study showed a consistent pattern, across all primals and the half-carcass, of growth in the ratio of intermuscular to subcutaneous fat as the carcass got heavier, which is in conflict with previous studies [8] which showed stability in the shoulder and loin, a decrease in the ham and an increased ratio in the belly. Whilst these differences in results may be a reflection of differences in methodology, they highlight the variation in fat growth that occurs in the pig.

IV. CONCLUSION

These findings show that the growth of pigs to heavier weights is unlikely to see a significant change in the relative proportion of body tissues, although there may be specific areas within the carcass that need particular attention. This study has further shown that intermuscular fat is a very different depot to the subcutaneous fat that can be easily measured and selected for in the live animal or trimmed from the carcass. Given the impact that intermuscular fat content can have on the consumer, especially in cuts such as the belly, better targeted technologies or methods of selection would appear warranted.

ACKNOWLEDGEMENTS

The author thanks PIC Australia Pty Ltd and Australian Pork Ltd for their help and financial assistance in the conduct of this experiment.

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