THE INCIDENCE AND USE OF BRUISED BEEF IN MEAT PRODUCTS IN TROPICAL AFRICA

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SUMMARY

The extent and nature of bruising in beef carcases were surveyed in five abattoirs in three African countries. Losses between 0.25 and 0.70% of carcase weight were recorded which, if extrapolated over a full year would represent 1150mt of beef valued at about US$1.5m. Bruised material was incorporated into beef salami and blood sausage at 10% level and beefburger at 10 and 25%. All products were microbiologically sound. Bruised tissue was either undetected or preferred by a taste panel at 10% inclusion level. The panel thought the bruised tissue enhanced the appearance of the salami. The colour of the cooking exudate of the beefburgers containing bruised tissue was unpleasing. It was concluded that some types of bruised tissue could be used safely in selected meat products but there are serious problems regarding the identification, inspection and collection of the material which would need to be addressed.

INTRODUCTION

A bruise is the result of a trauma to the body of the living animal. Blood vessels are broken and whole blood escapes into the surrounding tissue. Traumae result from many factors which may have broken the skin in exceptional cases. These factors are discussed by McManus and Grieve (1964), Meischke et al (1974), Hill (1975), Meischke (1975), Shaw et al (1976), Vowles (1976), Bleasel et al (1977), Marshall (1977), Yeh et al (1978), Wythes et al (1979) and Grandin (1980). They include poor handling during animal production, transport and subsequent operations up to and including slaughter and badly maintained abattoirs.

The economic losses due to bruising are considerable. Gracey (1986) noted that $61m each year was lost in the USA through bruising in cattle alone. Hill (1975) and Korn (1975) estimated that A$20/22m were lost in Australia in 1973/4. Data collected from 19 sources in 10 countries showed that between 0.07 and 11.5kg (weighted average 1.80kg) of bruised tissue was removed from each head of cattle slaughtered, which represented approximately 1% of carcase weight.

Meat hygiene regulations in many countries require bruised tissue to be removed and condemned before carcases are regarded as fit for human consumption. This is because it has been assumed that bruised tissue will contain a higher microbial load and the bacteria will grow more rapidly than on unbruised tissue (Thornton and Gracey, 1974; Mitchell, 1980 and Gracey, 1986). Marshall (1977) considered bruised tissue to be "a public health hazard due to its inherent capability of acting as a vehicle of infection and a medium which is more suitable for the proliferation and multiplication of potentially pathogenic and spoilage organisms than healthy tissue". Gill and his co-workers (1978, 1979 & 1982) have challenged these established views. They demonstrated that deep muscle tissue is normally sterile in healthy animals where the skin is not broken; that microorganisms grow at their maximum rate on unbruised tissue ie. they would grow no faster on unbruised tissue; and that there is no difference in the microbiological quality of bruised and unbruised tissue provided that they are treated the same way. They also showed that inclusion of 10% bruised tissue in fried mince was undetected by a taste panel, there is no reason to remove bruised tissue immediately from the carcase on the slaughterline and that there should be no objection to its inclusion in a meat product.

Food shortages mean that Africa can ill afford to waste that already produced. Although attention is being given to ways of improving livestock handling in developing countries so as to reduce the incidence of bruising, changes will only be possible through investment in improved communications, marketing infrastructure and training. On the assumption that bruising losses will continue to remain high, the current study was undertaken to establish the order of magnitude of bruise losses of beef in Africa, examine the methods for its removal from beef carcases and subsequent disposal, determine the nature of the material removed from the carcase and observe possibilities for changes in meat handling procedures to reduce losses. As the losses through bruising were significant and it was considered possible to salvage the trim, three different meat products were made and subjected to organoleptic assessment, microbiological and other analyses to determine consumer appeal and general product safety.

MATERIALS AND METHODS

A survey of bruising of beef carcases in five abattoirs in three countries in Eastern and Southern Africa was undertaken in July 1984. Three central and two regional abattoirs were involved. Data on the nature and extent of bruising from 1225 carcases were collected (see Tables 1 & 2). Comparisons were made between slaughter lots or "mobs" of cattle to determine the influence of pre-slaughter handling variables (transport, time, distance, etc.) - unpublished.

Bruised tissue was incorporated into selected meat products at the TDRI laboratories in the United Kingdom using routine trimmings from several beef carcases dressed in an Oxfordshire abattoir. Meat was separated from other tissues, minced coarsely, packed in 1kg batches, frozen and held at -15°C until required.

Results of chemical analyses of the ingredients were used in the formulation of the salami and blood sausage. Test and control samples were formulated to give similar final chemical compositions.

Beefburgers consisted of 0, 10 and 25% bruised beef, 12% beef suet, 2% NaCl, 5% water made up to 100% with 80% Visual Lean forequarter beef. The products were made using catering scale equipment. Samples of each product were stored at -15°C and +4°C for 7 days.

Control and test samples of salami were made from bruised tissue (0 and 10%), topside beef (70 and 64%), brisket fat (26 and 22%), salt (2.4%), spices, sucrose and sodium nitrite. Coarsely minced beef was mixed with the cure ingredients and stored overnight at +5°C. The beef was then minced again, mixed with coarsely minced fat and spices and passed through a fine mincing plate before stuffing into cellulose casings. The sausages were placed in a preheated oven operating between 55°C and 81°C. Samples of control and test sausages were removed from the oven when their core temperature had reached 60°C and others when they had reached 70°C. All sausages were cooled for 30 minutes under water sprays immediately after cooking. The salamis were stored at +5°C for 15 days.

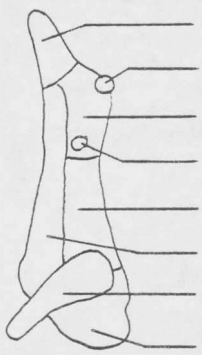
Control and test blood puddings were made using bruised tissue (0 and 10%), citrated beef blood (50 and 45%), beef suet (30 and 26%), pinhead oatmeal (10%), rice (4% dm), salt (2.3%) and spices. Boiled rice was cooled to 5°C and added to the finely minced

suet, oatmeal and spices. The blood was heated gently and added to the rest of the ingredients and mixed. The mix was stuffed into cellulose casings and cooked in a waterbath at 88°C until the core temperature reached 70°C. The sausages were cooled under a water spray for 15 minutes and stored at +5°C for 16 days.

Samples of all products were subjected to microbiological, chemical, organoleptic analysis and assessed for cooking losses, using ICMSF (1978) and AOAC (1984) methods as appropriate. Results are given in Tables 3, 4 and 5.

RESULTS

Table 1
Number of Bruises and Percentages of Carcases bruised, by Country

Country	A	B	C	Combined
	6 (0.9)	3 (0.2)	3 (0.5)	12 (0.5)
	468 (74.1)	560 (44.9)	8 (1.4)	1036 (42.3)
	210 (33.2)	241 (19.3)	18 (3.1)	469 (19.1)*
	551 (87.2)	619 (49.7)	10 (1.7)	1180 (48.1)
	305 (48.3)	227 (18.2)	11 (1.9)	543 (22.2)
	39 (6.2)	137 (11.0)	149 (26.0)	325 (13.3)
	376 (59.5)	336 (27.0)	51 (8.9)	763 (31.1)
	1 (0.2)	9 (0.7)	1 (0.2)	11 (0.5)

* (%) carcases which had bruising in the region indicated,
eg. 19.1% of all carcases examined were bruised in the buttocks.

Table 2
Losses Due To Bruising in African Beef Carcases in Three Countries in July 1984

Country		A	B	C	Combined
Carcases examined	No.	316	623	286	1225
Carcases bruised	No.	306.50	451.50	106.50	864.50
Carcases bruised	%	97.00	72.50	37.20	70.60
Total mass of carcases	kg	66112	133370	27340	226822
Total mass of bruised tissue trimmed	kg	462.50	512.30	68.00	1042.80
Mass of bruised tissue trimmed	%	0.70	0.38	0.25	0.46
Total no of bruises	No.	1956	2132	251	4339
Av mass of each bruise	g	236	240	271	240
Total value of mob to producer	$	75615	152110	21460	249185
Av price/kg carcase	$	1.14	1.14	0.84	1.10
Loss of income to producer	$	529.79	584.03	54.75	1168.56
Loss of income/animal	$	1.68	0.92	0.18	0.95
Loss of income/bruise	$	0.27	0.27	0.23	0.27

Notes to Tables 1 & 2

1 In the central abattoirs, some bruises were not trimmed from the carcase; the speed of the slaughterline and the severity of bruising often precluded this. This factor may reduce the impact of the figures in table 2.

2 In the central abattoirs, the fast speed of the dressing line, variations and "peaking" of bruising were not conducive to accurate trimming. Excess trimming seemed a common fault which would exaggerate the figures in table 2. Conversely, a slow dressing line allowed the inspector to trim more accurately, as observed in the regional abattoirs.

Table 3
Chemical Analysis of Meat Products Containing Bruised Tissue

Product	Beefburgers			Beef Salami				Blood Pudding		Bruised Tissue
Storage Temp °C	-15/+4			5				5		
Processing Temp °C	4			60		70		71		
Bruised Meat Inclusion Level %	0	10	25	0	10	0	10	0	10	
Analysis / Day										
Crude protein % 0	-	-	-	18.08	17.33	18.24	17.30	11.96	12.13	19.75
Fat % 0	18.65	18.53	17.31	22.46	23.31	23.61	23.80	26.04	24.46	11.32
Ash % 0	-	-	-	3.21	3.19	3.22	3.22	3.63	3.49	0.62
Salt % 0	-	-	-	2.74	2.60	2.40	2.41	2.33	2.40	0.05
Moisture % 0	57.08	59.45	61.40	55.63	54.39	54.12	54.75	54.82	52.34	68.50
Moisture % 6	-	-	-	54.48	54.54	56.38	54.70	50.35	47.34	-
pH 0	6.12	6.05	6.13	5.80	5.82	5.82	5.87	7.45	7.38	5.45
a_w 6	-	-	-	5.70	5.79	5.74	5.85	7.42(3)	7.21(3)	-
a_w 1	-	-	-	-	-	-	-	0.923	0.926	
a_w 6	-	-	-	0.929	0.917	0.916	0.900	0.931(16)	0.923(16)	

Figures in parentheses indicate day no., if different from that under day header

Table 4
Taste Panel Assessment of Meat Products Containing Bruised Meat, 3 Days after Manufacture.

Product	Beefburgers						Beef Salami*			
Storage Temp °C	-15			4			5			
Processing Temp °C	4			4			60		70	
Bruised Meat Inclusion Level%	0	10	25	0	10	25	0	10	0	10
Production Cooking Loss %	-	-	-	-	-	-	4.32	4.40	5.96	6.00
Storage Loss (5 days) %	-	-	-	-	-	-	2.85	2.88	2.35	2.36
Consumers Cooking Loss %	26.92	18.79	23.94	-	-	-	-	-	-	-
Toughness 0=tender, 10-tough	5.0	5.4	3.3	4.4	2.9	3.9	-	-	-	-
Chewiness 0=none, 10=much	5.3	6.0	3.9	4.9	4.1	3.8	50	50	66	33
Crumbliness 0=none, 10=much	2.8	2.3	4.6	3.1	3.8	3.0	33	66	75	25
Fattiness 0=none, 10=much	4.5	3.8	3.7	4.3	3.2	3.7	75	25	50	50
Flavour 0=weak, 10=strong	5.1	5.9	5.1	3.9	6.6	3.3	50	50	33	66
O/all accept'y 0=dislike, 10=like	5.4	5.3	4.0	4.3	6.3	3.1	-	-	-	-
Appearance	-	-	-	-	-	-	50	50	0	100
Overall preference	-	-	-	-	-	-	0	100	25	75

* Figures for beef Salami represent the % of panel members who preferred the product

Table 5
Microbiological Analysis of Meat Products Containing Bruised Tissue

Product	Beefburgers						Beef Salami				Blood Pudding		Control Tissue	Bruised Tissue	Fat
Storage Temp °C	-15			4			5				5				
Processing Temp °C	4			4			60		70		71				
Bruised Meat Inclusion Level%	0	10	25	0	10	25	0	10	0	10	0	10			
Analysis / Day															
SPC (cfu/g) at 30°C 0/1	4.2×10^5	1.5×10^6	3.3×10^6	4.2×10^5	1.5×10^6	3.3×10^6	$<2 \times 10^3$	$<2 \times 10^3$	$<2 \times 10^3$	$<2 \times 10^3$	5.9×10^4	4.0×10^4	3.0×10^6	1.6×10^7	2.3×10^7
SPC (cfu/g) at 30°C 6/7	6.9×10^5	2.0×10^6	5.0×10^6	8.3×10^7	2.4×10^7	4.2×10^7	1.8×10^3	7.7×10^3	2.0×10^2	1.5×10^2	8.4×10^4	7.3×10^4			
SPC (cfu/g) at 30°C 15/16							5.5×10^2	3.1×10^4	2.5×10^2	2.0×10^2	6.6×10^4	9.5×10^4			
Spoilage Organisms (cfu/g) 35°C 1/6							100	250	100	<100	9.0×10^2	450	<100	200	

DISCUSSION

The observed area and depth of a bruise are not necessarily accurate indicators of its true area and depth. Once a cut is made into the tissue, bruising can be considerably more extensive than the initial observation indicated. The type of material trimmed for bruising comprised fat, connective and oedematous tissue in addition to muscle tissue. Animals with a better finish (fat cover) tended to show less bruising although they were not necessarily less bruised. Although the age of the bruises could not be identified accurately, old and new bruises could be identified by colour. By far the majority of bruises examined were recent. Certain types of bruises could be identified by their shape to have been caused by specific artefacts. The use of the stick, for example, could be most easily seen and some types of horn rake were identifiable. An animal which had "gone down" during transportation and had been trampled was also easily identified. At one abattoir it was noticed that the right hand sides of carcases were more bruised than the left. During the survey, the stunning box was operating incorrectly and, as the animals were cast onto their right sides, showed that damage could occur between stunning and sticking. Meat inspectors worked for the veterinary authorities and not under the abattoir management. Their management was more difficult in a large abattoir, where there were many staff working on a fast slaughterline, than in a smaller abattoir, where their management was more effective and unnecessary trimming was reduced. Bruised tissue was removed with condemned materials, often by the same meat inspector using the same equipment. For bruised material to be removed hygienically from the carcase separate facilities and staff, perhaps at a work station away from meat inspection,would be required. Veterinary authorities indicated that they were under instruction to remove all bruised tissue and classify it as condemned. Bruised material was sent with condemned material for heat rendering into animal feed. To change the system would require retraining of meat inspectors in the separation of bruises caused by traumae where the skin had been broken or not. The three central abattoirs had facilities for the separation of meat into its separate categories and the manufacture of processed meats for human consumption. The two smaller abattoirs did not have this facility. Most managers and handlers were aware of the problems of bruising. They also appreciated that a considerable amount of training and investment would be required to reduce the losses from this cause significantly. It is universally accepted that elimination of bruising is practically impossible.

Table 1 shows that most bruising took place in the hip region, (48.1% of carcases), over the pin bones by the tail (42.3% of carcases) and in the shoulder (31.1% of carcases). In country C, most bruising was observed in the flank/barrel region (26.0% of carcases). The hip, pin and shoulder bones are generally closer to the surface of the animal than other bones and protrude in less finished stock. If bruising was to occur then it would be expected at these points during transport to the abattoir. The barrel bruising in country C was possibly due to the poor condition of the animals which rested on the ground more frequently than better fed animals. They were thus more likely than those standing to be trampled. In standing animals, the rib cage was probably the widest part of the beast and would be most vulnerable in weak animals without the strength and reflexes to react adequately to standing in a moving vehicle.

Table 2 shows that the mass of bruised tissue trimmed from beef carcases ranged from 0.25 to 0.70% of carcase weight with an average of 0.46%. Although this survey covered only 0.05% of the annual slaughter of the three countries combined, extrapolation of the losses shows that about 1150 mt of bruised material valued at about $1.5m was downgraded. This was considered sufficient justification to look at ways to add value to the damaged meat.

Chemical analysis of the beefburgers (Table 3) reflects the increased moisture and reduced fat content of the bruised tissue used in the formulation. The chemical composition of the test and control samples of each of the other types of meat products was similar, reflecting some success with formulation.

Taste panel assessments of the meat products are shown in Table 4. Beefburgers stored at -15°C show reduced toughness, chewiness and fattiness, and were more friable. No flavour differences were noted between control and 25% bruised tissue inclusion but at 10%, the flavour was reported to be stronger. Overall acceptability at the 10% inclusion level was similar to the control, although it was reduced at 25%. In beefburgers stored at +4°C similar results were obtained except that the flavour was stronger and overall acceptability at 10% was markedly higher than controls or 25% inclusion levels. The cooks who prepared the taste panel samples remarked upon the heterogenous appearance of the test samples and dark-coloured exudate on cooking, neither being liked. Further trials using different methods of preparation reduced the problems of appearance but could not alter those of the exudate.

The taste panel showed no specific preferences for test or control salami sausages cooked to 60°C except that the test samples were unanimously preferred overall. In sausages cooked to 70°C, the appearance and moistness of the test products were unanimously preferred and the overall preference was generally preferred. Panelists remarked on the attractive "dark flecks" (bruised meat) in the test samples which were also responsible for the slight extra colour in the 70°C test samples which were generally paler than those cooked conventionally to 60°C.

As examination of blood sausage by preparation staff showed the differences between test and control to be visually and microbiologically undetectable, the time and expense of a taste panel assessment was avoided.

The microbiological results (Table 5) showed that the control and bruised tissue was of an acceptable quality. The control tissue had a slightly lower bacterial load (10^6 cfu/g) compared to the bruised tissue (10^7 cfu/g) and backfat (10^7 cfu/g). This may have been caused by excessive handling of bruised tissue and fat during trimming. There were no marked microbiological differences between products prepared with and without bruised tissue. Aerobic plate counts increased with storage at 5°C.
Staphylococcus aureus was not detected at significant levels in any of the products examined. Spices are regularly blamed for the addition of sporeforming pathogens (Kim and Goepfert, 1971) and spoilage bacteria (Palumbo et al, 1975). However, excessive levels of sporeformers were not present in either salamis or blood sausage.

CONCLUSIONS

This survey showed that a considerable weight of carcase beef in three African countries is condemned as bruised. The results show that some types of bruised meat can be safely included in meat products and may even enhance the appearance of the product. The use of bruised tissue could help to reduce some post harvest losses in the meat industries of Africa. The need to remove some kinds of bruised tissue from the carcase on the dressing line is not necessarily indicated. Bruised tissue needs special handling since it consists of fatty and oedematous tissues in addition to muscle. The method of removal of bruised

tissue from the carcase needs revision, however, since it must not be treated with condemned materials. Staff would need to be retrained in the identification of different types of bruises. Special facilities would be required for removal and handling of bruised tissue. The factory must be able to process and sell the meat products made from this material.

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