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Enhancing Meat quality and value: Cold-set restructuring with type II and type III quality beef cuts#

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Abstract

This study sought to optimise the amalgamation of type II and type III quality beef cuts in cold-set restructured beef, employing the cold-binding agent microbial transglutaminase. Type III quality beef cuts, include brisket, plate, and flank, which were blended in a 1:1:2 ratio, while type II quality beef cuts, encompassing round and chuck, were mixed in a 1:1 ratio. The type II cuts were cubed to dimensions of 10 × 7.5 × 5 centimeters, while the type III cuts were minced through a 13 millimeters mincer plate. Three proportion variants were examined: Control (C_1, 100% type II meat), T_1 (70% C_1 + 30% type III meat), T_2 (60% C_1 + 40% type III meat), and T_3 (50% C_1 + 50% type III meat). The ingredients utilised included microbial transglutaminase and curing agents. The creation of cold-set beef loaves entailed sequential steps such as vacuum tumbling, vacuum packaging, equilibration and freezing. The resultant cold-set beef loaves were then sliced into 5 millimeters thick beef steaks and seasoned with a spice blend before pan-frying and subjected to sensory evaluation. Cooking yield and sensory attributes (both raw and shallow-fried) were meticulously analysed. Our findings indicated that there were no statistically significant differences (p>0.05) in cooking yield, with T_3 demonstrating the highest mean (53.8 ± 3.45). Concerning sensory attributes in both raw and shallow-fried restructured beef steaks, all attributes exhibited significant differences (p< 0.05), with T_3 achieving the highest scores. Thus, the restructured beef steaks (T_3) incorporating 50 per cent type II quality beef and 50 per cent type III quality beef emerged as the preferred composition among the treatments.

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Despite the fact that meat and meat products are widely recognised for their health benefits, eating them is frequently linked to colon cancer and cardiovascular illnesses. Across the world, scientists and food processors are working to change the composition of meat to enhance its quality. Customers now want meat products with less fat, less salt, more fibre, and fewer artificial additives because of shifting circumstances and more understanding. The beef product that has been reformed has several advantages, including low fat content and calorific value (Gadekar *et al.,* 2015).

The two main methods used to produce restructured beef products are the cold-binding method, which uses binders that may be used in a refrigerated environment, and the traditional hot-setting method that uses salt/phosphate and further thermal processing (Payne, 2000). The use of microbial transglutaminase has been proposed as a method for cold gelification of muscle proteins, reducing or eliminating the need for phosphate and NaCl additives (Kuraishi *et al.,* 2006). In restructuring of meat, tumbling and massaging are the two techniques used quiet commonly. Tumbling utilises impact energy and massaging utilises frictional energy (Sharma *et al*., 2014). One significant advantage of this restructuring technique is its potential to add value to meat trimmings (Ford *et al.,* 1978).

This study aims to enhance the value of tough quality beef cuts by incorporating type III quality cuts with less tender cuts (type II meat). It seeks to improve tenderness and overall quality. Specifically, this research focuses on the incorporation of tough cuts (brisket, flank and plate) and less tender cuts (round and chuck) to assess the impact on sensory attributes and cooking yield. The findings of this study have implications for the value addition of tough cuts and potential improvements in tenderness, benefiting both consumers and the meat industry.

Materials and methods

The research procedure was conducted at the Department of Livestock Products Technology (Meat Technology Unit), College of Veterinary and Animal Sciences, Mannuthy. Beef cuts (round, chuck, brisket, plate and flank) were obtained from aged animals that had been humanely slaughtered and deboned at the Meat Technology Unit in Mannuthy. For the ageing process, the purchased beef cuts were promptly chilled (4±1°C). Meat that had been deboned was aerobically packed in high-density polyethylene (HDPE) bags, stored at a freezing temperature of -22±1°C, and then thawed at a temperature of 4°C before being taken for preparation of restructuring of meat.

Deboned aged beef cuts (round, chuck) sectioned into chunks of standardised dimension, 7.5 cm × 10 cm × 5 cm (Breadth × Length × Thickness) were taken in a 1:1 ratio. Then deboned aged beef cuts (brisket, plate and flank) were taken in a ratio of 1:1:2 and minced through a 13 millimeters grinder plate using a meat mincer (MADO primus Model MEW 613, Germany). The chunks were brushed with microbial transglutaminase then blended along with curing ingredients such as salt, sodium tripolyphosphate, sodium nitrite and at the level of 0.75 per cent, 1 per cent, 0.3 per cent, and 120 parts per million respectively. After pre-blending, the chunks were vacuum tumbled (BIRO Vacuum Marinade Tumbler, Table Top Model: VTS-43, United States of America) for 1 hour period with 10 minutes break after 30 minutes of tumbling, before which the vacuum tumblers were chilled by adding ice flakes. The chunks were then tightly packed in PE/Al/PA laminate pouches and vacuum packed (Vacuum packaging machine, Model: WM-19/S/CE-OSNAVAC, Germany) and kept at refrigeration temperature (4±1 °C) for 12 hours for equilibration and then kept at deep freezer (-22±1 °C) for 24 hours. On the day of sensory analysis, the formed restructured beef loaves were thawed at refrigeration temperature (4±1 °C) until it attained 5 °C and then sliced into steaks of thickness 5 millimeters using meat slicer (Slicer Automatic, Model: 300 VV-CE, Chennai). Before doing sensory evaluation, the steaks were seasoned with spice mix and pan-fried till golden yellow colour was obtained.

Experimental design

The experiment was carried out in two phases: The first phase was the standardisation of the chunk size of the restructured beef. Restructured beef was prepared by using type II quality beef chunks (round and chuck cuts at 1:1 ratio) of three different dimensions. Three chunk sizes considered were: 7.5×10×5 cm cube, 10×10×5 cm cube and 10×12.5×5 cm cube. The chunk size with the dimension of 7.5×10×5 cm cube was selected based on the sensory evaluation and it was used as control for phase two. The second phase involved the standardisation of the level of incorporation of type II (round and chuck cuts at 1:1 ratio) and type III (brisket, plate and flank at 1:1:2 ratio) quality beef cuts. Three proportions were considered and compared with control *viz.,* Control (C_1, 100% type II meat), T_1 (70% C_1 + 30% type III meat), T_2 (60% C_1 + 40% type III meat), and T_3 (50% C_1 + 50% type III meat)

Estimation of cooking yield

The weight of restructured beef steaks before and after cooking was recorded. Cooking yield expressed in per cent (Yashodhan *et al.*, 2022).

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked beef steak}}{\text{Weight of raw beef steak}} \times 100$$

Sensory attributes

Sensory attributes were assessed organoleptically using 8 point Hedonic scale scorecard (AMSA, 1983) with the help of ten semi-trained panellists. The evaluation of the best proportion of incorporation of type III quality meat to the standardised control restructured beef steak was done in two parts: One with raw restructured beef steak which includes appearance and colour, odour, texture, cohesiveness and overall acceptability; other with shallow fried restructured beef steak which includes appearance and colour, flavour, tenderness, juiciness, saltiness, cohesiveness and overall acceptability.

Statistical analysis

Descriptive statistics were computed for all variables. A one-way ANOVA was employed to assess any statistically significant differences in the cooking yield among the control and treatments and non-parametric Friedman's test was employed for the sensory attributes and those recorded are at the conclusion of the study using SPSS Software Version 24.0 (Vandana *et al.,* 2022).

Results and discussion

Three different proportions of type III quality minced meat were incorporated into the standardised restructured meat with type II quality as per the experimental design. The aim was to determine the optimal proportion of type III quality meat to be incorporated among the three treatments (T_1, T_2 and T_3). The selection of the best proportion of type II and type III quality meat was selected based on cooking yield (%) and sensory characteristics.

Physicochemical parameter

The physico-chemical characteristic evaluated in this phase was the cooking yield (%). The observations for this parameter are presented in Table 1.

The control and treatment samples had no significant difference about the cooking yield. Even though there was no significant difference the highest value was attained by the T_3 (53.8 ± 3.45) and the lowest value by T_1 (50.23 ± 3.75). These findings suggest that the increased proportion of type III quality meat did not negatively affect the cooking yield of the restructured beef steak. A slight increase in cooking yield was observed as the percentage of type III quality meat increased. This could be attributed to the smaller particle size resulting from mincing the type III meat cuts and tumbling process, which may have enhanced the effectiveness of salt and phosphate in retaining moisture during cooking, as supported by study of Reddy (2011).

Sensory quality

Sensory evaluations were conducted

to determine the optimal proportion of type III quality meat incorporated into the standardised control restructured beef steak (C_1). The sensory assessments were performed in two parts: one involving raw restructured beef steaks and the other involving shallow fried restructured beef steaks. Sensory attributes included appearance and colour, odour, texture, cohesiveness, flavour, tenderness, juiciness, saltiness, and overall acceptability. The results are presented in Table 2 (for raw) and Table 3 (for shallow fried).

For raw restructured beef steak, significant differences were observed in appearance and colour, odour, texture, cohesiveness, and overall acceptability among the control and treatment groups. T_3 consistently outperformed the other treatments, achieving the highest scores for appearance and colour (7.60 ± 0.28), odour (7.28 ± 0.28), texture (7.55 ± 0.28), cohesiveness and overall acceptability (7.59 ± 0.28). Conversely, T_1 generally received lower scores across these attributes.

For shallow fried restructured beef steaks, significant differences were noted in appearance and colour, flavour, tenderness, saltiness, juiciness, cohesiveness, and overall acceptability among the control and treatment groups. As in raw, T_3 stood out, achieving the highest scores in most attributes, including appearance and colour (7.59 ± 0.28), flavour (7.48 ± 0.28), tenderness (7.56 ± 0.28), saltiness (7.44 ± 0.28), juiciness (7.48 ± 0.28), cohesiveness (7.69 ± 0.28), and overall acceptability (7.65 ± 0.28).

Table 1. Effect of different proportions of type III quality meat incorporation on the cooking yield of the restructured beef

PARAMETER	C_1	T_1	T_2	T_3	F value (p-value)
Cooking yield	51.65±3.92	50.23±3.75	52.25±3.41	53.8±3.45	0.165 (0.919)^{ns}

ns – non-significant at 0.05 level
Means with same superscript have no significant difference between them.
The values are expressed as their Mean ± Standard error.
Number of observations = 6
C_1: Control restructured beef steak (without incorporation of type III quality meat)
T_1: 70% C_1 + 30% quality III meat (brisket, plate, flank)
T_2: 60% C_1 + 40% quality III meat (brisket, plate, flank)
T_3: 50% C_1 + 50% quality III meat (brisket, plate, flank)

Table 2. Effect of different proportions of type III quality meat incorporation on the sensory attributes of the raw restructured beef

Sensory attributes	C_1	T_1	T_2	T_3	χ^2 value (p-value)
Appearance and colour	7.32 ^{b} ±0.28	7.13 ^{b} ±0.28	7.31 ^{b} ±0.28	7.60 ^{a} ±0.28	27.590** (<0.001)
Odour	7.07 ^{b} ±0.28	6.93 ^{b} ±0.28	7.03 ^{b} ±0.28	7.28 ^{a} ±0.28	26.751** (<0.001)
Texture	7.32 ^{b} ±0.28	6.85 ^{c} ±0.28	7.19 ^{b} ±0.28	7.55 ^{a} ±0.28	48.162** (<0.001)
Cohesiveness	7.39 ^{b} ±0.28	6.69 ^{c} ±0.28	7.26 ^{b} ±0.28	7.68 ^{a} ±0.28	71.767** (<0.001)
Overall acceptability	7.34 ^{b} ±0.28	6.83 ^{c} ±0.28	7.26 ^{b} ±0.28	7.59 ^{a} ±0.28	68.608** (<0.001)

** Significant at 0.01 level
Means with same superscript in rows have no significant difference at 0.05 level
The values are expressed as their Mean ± Standard error.
Number of observations = 44
C_1: Control restructured beef steak (without incorporation of type III quality meat)
T_1: 70% C_1 + 30% quality III meat (brisket, plate, flank)
T_2: 60% C_1 + 40% quality III meat (brisket, plate, flank)
T_3: 50% C_1 + 50% quality III meat (brisket, plate, flank)

Table 3. Effect of different proportions of type III quality meat incorporation on the sensory attributes of the cooked restructured steaks

Sensory attributes	C_1	T_1	T_2	T_3	χ^2 value (p-value)
Appearance and colour	$7.38^{c} \pm 0.28$	$7.18^{b} \pm 0.28$	$7.48^{ab} \pm 0.28$	$7.59^{a} \pm 0.28$	40.653** (<0.001)
Flavour	$7.26^{b} \pm 0.28$	$6.86^{c} \pm 0.28$	$7.20^{b} \pm 0.28$	$7.48^{a} \pm 0.28$	54.162** (<0.001)**
Tenderness	$7.01^{b} \pm 0.28$	$6.76^{c} \pm 0.28$	$7.21^{b} \pm 0.28$	$7.56^{a} \pm 0.28$	61.715** (<0.001)
Saltiness	$7.23^{b} \pm 0.28$	$6.85^{c} \pm 0.28$	$7.23^{b} \pm 0.28$	$7.44^{a} \pm 0.28$	50.493** (<0.001)
Juiciness	$7.19^{b} \pm 0.28$	$6.80^{c} \pm 0.28$	$7.15^{b} \pm 0.28$	$7.48^{a} \pm 0.28$	60.321** (<0.001)
Cohesiveness	$7.34^{b} \pm 0.28$	$6.88^{c} \pm 0.28$	$7.29^{b} \pm 0.28$	$7.69^{a} \pm 0.28$	85.363** (<0.001)
Overall acceptability	$7.23^{b} \pm 0.28$	$6.69^{c} \pm 0.28$	$7.26^{b} \pm 0.28$	$7.65^{a} \pm 0.28$	94.809** (<0.001)

** Significant at 0.01 level
Means with same superscript in rows have no significant difference at 0.05 level.
The values are expressed as their Mean ± Standard error; Number of observations = 44
C_1: Control restructured beef steak (without incorporation of type III quality meat)
T_1: 70% C_1 + 30% quality III meat (brisket plate, flank)
T_2: 60% C_1 + 40% quality III meat (brisket, plate, flank)
T_3: 50% C_1 + 50% quality III meat (brisket, plate, flank)

With an increase in the addition of type III minced meat in the control sample, there was a notable improvement in the scores for all sensory attributes. This enhancement in sensory attributes can be attributed to several factors related to the incorporation of type III meat.

Firstly, the incorporation of type III meat in minced form likely improved the action of curing ingredients by facilitating better penetration. Boles' study in 2011 supports this notion, suggesting that the improved penetration of curing agents positively impacted the flavour scores of the restructured beef.

Moreover, the enhanced tenderness observed in the meat can be attributed to the increased mechanical action during tumbling. The smaller size of the minced meat likely led to more effective mechanical impact forces, which aided in the better extraction of myofibrillar proteins which aid in binding of meat pieces during cooking. This, in turn, contributed to the overall tenderness and cohesiveness of the product, improving its texture and mouthfeel.

Additionally, the increased incorporation of type III meat resulted in notable improvements in appearance and colour, commonly referred to as bloom colour. This effect may be linked to improved oxygen penetration into the minced meat, resulting in a more vibrant cherry-red colour and an overall enhanced appearance. These observations align well with the findings of Bourne's study in 1978, which emphasised the significance of oxygen penetration in influencing meat colour.

The incorporation of type III meat in minced form yielded several positive effects, including enhanced flavour due to improved curing agent penetration, improved tenderness and cohesiveness resulting from more effective mechanical action, and improved appearance and colour attributed to increased oxygen penetration. These findings are consistent with prior research by Boles (2011) and Bourne (1978), highlighting the significance of thoughtful meat formulation and processing techniques in achieving desirable sensory attributes.

Conclusion

The research indicated that the incorporation of type III quality beef cuts into type II quality cuts through cold-set restructuring enhances sensory attributes, particularly in appearance and colour, flavour, tenderness and overall acceptability. While there was no significant difference in the cooking yield, the combination of 50 per cent type II and 50 per cent type III meat emerged as a preferred composition for improved quality and value.

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Conflict of interest

The authors declare that they have no conflict of interest.

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