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Chunk Size Optimisation for Improved Sensory Quality of Restructured Beef

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ABSTRACT

The research aimed at standardisation of chunk size for cold-set restructured beef prepared using microbial transglutaminase (MTGase) as binding agent. Type II quality beef cuts, includes round and chuck were mixed in 1:1 ratio and compared at three different dimensions *viz.*, T_1 [7.5 cm (Breadth) × 10 cm (Length) × 5 cm (Thickness)], T_2 [10 cm (Breadth) × 10 cm (Length) × 5 cm (Thickness)] and T_3 [10 cm (Breadth) × 12.5 cm (Length) × 5 cm (Thickness)]. Microbial transglutaminase and curing agents were used as ingredients. Cold-set beef blocks were created by a series of stages including vacuum tumbling, vacuum packaging, equilibration and freezing. The resulting cold-set beef blocks were then sliced into 5 mm thick beef steaks, seasoned with a spice and cooked. The steaks were subjected to sensory evaluation both as raw and cooked. Sensory evaluations indicated that smaller chunk sizes resulted in a more favourable sensory experience, particularly in terms of appearance, flavour, tenderness, saltiness, juiciness, cohesiveness and overall acceptability. According to the findings of this study, the chunk size of 7.5 cm (Breadth) × 10 cm (Length) × 5 cm (Thickness) was chosen as the standardized size for cold-setted restructured beef block.

Key words: Restructured beef block, microbial transglutaminase, chunk size, sensory evaluation, standardisation

INTRODUCTION

The increasing demand for meat products, coupled with a notable shift in urban consumer preferences towards fast food consumption, presents an opportunity for the development of affordable processed meats that offer enhanced health and nutritional characteristics, as well as ease of preparation. The meat industry has witnessed significant advancements in meat processing techniques, and one such innovation is the creation of restructured meat products.

A series of techniques known as restructuring involve first shrinking the size of the meat's particles and then reforming them into a form resembling high valued steak, chop, or roast (Najeeb *et al.*, 2015). Restructured meat products, such as steak-like items, have traditionally been manufactured using the conventional salt/phosphate technology or cold binding (chemical binding) technologies, often involving binding mechanisms capable of functioning under refrigeration conditions (Means and Schmidt, 1987). Restructuring entails the partial or complete disassembly of meat, followed by its reformation into the same or different shapes. Due to their convenience in preparation and cost-effectiveness in production, restructured products have become integral components of the processed meat sector. In the case of restructured beef products, muscle proteins are extracted using salt and phosphate, leading to the formation of a heat-set protein gel shortly after cooking (Raharjo *et al.*, 1994). Cold-set binders have the versatility to be used with various types of meat products, including poultry, fish, and seafood (Moreno *et al.,* 2008). To meet the demand for restructured and bound meats that can be sold in a raw, refrigerated state, multiple cold-set binding techniques have been developed. These systems include the calcium alginate binding system, microbial enzyme-based binders (ActivaTM transglutaminase products), blood-based binders (Fibrimex®, FX Technology and Products), and protein/chemical binders (Pearl Meat Binders, Chiba Flour Mills). Transglutaminase, in particular, has been recognized as a method for cold gelation of muscle proteins, which can reduce or eliminate the need for adding or reduction of sodium chloride and phosphate (Wijngaards and Paardekooper, 1987). Two common restructuring methods include tumbling and massage, where tumbling relies on impact energy, while massage relies on frictional energy. The primary objective of both procedures is to extract sufficient salt-soluble proteins to enhance tenderness, juiciness, and slicing characteristics.

Numerous approaches have been adopted for size reduction. Manual cubing, requiring the least effort, is one such process. Other methods involve the use of slicers, flakers, cubers, grinders, and various equipment to achieve consistent particle sizes (Boles, 2011). Fine flakes result in a more aesthetically pleasing look, increased tenderness, and a lower shear force value (Mandal *et al.*, 2011). Prajwal (2019) in his study concluded that, the chunk size of 10×12.5 cm ensured, thaw rigor will not happen even when hot boned buffalo meat was frozen within one hour post-exsanguination and chunk size of 10×10 cm ensured, cold shortening would not happen even when hot boned buffalo meat was chilled within one hour post-exsanguination (with uniform thickness of approximately five cm). The size of meat particles plays a pivotal role in influencing nearly all sensory attributes, including appearance, color, flavor, texture, cohesiveness, tenderness, juiciness, saltiness, and overall acceptability (Bhaskar Reddy *et al.,* 2015). This study seeks to standardise the chunk size in restructured beef blocks while maintaining acceptable sensory qualities.

MATERIALS AND METHODS

Ingredients

Beef cuts, sourced from mature cattle aged five years or older, were obtained and handled under strict ethical and hygienic standards at the Meat Technology Unit, Mannuthy. The cattle were humanely and scientifically slaughtered, followed by the meticulous deboning process. The procured beef cuts were immediately subjected to chilling at 4±1°C for twenty-four hours to facilitate the aging process. Subsequently, the deboned meat was aerobically packed in high-density polyethylene bags and stored under frozen conditions at -22±1°C. Before use in the preparation process, the frozen meat was carefully thawed at 4±1°C.

Additional Ingredients

Refined Sunflower Oil: High-quality refined sunflower oil (Fortune, India) was consistently used as the cooking oil during the sensory evaluation study.

Spice Mixture: The spice mixture included a blend of coriander powder, beef masala powder, black pepper, red chili powder, turmeric powder, cinnamon, cloves, and nutmeg.

Curing Ingredients: Curing agents, such as sodium chloride, sugar, sodium tri-polyphosphate, and sodium nitrite, were carefully selected based on an extensive series of preliminary pilot studies to meet the desired product specifications.

Product formulation

The formulation of the restructured beef block underwent a rigorous standardisation process through multiple preliminary trials. The standardised formulation, which was employed throughout the entire study, is detailed in Table 1.

Table 1: Standardized Formulation for Restructured Beef Block

S. No.	Ingredients	Specification	In Percentage
A	Type II quality	Round, Chuck (1:1)	100
B	Cold-set binder	Microbial transglutaminase	0.75 of total meat
C	Curing ingredients	Sodium chloride	1 of total meat
		Sodium tripolyphosphate	0.3 of total meat
		Sodium nitrite	120 parts per million of total meat

The standardized formulation provided consistency and reliability for the production of restructured beef blocks, ensuring accurate representation of the ingredients and their respective proportions.

Preparation of restructured beef block

The deboned aged beef cuts, sourced from round and chuck, were meticulously processed into chunks of three different dimensions: 7.5 cm × 10 cm-(T_1), 10 cm × 10 cm-(T_2), and 10 cm × 12.5 cm-(T_3), each possessing an approximate thickness of five centimeters. These chunks were taken in a 1:1 ratio for uniformity. The surfaces of the beef chunks were then coated with a slurry of microbial transglutaminase (MTGase, one part mixed with distilled water four parts) utilizing a rubber basting brush. Furthermore, the chunks were pre-blended with the necessary curing ingredients, including salt, sodium tripolyphosphate and sodium nitrite, as per the specifications outlined in Table 1.

Following the pre-blending process, the beef chunks were subjected to mechanical tenderisation and the acceleration of the curing process within a vacuum tumbler (BIRO Vacuum Marinade Tumbler, Table Top Model: VTS-43, United States of America). The vacuum tumbler was set to operate at an eight RPM drum speed, with the tumbling procedure lasting for one hour, including a ten-minute break after the initial thirty minutes. Prior to tumbling, the vacuum tumbler's temperature was lowered by the addition of ice flakes.

Subsequently, the processed beef chunks were tightly sealed within PE/Al/PA laminated pouches using a vacuum packaging machine (Vacuum packaging machine, Model: WM-19/S/CE-OSNAVAC, Germany). The vacuum-sealed meat was stored at a refrigeration temperature of 4±1°C for a duration of twelve hours to allow for equilibration. Thereafter, it was transferred to a deep freezer at -22±1°C for an additional twenty-four hours.

On the day designated for sensory analysis, the restructured beef blocks were cautiously thawed at refrigeration temperature (4±1°C) until they reached a core temperature of 5°C. Following this, the blocks were sliced into steaks with a consistent thickness of five millimeters, achieved using a meat slicer (Slicer Automatic, Model: 300 VV-CE, Chennai). These steaks were subsequently seasoned with the spice mix, adhering to the specified levels, and cooked until they attained a golden yellow color.

Experiment design

The experimental investigation aimed to standardise the chunk size of cold-set restructured beef block. Restructured beef block was prepared using type II quality meat, comprising a 1:1 ratio of chuck and round beef cuts. The microbial transglutaminase and curing ingredients were utilised as per the specifications detailed in table 1. The production of restructured beef block involved several sequential processing steps, including vacuum tumbling, vacuum packaging, equilibration and freezing. Subsequently, the cold-set beef blocks were sliced into beef steaks for sensory evaluation. To investigate the impact of chunk size on the final product, three different sizes were assessed:

T_1: 7.5 cm (Breadth) × 10 cm (Length) × 5 cm (Thickness)

T_2: 10 cm (Breadth) × 10 cm (Length) × 5 cm (Thickness)

T_3: 10 cm (Breadth) × 12.5 cm (Length) × 5 cm (Thickness)

Sensory Evaluation: Sensory assessments were conducted on the three treatments (T_1, T_2 and T_3) using sliced restructured beef steaks, both before and after shallow frying. The treatment that garnered the highest sensory score was selected as optimum size of the cubes. Four batches of samples were meticulously prepared and analysed. Based on the sensory score results, T_1, representing restructured beef steaks produced with chunk dimensions of 7.5 cm × 10 cm × 5 cm (breadth × length × thickness), was chosen as the optimised product for experiment.

Product Analysis

Samples: For each of the three product types (treatments T1, T2, and T3), a total of twelve samples (triplicate in four batches) were subjected to sensory evaluation.

i. ***Organoleptic Evaluation.*** The sensory evaluation was scheduled in two separate sessions, one in the forenoon and another in the afternoon. During the first session, raw beef steaks were assessed, while the second session involved the evaluation of cooked steaks. The average individual scores were considered the score for a specific attribute. Panelists were provided with filtered water to cleanse their palate between samples during sensory evaluation.

ii. ***Raw Beef Steak Sensory Evaluation.*** The sensory evaluation of raw beef steaks was conducted within a partitioned booth by using a semi-trained panel consisting of ten members, including faculty and post-graduate students from the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy. Panelists were briefly briefed about the experiment's nature, with the identity of samples withheld. After partially thawing the frozen restructured beef blocks at 4±1°C until they reached 5°C, the beef blocks were sliced into steaks of equal thickness (five millimeters) for sensory evaluation. Panelists were instructed to score the raw steak samples on an eight-point hedonic scale (AMSA, 1983).

iii. **Cooked Beef Steak Sensory Evaluation.** The sensory evaluation of cooked beef steaks was similarly conducted within a partitioned booth by a semi-trained panel consisting of ten members, including faculty and post-graduate students from the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Mannuthy. The panelists were provided with a brief overview of the experiment without revealing the sample identities. Beef steak samples, cut into slices of equal thickness (five millimeters), were pan-fried for 3-4 minutes until they achieved a golden yellow color and were served hot. All panelists were requested to assess the samples using an eight-point hedonic scale (AMSA, 1983).

STATISTICAL ANALYSIS

The study adopted a 3 (treatment) x 4 (replication) randomized block design. Ten sensory determinations were made for each treatment-replication combination. Data collected from the organoleptic evaluation of different products underwent statistical analysis, including one-way ANOVA and the Friedmann test, utilizing the Statistical Package for Social Sciences (SPSS) software, version 24.0 (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Sensory evaluation

The standardisation of chunk size plays a pivotal role in the development of restructured beef block, influencing its sensory attributes and overall quality. In this study, we employed a systematic approach to determine the optimal chunk size, taking into consideration the selection of beef cuts, binders and mechanical techniques, as well as evaluating sensory attributes. The formulations for restructured blocks were prepared with microbial transglutaminase, curing ingredients as shown in table 1 and with spice mix as specified. Selection of beef cuts, binder and mechanical technique for standardisation of chunk size: The choice of beef cuts, specifically round and chuck cuts, was based on their representation of less tender quality, categorised as type II quality according to Kim *et al.* (2010). This selection ensured that the study focused on cuts with inherent challenges related to tenderness, which are relevant in the context of restructured meat products. Regarding binders, cold-set binders were opted, which encompassed various options such as alginate binding systems, microbial enzyme-based binders, blood-based binders and protein/chemical binders, as described by Boles (2011). Microbial transglutaminase, a calcium-independent enzyme chosen for its cost-effectiveness and simplicity of purification (Ando *et al.,* 1989), emerged as the most suitable binder for our purposes. To enhance the tenderness of the beef cuts, tumbling technique was employed, as supported by the study of Sharma *et al.* (2014). This technique utilises impact energy to break down muscle fibres and improve meat texture, aligning with our objective to optimise the chunk size for restructured beef block.

The sensory evaluation of restructured beef block involved two aspects: one with raw restructured beef steak and other with cooked restructured beef steak. These assessments encompassed various sensory parameters, including appearance and colour, odour, texture, cohesiveness, flavour, tenderness, juiciness, saltiness and overall acceptability. The scores of the sensory evaluation were compiled and given in the table 2 (raw) and table 3 (cooked).

Raw steaks sensory evaluation

The appearance and colour scores of the treatments differ significantly. T_1 attained the highest score for appearance and colour (7.39 ± 0.23). There was no significant difference between the treatment samples regard to the odour scores. With regards to the texture of the restructured beef steaks the treatments differed significantly with each other. The highest score attained by T_1 (7.46 ± 0.23).

Table 2: Effect of chunk size on the sensory attributes of raw restructured beef steaks

Sensory attributes	T_1	T_2	T_3	χ^2 value (p-value)
Appearance and colour	7.39^a ± 0.23	7.23^{ab}± 0.23	7.14^b ± 0.23	7.947* (0.019)
Odour	7.06 ± 0.23	6.95 ± 0.23	6.89± 0.23	5.250 (0.072) ^{ns}
Texture	7.46^a ± 0.23	7.15^{ab}± 0.23	6.92^b ± 0.23	10.352** (<0.001)
Cohesiveness	7.39^a ± 0.23	7.21^a ± 0.23	6.51^b ± 0.23	20.685** (<0.001)
Overall acceptability	7.58^a ± 0.23	7.31^a ± 0.23	6.92^b ± 0.23	17.769**(<0.001)

* Significant at 0.05 level; ** Significant at 0.01 level; ns – non- significant at 0.05 level

Means with different superscripts in rows have significant difference at 0.05 level.

The values are expressed as their Mean ± Standard error.

Number of observations = 40

T_1: 7.5×10×5 cm cube (Breadth × Length × Thickness)

T_2: 10×10×5 cm cube (Breadth × Length × Thickness)

T_3: 10×12.5×5 cm cube (Breadth × Length × Thickness)

Cohesiveness scores also differed significantly between treatments. The score ranged from 6.51 ± 0.23 to 7.39 ± 0.23 where T_3 sample attained the lowest value and T_1 attained the highest value. Overall acceptability scores differed significantly ($p<0.001$) among the treatments. The highest score was noted for T_1 (7.58 ± 0.23) and the lowest for T_3 (6.92 ± 0.23).

Cooked steaks sensory evaluation

In the case of cooked restructured beef steak, significant differences were observed across the treatment samples for various sensory attributes like appearance and colour, flavour, tenderness, saltiness, juiciness, cohesiveness and overall acceptability scores, with T_1 standing out as the preferred option compared to T_2 and T_3.

Table 3. Effect of chunk size on the sensory attributes of cooked restructured beef steak

Sensory attributes	T_1	T_2	T_3	χ^2 value (p-value)
Appearance and colour	7.56 ^{a} ± 0.23	7.03 ^{b} ± 0.23	7.22 ^{b} ± 0.23	24.592** (<0.001)
Flavour	7.33 ^{a} ± 0.23	6.94 ^{b} ± 0.23	6.96 ^{b} ± 0.23	13.775** (0.001)
Tenderness	7.26 ^{a} ± 0.23	6.44 ^{b} ± 0.23	6.67 ^{b} ± 0.23	27.051** (<0.001)
Saltiness	7.30 ^{a} ± 0.23	6.89 ^{b} ± 0.23	6.77 ^{b} ± 0.23	20.632** (<0.001)
Juiciness	7.01 ^{a} ± 0.23	6.24 ^{b} ± 0.23	6.26 ^{b} ± 0.23	28.971** (<0.001)
Cohesiveness	7.48 ^{a} ± 0.23	6.95 ^{b} ± 0.23	6.83 ^{b} ± 0.23	29.596** (<0.001)
Overall acceptability	7.65 ^{a} ± 0.23	6.84 ^{b} ± 0.23	6.78 ^{b} ± 0.23	41.221** (<0.001)

** Significant at 0.01 level
a-b Means with different superscripts in rows have significant difference at 0.05 level.

The values are expressed as their Mean ± Standard error.

Number of observations = 40

T_1: 7.5×10×5 cm cube (Breadth × Length × Thickness)

T_2: 10×10×5 cm cube (Breadth × Length × Thickness)

T_3: 10×12.5×5 cm cube (Breadth × Length × Thickness)

The sensory scores of, both raw and cooked restructured beef, showed that treatment labelled as T_1 exhibited superior attributes, with the highest scores for appearance and colour, texture, cohesiveness and overall acceptability. These findings suggest that the chunk size of approximately 7.5×10×5 cm cube, as represented by T_1, yielded the most favourable sensory outcomes. These results align with the findings of Seideman *et al.* (1982), which indicate that smaller meat sizes can contribute to increased tenderness, cohesiveness, improved texture and overall acceptability. These findings underscore the significant role that chunk size plays in shaping the sensory characteristics of both raw and cooked restructured beef block. Improved action of curing ingredients by facilitating better penetration can be attributed to the increased mechanical action during tumbling which positively impacted the flavour with enhanced tenderness and cohesiveness. Boles' study in 2011 supports this notion, suggesting that the improved penetration of curing agents positively impacted the flavour scores of the restructured beef steaks.

CONCLUSION

Through meticulous experimentation and optimization, it was concluded that smaller chunk sizes, specifically those with dimensions of 7.5 cm × 10 cm, yielded significantly enhanced sensory attributes. This included improvements in appearance, flavor, tenderness, saltiness, juiciness, cohesiveness, and overall acceptability. Consequently, it was identified as the optimal chunk size for the preparation of restructured beef blocks. These findings have practical implications for the meat processing industry, offering a pathway to enhance product quality and consumer satisfaction.

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COMPETING INTERESTS

The authors do not have any competing interests among themselves or others related to this research work.

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