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Development of restructured products from beef, mutton and turkey

(Penghasilan produk yang distruktur semula daripada daging lembu, kambing dan ayam belanda)

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Key words: restructured meat, processing parameters, beef, mutton, turkey

Abstrak

Potongan daging lembu dan kambing yang murah serta daging ayam belanda tua digunakan untuk menghasilkan produk distruktur semula yang seakan-akan stik. Kesan beberapa ramuan fungsian seperti natrium tripolifosfat dan natrium kaseinat serta parameter pemprosesan iaitu masa campuran, aras tekanan yang digunakan pada daging terubahsuai dan saiz partikel daging telah diselidiki untuk menghasilkan produk yang boleh diterima.

Abstract

Beef and mutton meat cuts of low commercial value as well as meat from spent turkey were used to develop restructured steak-like products. The effects of various functional ingredients such as sodium tripolyphosphate and sodium caseinate as well as processing parameters viz. mixing time, amount of pressure applied to the tempered meat and the meat particle size were investigated to develop acceptable products.

Introduction

The economic growth in Malaysia has been exceptionally good, averaging about 8.7% annually for the period of the Sixth Malaysia Plan (Anon. 1996). However, the sharp rise in the cost of meat, especially high quality imported meat which is used mainly for steak, has priced itself out of the reach of many Malaysians. As such, it is a challenge for meat processors to come up with a cheaper alternative.

One of the ways of producing cheaper steak-like products is through the process of restructuring. It has been found that meat from spent hen could be converted into acceptable restructured products (Chuah 1994). Cheaper cuts of meat can also be used to produce such products which give satisfactory eating qualities at an acceptable cost (Seideman and Durland 1983). As such, lower quality meat as that of brisket or even trimming with minimum amount of connective tissue or tendon can be used to fabricate restructured steak. Other advantages of such products would include precise control of composition, size, shape and taste. In developed countries such as United Kingdom, restructured grillsteak from various meat sources is fast gaining popularity (Anon. 1986).

The quality of the restructured steak depends highly on the degree in which the

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meat particles bind. Salt and sodium tripolyphosphate have traditionally been used in the meat industry to aid in the binding of meat particles as well as improving other physical properties of meat products (Penfield et al. 1992; Li et al. 1993). However, due to the adverse effects of salt on the product such as discolouration and hastening of the rancidity process during frozen storage (Chen and Trout 1991) as well as increased hypertension on consumers, the use of salt needs to be reduced. As a result of salt reduction in the formulation, the binding property of restructured products is poor. To overcome this physical defect, the use of non-meat binders has been investigated (Chen and Trout 1991; Shand et al. 1993). Other physical effects on the quality of restructured steak such as mixing time (Durland et al. 1982), particle size (Cardello et al. 1983; Johnson et al. 1990), application of pressure (Costello et al. 1981) and the effect of fat (Berry et al. 1985) have also been looked into. This study was aimed at establishing the processing parameters for the development of restructured steak-like products from low-value cuts of beef and mutton as well as from meat of spent turkey.

Materials and methods

Raw materials

Three meat sources were used in the development of restructured steak-like products. Frozen beef brisket from India and frozen sheep leg meat from New Zealand were bought from the local market. A mixture of deboned breast and thigh meat from spent turkey was obtained from a MARDI farm.

Processing method

A series of experiments were carried out to establish the processing parameters in the development of restructured steak-like products from the three meat sources. The parameters investigated were the level of sodium tripolyphosphate (STPP), degree of pressure applied, meat particle size, mixing time and the addition of fat and binder as well as ingredients to improve the mouth-feel of the products produced.

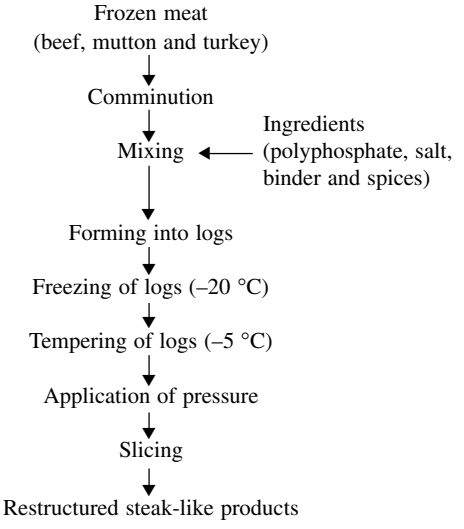

Figure 1. Processing of restructured steak-like products from beef, mutton and turkey

The products were manufactured following the method outlined by Chuah (1994) except that the products were not battered and breaded *(Figure 1).*

Beef

Restructured beef steak was produced from meat pieces tempered to about –5 °C which were either minced, cubed or flaked. Processing conditions evaluated included three levels of STPP (0, 0.3 and 0.5%), compaction using three pressures (0, 500 and 1 000 psi), with or without added fat (10%), with or without sodium caseinate (1%), with or without calcium carbonate (0.25%) and two mixing times (4 and 8 min).

Mutton

Variables in the processing parameters evaluated for restructured mutton were three levels of polyphosphate (0, 0.3 and 0.5%), flaked or minced, 0 or 500 psi pressure, addition of sodium caseinate (1%) or soy protein isolate (2%), with or without added fat (10%), with or without maltodextrin (2.5%) and mixing for either 4 or 8 min.

Turkey
Processing and ingredient variables in the quality evaluation of restructured turkey steak included the three levels of STPP and three types of meat particle sizes mentioned previously, use of 0 or 500 psi pressure, with or without added chicken fat (10%), with or without maltodexdrin (2.5%), with or without sodium caseinate (1%) and mixing for 4 or 8 min.

Product preparation
The restructured steaks were cooked for a total of 10 min at 180 °C on a griddle (Bakbaa Model E92), greased with a little cooking oil. After 6 min, the steaks were turned over and cooked for another 4 min before presenting the products to a taste panel of 10 for their evaluation.

Statistical method
Data were collected in a randomised complete block design experiment (Gomez and Gomez 1984) with 10 trained panelists (Kramer et al. 1963; Lowe 1963). The sensory attributes of these products encompassed cohesiveness, flavour, texture, juiciness, tenderness and overall acceptability. Sensory evaluation scores were assessed using a 9-point hedonic rating scale, ranging from 1 (dislike extremely) to 9 (like extremely) (Larmond 1970). For the development studies, the three types of restructured steaks with all the treatments (*Table 1* to *Table 3*) given such as processing parameters and varying amounts of functional ingredients were presented to the panelists separately.

The analyses of variance (Larmond 1970) of the categorical sensory measurements were performed on an IBM mainframe computer using PROC GLM SAS package (SAS 1985). DMRT multiple comparison procedures (Hochberg and Tamhane 1987) on possible pairs of treatment means were conducted to estimate the level of significance between the means.

Proximate analysis
Proximate anaylsis was carried out on the most acceptable sample from each type of meat using AOAC (1990). The results obtained are the average of three analyses.

Results and discussion
Restructured steak-like product from beef
For the restructured steak-like product from beef, factors evaluated were cohesiveness, flavour, texture, juiciness, tenderness and overall acceptability. Except for the samples with and without added calcium carbonate and sodium caseinate, significant differences were noted in some of the factors for the other treatments given. For the degree of pressure given, a significant difference was noted in the tenderness score. The taste panelists preferred sample treated with 500 and 1 000 psi pressure. It is presumed that with the application of pressure, the product would be more compact, thus giving a more steak-like bite. As expected, the texture would have higher scores as indicated in *Table 1*. On the other hand, no significant difference was noted among the three pressure treatments given.

The addition of sodium tripolyphosphate (STPP) was to increase the water holding capacity, thus making the products more juicy. This purpose has been achieved as the scores for the samples with added STPP were significantly higher than that without added STPP. Significant differences were also observed with regard to flavour between 0% and 0.3% as well as between 0.3% and 0.5%, with the score being higher for the higher phosphate level. This observation could be related to the better juiciness and tenderness scores with the increased phosphate level. There was a significant difference between the samples with and without added STPP for juiciness but not for tenderness. Although there was no significant difference between samples for cohesiveness and texture as well, nevertheless, generally samples with higher phosphate levels tend to have higher organoleptic scores. Overall acceptability

indicated a significant difference between samples with and without added STPP.

Fat not only imparts flavour but also juiciness and thus tenderness to meat products. As can be observed in *Table 1*, a significant difference was noted by the panelists in texture, tenderness and overall acceptability when evaluating samples with and without added fat, with the former having higher scores. No significant difference was noted for cohesiveness, flavour and juiciness although the scores were higher in samples with added fat.

The duration for which comminuted meat is mixed affects the overall texture as the longer the mixing time, the finer will the meat mass be. This will in turn affect the surface area and thus the cohesiveness capacity. A significant difference was seen in cohesiveness, texture, tenderness and overall acceptability while no significant difference was noted for flavour and juiciness. However, sensory scores were higher for all factors evaluated for longer mixing time. This observation generally agrees with the findings of other researchers (Belohlavy and Mandigo 1974).

The size of the meat particles has been found to affect the acceptability of restructured meat products, as observed by many researchers discussed earlier. Flaking increases the surface area of the meat, thus exposing more areas for binding and improving the cohesiveness factor of the product. This will also lead to better texture as compactness will increase. The results

Table 1. Mean scores for six sensory attributes of restructured steak-like product made from lower quality beef cuts

Treatment	Cohesiveness	Flavour	Texture	Juiciness	Tenderness	Overall acceptability
Pressure						
0 psi	5.7a	5.8a	5.0a	5.4a	4.9b	5.4a
500 psi	6.7a	6.3a	6.1a	6.1a	6.3a	6.2a
1 000 psi	6.3a	6.2a	6.1a	6.1a	6.3a	6.1a
Phosphate						
0%	6.8a	6.3b	6.1a	5.2b	6.1a	5.6b
0.3%	6.9a	6.7ab	6.1a	5.9a	6.2a	6.1a
0.5%	6.7a	7.0a	6.2a	6.2a	6.4a	6.5a
Mixing						
4 min	5.6b	6.4a	4.8b	5.5a	4.9b	5.2b
8 min	6.9a	6.6a	5.8a	5.9a	6.6a	6.2a
Cutting						
Cube	5.3b	6.6a	5.6b	6.1ab	5.8a	5.9a
Flake	6.6a	6.5a	6.5a	6.2a	6.2a	6.4a
Mince	6.6a	6.2ab	6.2ab	5.1a	6.1a	5.6a
Fat						
Added	6.4a	6.3a	6.4a	6.1a	6.5a	6.3a
Not added	6.0a	5.8a	5.0b	5.9a	5.0b	5.2b
Caseinate						
Added	6.7a	6.5a	6.4a	6.3a	6.2a	6.1a
Not added	6.5a	6.6a	6.4a	6.6a	6.6a	6.4a
Calcium carbonate						
Added	6.9a	6.6a	6.8a	6.6a	6.8a	6.9a
Not added	6.6a	6.1a	6.2a	6.1a	6.2a	6.2a

Mean values in each column with same letter under each treatment are not significantly different ($p > 0.05$)

showed that flaked meat gave higher sensory scores for all the factors evaluated, even though no significant difference was observed in flavour, juiciness, tenderness and overall acceptability.

Restructured steak-like product from mutton

With mutton restructured product, no significant difference was observed between samples comparing meat particle size, binders such as maltodextrin and sodium caseinate, with and without added fat and mixing time *(Table 2)*. Generally, samples made with flaked meat, added binder and added fat gave higher sensory scores. Contrary to earlier finding for beef, the sample with a shorter mixing time and no pressure applied was preferred by the taste panelists. This result could be due to factors such as different cuts of meat with different connective tissues, toughness of the meat and the size of muscle fibres. In the addition of STPP, results obtained were similar to that observed in beef where higher STPP level gave higher scores with significant differences noted for juiciness, tenderness and flavour.

Restructured steak-like product from turkey

Sensory results for restructured product from turkey tend to be more similar to that of beef, as indicated in *Table 3*. Although no significant difference was noted between

Table 2. Mean scores for six sensory attributes of restructured steak-like product made from lower quality mutton cuts

Treatment	Cohesiveness	Flavour	Texture	Juiciness	Tenderness	Overall acceptability
Pressure						
0 psi	7.0a	6.5a	6.9a	6.5a	6.8a	6.8a
500 psi	6.5b	6.5a	6.6a	6.2a	6.7a	6.6a
Phosphate						
0%	6.5a	6.3ab	6.5a	5.7b	6.3b	6.3a
0.3%	6.8a	6.7a	6.9a	6.5a	7.0a	6.7a
0.5%	6.5a	6.2b	6.6a	6.5a	6.9a	6.4a
Mixing						
4 min	7.0a	6.7a	7.1a	6.4a	6.9a	6.7a
8 min	6.8a	6.8a	6.8a	6.1a	6.7a	6.3a
Cutting						
Flake	6.9a	6.7a	6.5a	6.5a	6.6a	6.7a
Mince	6.6a	6.1a	6.2a	6.2a	5.8a	6.0a
Fat						
Added	6.7a	6.5a	7.1a	6.7a	6.6a	6.6a
Not added	6.7a	6.5a	6.8a	6.5a	6.4a	6.6a
Caseinate						
Added	6.9a	6.7a	7.3a	7.3a	7.2a	7.2a
Not added	6.9a	6.9a	7.0a	6.4b	6.8b	7.2a
Maltodextrin						
Added	6.8a	6.7a	7.0a	6.4a	6.7a	6.8a
Not added	6.8a	6.5a	6.9a	6.6a	6.5a	6.7a
Soy isolate						
Added	6.8a	5.9a	6.7a	5.6a	6.9a	6.2a
Not added	6.6a	6.5a	6.5a	5.6a	6.3a	6.2a

Mean values in each column with same letter under each treatment are not significantly different ($p > 0.05$)

samples with and without added binders such as sodium caseinate and maltodextrin, with and without added fat as well as pressure applied, samples with added binders, added fat and with pressure applied tend to have higher sensory scores. Significant differences were seen in some of the factors evaluated when samples with different levels of STPP and meat particle sizes were compared. The product made from flaked meat appeared to be more favoured by the taste panelists. On the other hand, the added STPP did not appear to be effective. There was no significant difference between samples without STPP and with higher level of added STPP. Being meat from spent turkey could be the reason for this observation as the meat generally has lower moisture content. Thus it may require higher phosphate level to increase the water holding capacity effectively.

Effect of particle size

For all products from the three meat sources, the panelists found that flaked meat was more superior to minced or cubed meat in the production of restructured steak in terms of cohesiveness, texture, juiciness, tenderness and overall acceptability *(Table 1* to *Table 3*).

Several researchers (Randall and Larmond 1977; Cardello et al. 1983) have reported similar findings as this study, i.e. restructured steak made from flaked meat was more superior to other meat particles as flaking would produce a larger surface area and thus assist in improving the binding property of the product. Ferren (1972)

Table 3. Mean scores for six sensory attributes of restructured steak-like product made from spent turkey meat

Treatment	Cohesiveness	Flavour	Texture	Juiciness	Tenderness	Overall acceptability
Pressure						
0 psi	6.8a	6.0a	6.8a	6.2a	6.3a	6.2a
500 psi	6.9a	6.3a	6.8a	6.5a	6.5a	6.2a
Phosphate						
0%	6.8a	7.0a	7.0a	6.4ab	7.3a	6.8a
0.3%	6.7a	6.6a	6.8a	6.2b	6.8b	6.5a
0.5%	6.6a	6.9a	7.1a	7.0a	6.9ab	7.1a
Mixing						
4 min	6.7a	6.8a	6.4a	5.8a	6.3b	6.2a
8 min	6.7a	6.7a	6.9a	6.4a	6.9a	6.7a
Cutting						
Cube	6.3a	6.2a	5.8b	5.5b	5.8b	5.7a
Flake	6.4a	6.9a	6.8a	6.8a	6.7a	6.4a
Mince	5.9a	5.9a	6.4ab	6.0ab	6.3ab	6.2a
Fat						
Added	6.8a	6.6a	7.0a	6.7a	7.2a	6.8a
Not added	6.8a	6.4a	6.7a	6.4a	6.8a	6.8a
Caseinate						
Added	7.0a	6.5a	6.9a	6.6a	7.0a	7.1a
Not added	7.0a	6.4a	6.9a	6.4a	7.1a	6.8a
Maltodextrin						
Added	6.7a	7.1a	7.0a	6.9a	7.3a	7.3a
Not added	6.6a	6.9a	6.8a	6.9a	7.2a	6.9a

Mean values in each column with same letter under each treatment are not significantly different ($p > 0.05$)

claimed that flaked meat improved texture, retained more natural juice, and had better cohesive property and sensory characteristics. Flaked meat has also been used by several researchers in their experiments (Penfield et al. 1992; Swanson et al. 1994).

Effect of fat content

Sensory results showed that restructured steak samples with higher fat content (10%) obtained better scores. In restructured steaks made from beef and turkey, all attributes evaluated received higher scores from the panelists for samples with higher fat content. For mutton restructured steak, the attribute scores were either higher or similar when comparing the sample with higher fat to that of the lower one. Such a finding has also been reported by Cross and Stanfield (1976) as well as Berry et al. (1985) who noted that restructured beef steak containing 30% fat gave higher scores for juiciness, tenderness and overall acceptability than those containing 20% fat. With a higher fat content, the products tend to be softer and less chewy, reducing the shear resistance as well as increasing the juiciness and tenderness (Mandigo 1986). Working with restructured beef steak, Penfield et al. (1989) found that as fat level increased, softness and moisture scores also increased. The results obtained in this study indicated that higher sensory scores were given by the panelists, especially for juiciness, tenderness and flavour of all three products.

Effect of phosphate content

The addition of STPP has been found to improve the acceptability of the restructured steaks as shown by the sensory scores when compared to those without added STPP. For restructured steaks made from beef and turkey, it was generally found that the addition of 0.5% STPP gave the best results. Except for cohesiveness which had a slightly lower score than the other two levels of polyphosphate, all other attributes received higher scores. On the other hand, for mutton restructured steaks, the addition of 0.3% STPP was found to give higher scores for all the attributes evaluated. As the turkey steak was produced from spent meat which may tend to be drier, a higher level of STPP could be important in increasing the holding capacity of the natural juices in the product, especially when used in combination with salt as in this study. A level of STPP higher than 0.5% is not recommended as it could result in metallic taste in the product.

Mandigo and Booren (1981) have shown that STPP could increase juiciness and improve colour of the product. Furthermore, Teicher (1990) noted that flavour and texture were better and yield could be improved by 8–10% with the addition of STPP. The phosphate acts by modifying and solubilising the proteins, thus helping to emulsify the fat. A gel will then form which, when heated, aids in the binding property and gives a good texture. It has been noted that there appears to be a mild synergistic effect between salt and STPP in improving the acceptability of the product.

Effect of mixing time

In this study, a mixing time of 8 min was preferred by the taste panelists for restructured beef for all the attributes evaluated. For restructured turkey steaks with a mixing time of 8 min, all attributes except for cohesiveness and flavour received higher sensory scores. On the other hand, for restructured mutton steak, products with a 4 min mixing time had higher sensory scores for cohesiveness, texture, juiciness, tenderness and overall acceptability. Thus the duration of mixing in the production of restructured steak has been found to affect several sensory attributes.

The degree of extraction of salt-soluble proteins which contribute to the binding property of this product, is influenced by the duration of mixing the meat mass. Belohlavy and Mandigo (1974) reported that emulsion stability was better with mixing time increased up to 26 min when salt is

included in the formulation. Besides affecting the extraction of the proteins, the length of mixing will also affect the final texture of the product. Durland et al. (1982) found that restructured steaks made with 0–5 min of mixing had a coarser appearance than those which received 10–15 min of mixing. These workers also found that a 5 min mixing time would also gave higher scores for juiciness and tenderness of the product compared with a 15 min mixing time. Mandigo (1975) found that steaks made with a mixing time of 8–10 min were optimum in desirability. Poor water holding capacity was also observed by Belohlavy and Mandigo (1974) if the mixing time exceeded 14 min. In this study, texture and tenderness scores were higher in samples which received a longer mixing time.

Effect of pressure applied

Organoleptic evaluations showed that the panelists preferred restructured beef and turkey steaks which received a pressure of 500 psi during manufacturing. On the other hand, a slightly higher score was obtained for the mutton product made without the application of pressure. It has been noted that meat product made without substantial application of pressure such as when using a slide-plate forming machine in the production of hamburgers, had resulted in texture of patties rather than that of intact steak (Mandigo 1986). As such, these products would be inferior in texture and cuttability. With the meat logs properly tempered to a temperature of –3 °C to –5 °C, the application of a substantial amount of pressure would cause a certain degree of melting in the logs which would then bind more tightly after the release of pressure. This would result in a more compact log giving the restructured steak a better texture.

Effect of binder

Although the application of pressure to the tempered meat logs helps in the compaction, the binding effect of the meat particles is also an important factor in the manufacture of restructured steak. The use of salt and STPP in the formulation helps in the extraction of salt-soluble proteins which helps in the binding of the product. With the addition of sodium caseinate, the binding effect is expected to be enhanced. However, in this study, this observation was only noted in the restructured beef steak while the scores for cohesiveness were the same for restructured turkey and mutton steaks. The addition of calcium carbonate has resulted in better cohesiveness score, as seen in the beef steak. This result agreed with that of Trout et al. (1990) who showed that the tensile strength of restructured pork chops increased with the incorporation of calcium carbonate.

The use of binders in the development of restructured beef steak has also been studied by several researchers. The type of binders used include wheat gluten, soy isolate and whey protein concentrate (Chen and Trout 1991) as well as egg albumin (Endres and Monagle 1987). These binders depend on heat for their binding effect. The effectiveness of cold-setting hydrocolloid such as sodium alginate as a binder has also been investigated by Means et al. (1987).

Proximate analysis

Compositional analysis of the three types of restructured steak-like products was done in triplicate. Results indicated that the turkey product had a considerably lower fat content than the products from beef and mutton *(Table 4).* This is expected as turkey meat would have a much lower fat content than beef and mutton. However, there was not much difference in the other compositional values such as protein, moisture and ash.

Conclusion

The use of several functional ingredients such as STPP, salt and sodium caseinate or soy protein isolate together with appropriate processing technology has shown that acceptable restructured steak can be produced from low value cuts of meat, including that from spent animals.

Table 4. Proximate composition of restructured steak-like products from beef, mutton and turkey

Meat type	Protein (%)	Fat (%)	Moisture (%)	Ash (%)
Beef	20.92 ± 0.00	6.50 ± 0.02	72.99 ± 0.20	2.11 ± 0.05
Mutton	20.18 ± 0.32	6.27 ± 0.31	69.58 ± 0.32	2.15 ± 0.03
Turkey	19.04 ± 0.22	1.88 ± 0.30	70.87 ± 0.23	2.55 ± 0.01

Results from the sensory evaluations showed that the taste panelists preferred restructured beef steaks made from flaked meat containing fat and 0.3% phosphate, mixed for 8 min and compacted with a pressure of 500 psi. For restructured turkey steak, the choice was a steak made with flaked meat containing fat, 0.5% STPP and sodium caseinate, with a mixing time of 8 min and subjected to a pressure of 500 psi. Compared with these two products, restructured mutton steaks made from flaked meat containing fat, 0.3% STPP and 2% soy protein isolate, with a mixing time of 4 min and no application of pressure were preferred. The quality of products made from all other combinations of processing parameters and ingredients were found to have lower sensory scores than the above three.

The technology of restructuring will provide many advantages to both the manufacturers and the consumers because the physical parameters such as size, shape and composition of the products can be easily controlled besides being cheaper than the conventional steak.

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