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Research paper

Effect of Incorporation of Liver Protein Hydrolysate on Processing Characteristics of Fibre-Enriched Meat Loaves

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ABSTRACT

Present study was conducted for evaluation of effect of addition of porcine liver protein hydrolysates into formulation of pork loaves at four different levels viz. Control (0% C), 0.09% LA (T1), 0.06% LT (T2) and 0.09% LP (T3) and compared for different physico-chemical, instrumental texture and colour profile, and sensory quality attributes. Emulsion stability, pH and cooking yield value varied significantly among hydrolysate added sample than control whereas, fat content remained comparable amongst all groups. Products pH, moisture, ash, carbohydrate, energy content, cooking yield, cooking loss, and moisture retention of pork loves varied significantly ($P<0.05$) than control. However, water activity, protein, fat, fibre, fat retention and moisture protein ratio did not differ significantly ($P>0.05$) for both test and control. Liver hydrolysate addition in pork loaves resulted in significant reduction in lightness (L^*), yellowness (b^*) and chroma value whereas redness (a^*) and hue value remained comparable among all groups. All attributes of textural profiles varied significantly ($P<0.05$) with incorporation of liver hydrolysate as compared to control except cohesiveness. All sensory attributes were rated higher for pork loaves with 0.06% porcine liver protein hydrolysate. Therefore, result concluded that pork loaves with 0.06% liver hydrolysate was most suitable for preparation of meat loaves.

Keywords: *Meat loaves, Liver hydrolysate, Colour profile, Texture profile, Sensory attributes*

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INTRODUCTION

Large volumes of meat by-products is obtained from meat industry like blood, edible offal's, stomach, intestine, trimmings, feet, hoofs, horns etc. during slaughtering process. Proper utilization of these by-products enhances the revenue of meat industry and significantly reduce the environmental pollution. Liver is an important edible by-product obtained from meat industry, which are underutilized due to its shorter storage life. Liver is an excellent source of proteins, so it can be used as substrate for the enzymatic hydrolysis for the extraction of valuable biopeptides. Bioactive peptides having 2 to 20 amino acids sequences with low molecular weight exhibit better functional activity like emulsifying activity, oil holding capacity, water holding capacity, enhance sensory attributes, colour and instrumental profile of the hydrolysate added meat products. The functional properties of meat hydrolysates are due to bioactive peptides formed during hydrolysis of native proteins. The functional characteristics of these recovered bioactivity peptides varies with source of substrate, type of enzyme and enzymatic hydrolysis conditions.

In general, native protein do not have these physicochemical characteristics and bioactivities however, during hydrolysis these bioactive peptides are liberated from parent protein and exhibit better antioxidant activity and higher water-holding capacity (Cumby et al. 2008). The generated peptides can exhibit functional activity due to the presence of certain amino acid residues, such as tyrosine, methionine, histidine, tryptophan, and proline. Valorization of these meat by-products obtained from meat industry also create alternate path for the utilization of these low-value meat by-products either directly or through further processing (Mullen et al. 2017). Currently, studies have been done on development of meat products by incorpor[1]ation of meat byproduct hydolysates such as incorporation of mechanically deboned chicken meat hydrolysate in mortadella-type sausages (Cavalheiro et al. 2014), eel by-products protein hydrolysate in minced meat (Bougatef et al. 2020) and pork meat by-products hydrolysate in pork loave (Verma et al. 2021).

Therefore, the present study was conducted to obtain protein hydrolysate from porcine liver and to explore effect of protein hydrolysate obtained on processing quality, colour, texture and sensory quality of pork loaves.

MATERIAL AND METHODS

Enzymes used for preparation of liver hydrolysates viz. alcalase (EC 3.4.21.62, activity ≥5 units/g protein) was obtained from Sigma-Aldrich Chemical Co., India and trypsin (EC 3.4.21.4, activity >250 USP units/mg protein) and papain (EC 3.4.22.2, activity ≥10 units/mg protein) were obtained from MP Biomedicals, India. Other chemicals and ingredients used in this study were of analytical grade obtained from recognized firms.

Pigs were obtained from Livestock Farm Complex, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab. These animals were slaughter in departmental slaughterhouse as per the norm of animal welfare. Before deboning of meat fascia and extra fat were trimmed out and chilled overnight. Deboned chilled meat was packed in low-density polyethylene (LDPE) and was stored at -18 °C till use.

Preparation of blood hydrolysate and hydrolysates added fibre enriched loaves

Hydrolysate of liver was obtained as per method described by (Verma et al. 2022). Pork loaves were formulated and prepared by as per methods described by the (Verma et al. 2016) and

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formulation of the meat emulsion has been depicted in Table 1. The incorporation level of hydrolysate was selected based on antioxidant and antimicrobial efficacy of liver hydrolysate in meat model system (Verma et al. 2022; Verma et al. 2019) for the preparation of meat loaves.

Table 1: Formulation of liver hydrolysate added fibre enriched pork loaves

Ingredients (%)	C	T1	T2	T3
Meat	67.388	67.388	67.388	67.388
Inulin powder	2.00	2.00	2.00	2.00
Condiments	3.00	3.00	3.00	3.00
Salt	1.50	1.50	1.50	1.50
Sodium tetra pyrophosphate	0.30	0.30	0.30	0.30
Refined wheat flour	3.00	3.00	3.00	3.00
Spices mix.	2.00	2.00	2.00	2.00
Refined oil	5.00	5.00	5.00	5.00
Whole egg liquid	5.00	5.00	5.00	5.00
Ice water	7.00	7.00	7.00	7.00
Sugar	0.30	0.30	0.30	0.30
Baking soda powder	0.50	0.50	0.50	0.50
Texturize soya protein (1 part soya: 3 part water)	3.00	3.00	3.00	3.00
Sodium nitrite	120 ppm	120 ppm	120 ppm	120 ppm
*Liver hydrolysate	0.00	0.09	0.06	0.09

*C = pork loaf without porcine liver hydrolysate; T1 = pork loaf with 0.09% liver hydrolysate (alcalase); T2 = pork loaf with 0.06% liver hydrolysate (trypsin); T3 = pork loaf with 0.09% liver hydrolysate (papain)

Nutritional composition of meat loaves

Nutritional composition of pork loaves *viz*., moisture, protein, fat, fibre and ash content were determined as per method described by (AOAC 2000).

Physico-chemical analysis

Emulsion stability was determined by technique given by (Townsend et al. 1968). Twenty-five g of meat emulsion was taken in polyethylene bags and was kept in water bath for 20 min at 80 °C. Removed sample was cooled at room temperature; drained sample was weighed to calculate the emulsion stability.

Cooking yield, moisture retention and fat retention of cooked pork loaves were calculated following the methods of Singh et al. (2014) using following formulae:Ten (10) g of cooked meat loave was weighed and mixed in 100 ml of distilled water. The pH of prepared meat solution was determined with insertion of electrode of pH meter till reading became stable. Water activity of meat loaves was recorded with digital water activity meter at 25 ˚C.

Instrumental colour profile and texture analysis of meat loaves

Instrumental colour profile (L^*, a^* and b^* values) of meat loave was estimated with Lovibond Tintometer preceding to start observation instrument was set at 2^o of cool white light (D65). The 'L^*' symbolizes brightness (100) or lightness (0), a^* (+redness/-greenness) and b^* (+yellowness/-blueness) values. Hue and chroma attributes of meat loaves were mathematically calculated by the formula:

Hue = (tan-1 (b/a))

Chroma = $(a^2 + b^2)1/2$

Texture attributes of meat loaves was measured as per method described by (Bourne 1978) by texture analyzer equipment. For estimation of textural attributes, the meat loaves were cut homogeneously in to (1.0 × 1.0 × 1.0 cm) size. Cuts of meat loaves were subjected to analysis for compressing to half the original height of sample.

Sensory evaluation

Seven semi experienced sensory panelist were selected from scientific staff and postgraduate students of the Department of Livestock Products Technology, GADVASU, Ludhiana, India. Sensory evaluation of meat loaves was carried out based on 8-point descriptive scale for various sensory attributes viz. appearance and colour, flavor, tenderness, juiciness and overall acceptability (Keeton 1983) where 8 = extremely desirable and 1 = extremely undesirable. For sensory examination of meat loaves were served at room temperature and marked with coded numbers. Water was provided to each taster separately for rinsing their mouth cavity.

Statistical analysis

Data obtained from this study were subjected to analysis as per procedure given by (Snedecor and Cochran 1989) for one-way analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) to compare means using SPSS-16 (SPSS Inc., Chicago, IL, USA). The experiment was conducted thrice for the reliability of the results and data were recorded twice for all traits for each group. However, for instrumental colour, texture profile and data sensory evaluation were observed in triplicate. Level of significance was determined at 5 %.

RESULTS AND DISCUSSION

Effect of incorporation of liver protein hydrolysate on-physicochemical parameters of fibre enriched emulsion

The pH of liver protein hydrolysate incorporated emulsions was measured significantly (P<0.05) higher in T1 and T2 and remained comparable in control and T3 Table 2. It might be attributed to higher innate buffer pH of liver protein hydrolysate, presence of mixture of the peptides and free amino acids. The emulsion stability was significantly (P<0.05) higher in all treatments than control, however T3 remained comparable to T1 and T2. Similarly, moisture content was significantly (P<0.05) higher in all the treatments than control and T3 was comparable to T1. It might be due to interaction of lipid and water molecule with hydrolysed proteins (hydrophobic and hydrophilic) and free amino acids leading to form stable emulsions. An increase in the number of peptide molecules and exposed hydrophobic amino acid residues in the protein hydrolysates contributed significantly (P<0.05) for the improvement of emulsion quality. Vioque et al. (2000) reported that on the incorporation of rapeseed protein hydrolysates improved emulsifying capacity and stability. It might be attributed to better binding capacity of water and fat molecules with the interaction of hydrophilic and hydrophobic moiety of the protein molecules into the meat batter. This in turn causes lower loss of the protein, fat and other soluble components from emulsion. These findings were strengthened with higher pH of the emulsion leading to higher water retention capacity. Fat content in meat emulsion was comparable in all the treatments including control attributed to basic formulation of emulsion.

Effect of incorporation of porcine liver hydrolysate on physi-co-chemical attributes of fibre enriched pork loaves

The results obtained after analysis of various physico-chemical attributes (pH, a_W, proximate, energy, moisture-protein ratio, cooking yield, cooking loss, moisture retention and fat retention) of cooked pork loaves have been depicted in Table 2. The pH of trypsin liver hydrolysate (T2) was significantly (P<0.05) higher than control, alcalase liver hydrolysate (T1) and papain liver hydrolysate (T3). Perusal of Table 2 revealed that pH of the cooked products was higher than their respective raw emulsions. It might be attributed to the changes during cooking process *viz.* concentration of ingredients, deamination of proteins and release of sulfhydryl compounds. Similar observations were reported by Verma et al. (2015) in pork patties. The water activity (a_W) of the treated products and control did not differ significantly (P>0.05) however, the highest was in T2 and lowest in control. The variation in a_W values might be due to the addition of liver protein hydrolysate, which has excellent capacity for water retention. These findings were also reinforced by higher moisture content as well as moisture retention in treated products. Similar findings were reported by Kumar et al. (2015) in fibre enriched chevon patties. Moisture content was comparable in control, T1 and T3, however it was significantly (P<0.05) higher in T2. It might be attributed to the hydrophilic nature of the peptides and free amino acid, which form bond between water and hydrolysate proteins. In addition, smaller peptides and free amino acid have unique properties to retain water, which form hydrogen bonding with water molecule. Higher pH values of the treated products also supported the increase moisture content of the hydrolysate incorporated pork loaves. Similar results were reported by Jin et al. (2015) in sausages prepared with incorporation of mechanically deboned chicken meat hydrolysates. Protein and fat content of all the treated products were higher than control but did not differ significantly (P>0.05) with each other. Among various treatments, T1 recorded the highest crude protein contents. Protein content was higher in the treatments with protein hydrolysate, showing that the addition of protein hydrolysates can improve the protein content in meat products. Fat values ranged from 9.97±0.50 and 10.55±0.47 among different treatments. T2 recorded the highest crude fat contents. It might be attributed to relative better binding capacity of lipid with hydrophobic hydrolysates resulting in decrease of drip fat during cooking. This result agreed with Cavalheiro et al. (2014) in replacement of mechanically deboned chicken meat with its protein hydrolysate in mortadella-type sausages. The crude fibre content was comparable in all the treatments and control. It is attributed to similar formulation and low added protein hydrolysate levels (0.03, 0.06 and 0.09%). The ash content was comparable in all treatments, but significantly (P<0.05) higher than control except T3. The increase in ash content in the liver hydrolysate incorporated pork loaves might be due to the presence of some buffer salt in the liver hydolysate, which were added during the preparation of hydrolysate.

Table 2: Effect of incorporation of liver protein hydrolysates on physicochemical parameters of fibre-enriched raw emulsion and functional cooked pork loaves

Parameters	C	T1	T2	T3
Raw emulsion				
pH	6.08±0.01^{a}	6.13±0.01^{b}	6.18±0.02^{c}	6.10±0.01^{ab}
Emulsion Stability (%)	86.89±0.56^{a}	88.99±0.67^{b}	90.66±0.22^{c}	89.28±0.55^{bc}
Moisture (%)	60.15±0.39^{a}	62.69±0.60^{b}	64.20±0.55^{c}	62.08±0.35^{b}
Fat (%)	10.75±0.35	11.40±0.43	11.58±0.36	11.27±0.41
Cooked products				
pH	6.16±0.01^{a}	6.21±0.02^{a}	6.28±0.02^{b}	6.18±0.02^{a}
a_w	0.894±0.006	0.910±0.008	0.918±0.010	0.900±0.007
Moisture (%)	59.12±0.69^{a}	60.17±0.56^{a}	62.11±0.34^{b}	60.46±0.35^{a}
Protein (%)	19.31±0.46	20.11±0.36	19.65±0.31	20.10±0.57
Fat (%)	9.97±0.50	10.32±0.39	10.55±0.47	10.43±0.27
Fibre (%)	1.78±0.03	1.74±0.04	1.62±0.09	1.68±0.04
Ash (%)	2.72±0.05^{a}	2.88±0.03^{b}	2.94±0.06^{b}	2.84±0.05^{ab}
Carbohydrate (%)	8.88±0.63^{c}	6.51±0.31^{b}	4.75±0.68^{a}	6.17±0.43^{ab}
Energy (Kcal)	202.87±3.02^{b}	199.79±3.66^{ab}	192.94±1.39^{a}	199.37±2.45^{ab}
Moisture: Protein ratio	3.07±0.11	2.99±0.09	3.16±0.06	3.02±0.10
Cooking yield (%)	85.20±1.22^{a}	88.04±1.08^{ab}	91.63±0.98^{b}	87.11±1.72^{a}
Cooking loss (%)	14.80±1.22^{b}	11.97±1.08^{ab}	8.37±0.99^{a}	12.89±1.72^{b}
Moisture retention (%)	50.35±0.75^{a}	52.97±0.64^{a}	56.92±0.81^{b}	52.69±1.31^{a}
Fat retention (%)	78.93±3.10	79.93±2.65	82.76±3.24	80.82±2.10

Means values bearing different superscripts in a row differ significantly ($P<0.05$) n = 6. C: Control (pork loaves without porcine liver protein hydrolysate; T1: pork loaves with 0.09% porcine liver protein hydrolysate with alcalase (LA); T2: pork loaves with 0.06% porcine liver protein hydrolysate with trypsin (LT); T3: pork loaves with 0.09% porcine liver protein hydrolysate with papain (LP).

The calculated values of carbohydrate decreased significantly ($P<0.05$) in hydrolysate incorporated pork loaves than control and remain comparable in T3 as compared to T1 and T2. It was highest in the control and lowest in T2. This might be due to the addition of protein hydrolysate retained more water, fat etc. resulting in the decrease of the overall solid content in cooked products. The energy values varied between 202.87±3.02 kcal/100 g (C) and 192.94±1.39 kcal/100 g (T2). This could be attributed to the variation in protein fat and carbohydrate content in liver hydrolysates incorporated pork loaves than control. The estimated moisture-protein ratio values for all treated groups were comparable with control. Cooking yield was significantly ($P<0.05$) higher in treated products than control, however the higher cooking yield was recorded for T2 as compared to T1, T3 and control. It might be due to higher water retention and fat retention properties of liver hydrolysed protein. Among the three hydrolysates, trypsin hydrolysate was most effective in improving cooking yield, followed by hydrolysates prepared by alcalase and papain. Owing to the hydrolysis pattern of trypsin and its tendency to produce low-molecular-weight peptide, it appears that lower-molecular-weight peptides are more effective in water retention than their counter part large-size peptides. This is possibly because smaller fragments of peptides would be more hydrophilic, so it binds the water molecules more efficiently leading to improve cooking yield. Further analysis should be conducted to examine the exact amino acid composition of the hydrolysates developed in the present study and their relationship to water-holding/retention capacity and cooking yield of meat products. Cumby et al. (2008) also reported that on incorporation of the canola protein hydrolysates improved the water-holding capacity of the meat and thus improved cooking yield. Cooking loss values varied as per cooking yield. It was recorded minimum in T2 and maximum in control.

This result underlines the improved capability of the liver protein hydrolysate-added emulsions to bind and retain water/fat during cooking and suggests that liver hydrolysate addition improved the stability of the meat emulsion. The hydrolysis of liver proteins results in the additional release of small peptides and free amino acids. Thus, the addition of liver protein hydrolysate increases the proportion of both polar/nonpolar and charged groups within the meat emulsion matrix, which enhances water–protein/protein-fat interactions, increasing the ability of the gel to retain water and fat molecules. These results were in agreement with those of Wang and Xiong (2005), who reported that the addition of HPP reduced the cooking losses of patties and Nieto et al. (2009) also documented that the addition of HPP significantly (P<0.05) decreased cooking loss. The moisture retention increased significantly (P<0.05) in treated pork loaves as compared to control and an increasing trend was also influenced by the type of enzymes used for hydrolysis. The fat retention was increased in treated groups than control, attributed to interaction of the fat globule to the hydrophobic peptides and free amino acid. Hence, dripping of fat during cooking of the product was minimized. This finding was also supported by higher emulsion stability and cooking yield in treated products.

Instrumental colour profile

Colour is one of the most important characteristics influencing the assessment and purchasing behaviour of consumers (Umaraw et al. 2015; Dua et al. 2015). Hence, the evaluation of different colour characteristics becomes paramount important while incorporating any ingredient in processed meat products. Lightness values (L*) was comparable in all treatment, however it was lower in T3 than control pork loaves (Fig 1a-e). Decreased lightness (L*) in treated product was concomitant with the sensory evaluation that indicated increase in appearance and colour score of treated pork loaves than those made without liver protein hydrolysate. It could be due to reddish-brown colour of liver hydrolysate, less reflection of light from surface, less glossy surface of pork loaves. Nieto et al. (2009) also reported that meat homogenate made with the incorporation of hydrolyzed potato proteins (HPP) were darker in colour than control. Similarly, higher yellowness (b*) values were recorded for control and lowest for T3. Redness (a* values) was comparable among treatments and control. Jin et al. (2015) also reported the redness (a∗) of the sausages increased with the incorporation of mechanical deboned chicken meat hydrolysates compared to the control. These changes in colour were mainly attributed to the typical reddish-brown colour appearance of the liver hydrolysate powder. Fig. 1: Instrumental colour profile of the liver protein hydrolysates incorporated fibre enriched functional pork loaves

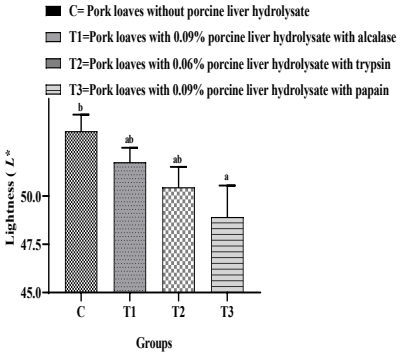

Fig. 1a

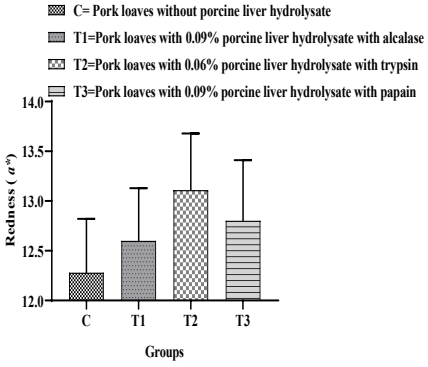

Fig. 1b

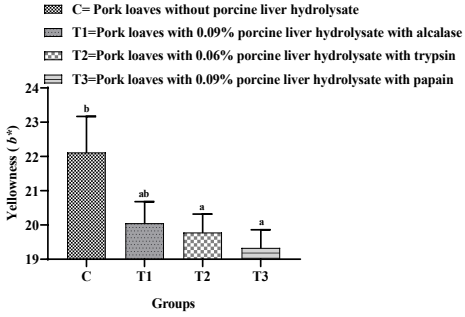

Fig. 1c

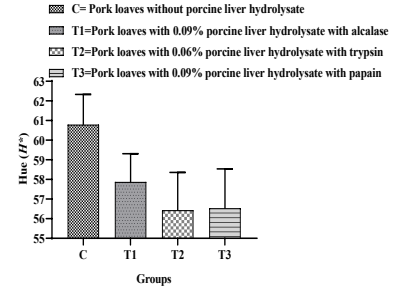

Fig. 1d

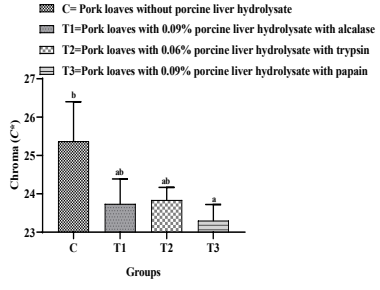

Fig. 1e

Means values bearing different superscripts differ significantly (P<0.05) n = 9. C: Control (pork loaves without porcine liver protein hydrolysate; T1: pork loaves with 0.09% porcine liver protein hydrolysate with alcalase (LA); T2: pork loaves with 0.06% porcine liver protein hydrolysate with trypsin (LT); T3: pork loaves with 0.09% porcine liver protein hydrolysate with papain (LP)

Several researchers have demonstrated that natural pigments in meat emulsion are influenced by various additives, which interact with each other and ultimately impart final colour to meat and meat products (Jamwal et al. 2015; Estevez et al. 2005). However, the observed changes in colour might be due to chemical interaction of liver hydrolysate with myoglobin and fat molecules in the fat–protein interfacial layers. In addition, there was an interaction effect of liver hydrolysate and fat on colour attributes. Chroma (saturation) values were comparable in treatments but were lower than control. The hue angle (h^*) value decreased non-significantly (P>0.05) for treated products than control. Chroma (C^*) and hue angle (h^*) are derived from a^* and b^* values and, consequently, influenced by both.

Instrumental texture profile analysis (TPA)

Hardness was lower in liver hydrolysate incorporated pork loves than control (Fig 2a-f). Decrease in hardness value might be due to moisture retention and fat retention properties of the liver hydrolysate, dilution effect of the solids in loaves matrix and due to weakening of the binding properties of the solid network of product, which led to softer texture. The results of hardness values were in agreement with Sun et al. (2010), who recorded a decrease in the hardness of Cantonese sausages due to the addition of mechanically deboned chicken residue hydrolysate. The springiness value differed significantly (P<0.05) for T3 and control pork loaves and remained comparable for T1 and T2 with control. Similarly, stringiness values were lower in all the treatments than control. It might be due to varying binding properties within meat particles due to the addition of protein hydrolysates. These findings were in harmony with the findings of McCord et al. (1998) and Feng et al. (2003) who reported that the replacement of muscle protein with hydrolyzed soy protein reduces strength of the products. The present results suggested that incorporation of liver protein hydrolysates to pork loaves lead to a greater tendency to fracture. Cohesiveness values did not differ significantly (P>0.05) between control and other treatments. The chewiness values decreased significantly (P<0.05) in T3 than control and were comparable for T1 and T2 with the incorporation of different type of liver hydrolysate.

Fig. 2: Instrumental texture profile of the liver protein hydrolysates incorporated fibre-enriched functional pork loaves

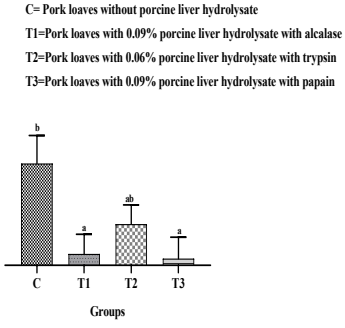

Fig. 2a

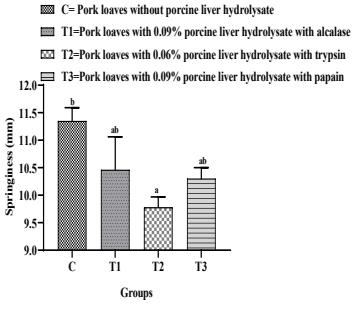

Fig. 2b

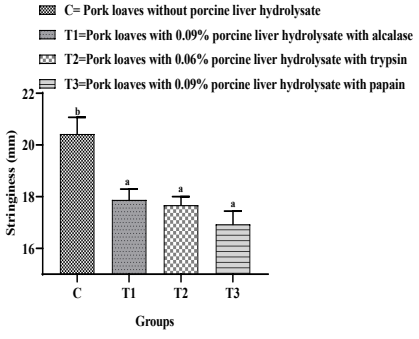

Fig. 2c

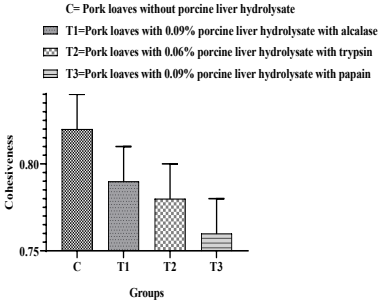

Fig. 2d

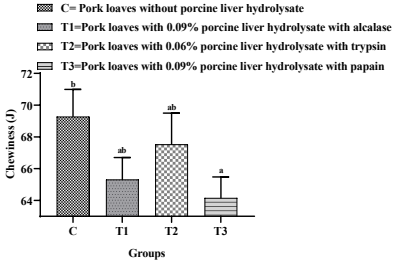

Fig. 2e

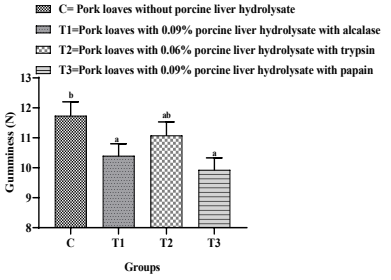

Fig. 2f

Means values bearing different superscripts differ significantly (P<0.05) n = 9. C: Control (pork loaves without porcine liver protein hydrolysate; T1: pork loaves with 0.09% porcine liver protein hydrolysate with alcalase (LA); T2: pork loaves with 0.06% porcine liver protein hydrolysate with trypsin (LT); T3: pork loaves with 0.09% porcine liver protein hydrolysate with papain (LP)

Gumminess values was comparable in treated products; however, it was lower than that of control. Lower values of instrumental texture characteristics of pork loaves with the addition of liver protein hydrolysates might be associated with weaker internal structure of the treated products than control.

Sensory evaluation

Appearance and colour value were comparable in treated products and was highest in T2 and lowest in control (Table 3). It might be due to the inherent colour (reddish brown) of the incorporated liver protein hydrolysates. Results were in harmony with the observations of instrumental colour profile. Jin et al. (2015) also observed favourable result for the colour score on addition of mechanical deboned chicken meat hydrolysates in sausages. Flavour score was significantly (P<0.05) higher for T2 than control and remain analogous for T1 and T3. Peptides play a crucial role in the development of flavours in both unprocessed and processed foods. Buffering capacity of peptides along with amino, carboxyl and other charged groups contribute to the development of complex sensory perception. In certain foods these peptides may either participate or influence the formation of odour and taste. These may foster a realm overall flavour ranging from 'continuity', 'mouthfulness' and 'mellowness' in taste to an anticipated 'after taste' (Kaji and Oshima 2010). Free amino acids, peptides, taste nucleotides and minerals being the stewards for creating these delicious tastes (Deng 2009). Out of these free amino acids and peptides are the key tastants, which play an important role. Tenderness and juiciness scores did not differ significantly (P>0.05) among treated products than control however, these values were slightly higher for T2 than control, T1 and T3. It might be due to more water retention, fat retention and transformation in structure of protein and polysaccharides interaction during cooking. Overall acceptability value differed significantly (P<0.05) in T2 than control and remained comparable for T1 and T3. However, sensory panelists rated higher scores for T2 than other treated groups and control, which might be due to the higher scores for colour and appearance, flavour, tenderness and juiciness.

Table 3: Sensory attributes of the liver protein hydrolysates incorporated fibre-enriched functional pork loaves

Parameter	C	T1	T2	T3
Appearance and Colour	6.98±0.08^{a}	7.19±0.07^{ab}	7.26±0.08^{b}	7.10±0.07^{ab}
Flavour	6.86±0.10^{a}	7.02±0.11^{ab}	7.17±0.07^{b}	7.00±0.11^{ab}
Tenderness	7.00±0.11	7.26±0.07	7.21±0.09	7.12±0.07
Juiciness	7.07±0.09	7.14±0.10	7.29±0.08	7.10±0.10
Overall acceptability	6.95±0.10^{a}	7.21±0.07^{ab}	7.31±0.07^{b}	7.17±0.11^{ab}

Means values bearing different superscripts in a row differ significantly (P<0.05) n = 21. C: Control (pork loaves without porcine liver protein hydrolysate; T1: pork loaves with 0.09% porcine liver protein hydrolysate with alcalase (LA); T2: pork loaves with 0.06% porcine liver protein hydrolysate with trypsin (LT); T3: pork loaves with 0.09% porcine liver protein hydrolysate with papain (LP)

CONCLUSION

Based on findings of this experiment, the cooking yield, emulsion stability nutritional composition, colour profile, texture profile and sensory quality of hydrolysate added meat loaves were better than control. Meat loaves formulated with incorporation of 0.06% porcine liver protein hydrolysate obtained by Trypsin (T2) was selected as best among the treated products.

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COMPETING INTERESTS

There is no conflict of interest.

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