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Standardization of Acidity Level in Hurdle Treated Chicken Croquettes using Lactic Acid

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ABSTRACT

Study was conducted to standardize the acidity level of hurdle treated chicken croquettes (treated with humectants in combination of 0.5% carrageenan + 5% texturized soya protein) using lactic acid. Three different treated meat batters having pH 6.0 (T_1), 5.6 (T_2), 5.2 (T_3) along with control (C) were prepared using chicken meat along with other ingredients in required quantity. The products were examined for different physico-chemical quality, texture & colour profiles and sensory quality. It was revealed that water activity was significantly (P<0.05) lower in T_3 than in T_2, T_1 and control. Product pH, emulsion stability and cooking yield was significantly (P<0.05) lower in T_3 as compare to other treatments and control. The colour profile showed a significantly lower *L* value and lower *a** value in T_3 as compare to C, T_1 and T_2, while the texture profile exhibited a significantly (P<0.05) lower value for hardness, springiness, stringiness, chewiness, gumminess and resilience and cohesiveness in the T_3 product as compared to other batches. The evaluation of sensory attributes showed a significantly higher score for flavour, juiciness and overall acceptability in respect of T_2. Hence it was concluded that meat batter having pH 5.6 was the preferred pH for the preparation of chicken meat croquettes.

Keywords: Lactic acid, chicken croquettes, quality characteristics

Poultry meat is the fastest growing component of global meat demand, and in India, the world's second largest developing country, is experiencing rapid growth in its poultry sector. Present meat production in India is estimated at 6.27 million tonnes (MT) of which poultry meat (2.30 MT**)** accounts for 36.68% (FAO, 2012). With the rapid growth in poultry industry culled birds are available in abundance at reasonable price for processing of a variety of convenience, value added meat products. Poultry meat products are highly desirable, palatable, digestible and nutritious for all ages.

In addition, they are low in price in comparison to beef and mutton. Processing of poultry meat involves conversion of raw poultry carcasses into value added products. Advantages of further processing of poultry meat are improving juiciness and flavour, shelf life and water holding capacity (Sahoo *et al*., 1996). Poultry meat is comprised of about 20 – 23% protein, which comminuted products, such as frankfurters, bologna and sausages typically contain about 17 – 20% protein, 0 – 20% fat, and 60 – 80% water (Smith, 2001).

The demand for processed meat products is ever increasing due to urbanization, improved standard of living and changing life styles. However, the processed meat sector is developing more slowly as only about 2 per cent of total meat is processed into products for trade while in developed countries it is above 60 per cent (Kondaiah, 2004). This is due to negative attitude by the meat eating consumers about the quality products and lack of cold chains for effective marketing as per consumer needs. Many processing techniques have been standardized for several meat products but most of them have limited acceptability and shorter shelf life at ambient temperature. Hence there is an imperative need to develop safe, nutritious and highly acceptable quality shelf stable meat products which can be stored and marketed without refrigeration facilities.

Microbial growth and lipid oxidation are the two important factors which affecting quality and safety of most traditional and novel meat products. As the main objective is to prevent the microbial spoilage and food poisoning, several hurdles or processes are used minimally in optimum combination for development of shelf-stable meat products. The hurdle technology is an intelligent combination of two or more processes, which allows improvements in safety, stability and quality of foods as well as their nutritional values and economic properties (Leistner, 1999). The hurdle technology concept proved very successful in many tradition foods like meat pickles, tandoor quails, fermented sausages etc. and that are processed by thermal processing in a sealed container and by adjusting hurdles like pH, water activity (a_w), food preservatives etc. A number of organic acids are being used to decrease microorganisms in meat products. Lactic acid is used as acidifier, pH control agent, curing and pickling agent and inhibitor of microbes (Burdock, 1997). Lactic acid is generally regarded as safe (GRAS) antimicrobial agents commonly use in meat and meat products.

Chicken croquettes are versatile traditional meat products and have greater acceptability amongst the people throughout the world. They are prepared in different shapes and forms depending on ethnic culture of many countries. But, all preparations are perishable in nature due to short shelf life. Thus, there is an urgent need to improve the existing methods of preservation which in turn would prolong the shelf-life of these products. In view of this, experiment was conducted to standardize the acidity level as hurdle technology preservation method while developing chicken meat croquettes.

MATERIALS AND METHODS

Materials

The culled broiler of IBL-80 breed of 24 weeks age were obtained from poultry farm of GADVASU, Ludhiana and slaughtered as per standard procedure in the experimental slaughterhouse of Department of Livestock Products Technology, College of Veterinary Science, GADVASU, Ludhiana, and Punjab. The dressed carcasses were brought to the laboratory and hot deboned manually. After removal of all separable connective tissues, fat, fascia and blood vessels the deboned chicken meat (DCM) was packed in low density polyethylene (LDPE) bags and stored over night at 4±1ºC in a refrigerator for conditioning and then frozen at -18±1ºC for subsequent use.

Preparation of chicken croquettes

Frozen meat samples were taken out as per requirement and cut into small chunks after partial thawing in a refrigerator (4±1ºC). Half of the meat was minced through a meat mincer (MADO Eskimo, Model No. MEW 714) using 3mm plate and half of the meat was cut into small chunks. The meat chunks were steam boiled for 10 minutes and then cooled. The steam boiled chunks and minced meat were mixed in equal proportion along with other ingredients viz. refined oil, salt, sugar, sodium nitrite, TSPP, skim milk powder, bengal gram flour, grated cauliflower/coriander leaves/spinach, spice mix and condiments(onion: ginger) in 3:1 ratio in control and all treated samples. Spice mix was prepared by grinding dried (50±2ºC for 2 hours) ingredients as tabulated in Table 1 to fine ground powder using Inalsa mixer and sieved through fine mesh screen.

Table 1: Ingredients of spice Mix

Ingredients	Percentage (%)
Coriander	15%
Cumin seeds	15%
Caraway seeds	10%
Aniseed	10%
Black pepper	10%
Capsicum	8%
Dry ginger powder	8%
Cinnamon	5%
Cloves	5%
Cardamom	5%
Mace	5%
Nutmeg	2%
Cardamom	2%

Additionally combination of both 5%, 0.5% Carrageenan were added to the treated samples. TSP and carrageenan were added with the replacement of minced meat. Three different treated batches T_1, T_2, T_3 having pH of 6.0, 5.6, 5.2 respectively were obtained by adding 2M Lactic acid. Trials were carried out to standardize the level of acidulant to be added to obtain three treated batches T_1,T_2,T_3. All the treated samples including control were moulded into oval shape lumps of 8-10 g. These lumps were then cooked in hot air oven at 175° C for 10 minutes. After cooling lumps were dipped in egg albumen and coated with bread crumbs (16gm/100gm product) and deep fat fried in deep fat fryer (Black and Decker, India) at 140°C-150°C for 10 minutes to achieve optimal products quality (golden brown fried appearance). After cooking and cooling all the treated products including control were packaged aerobically in LDPE bags and kept at refrigerated temperature (4±1 °C) temporarily till evaluation. Next day the samples were evaluated for emulsion stability, emulsion and product pH, cooking yield, water activity (a_w), Lovibond tintometer colour, texture profiles and sensory attributes.

Table 2: Formulation used to prepare hurdle treated chicken meat croquettes

Ingredients (%)	C	T_1	T_2	T_3
Meat chunks: Ground meat (50:50)	79.69	74.05	72.57	72.03
Refined oil	5.0	5.0	5.0	5.0
Salt	1.6	1.6	1.6	1.6
Sugar	0.2	0.2	0.2	0.2
Tetra sodium pyrophosphate (TSPP)	0.2	0.2	0.2	0.2
Sodium nitrite	0.01	0.01	0.01	0.01
Skim milk powder	1.5	1.5	1.5	1.5
Bengal gram flour	3.0	3.0	3.0	3.0
Spice mix	1.8	1.8	1.8	1.8
Condiments	5.0	5.0	5.0	5.0
Cauliflower:spinach:coriander (2:1:1)	2.0	2.0	2.0	2.0
Texturized soya protein (TSP)	—	5.0	5.0	5.0
Carrageenan	—	0.5	0.5	0.5
Lactic acid	—	0.14	1.62	2.16

C = Control (without lactic acid), T_1= 0.14 % 2M Lactic acid, T_2= 1.62% 2M Lactic acid, T_3= 2.16% 2M Lactic acid

Chemical analysis

Emulsion stability of chicken meat croquettes was obtained following the method of Baliga and Madaiah (1970) with suitable modification. Twenty gram of meat emulsion was taken in low density polythene (LDPE) bags of 150 gauge (11×10 cm^2), properly sealed and then placed in a thermostatically controlled water bath (Model: NSW 125) at 80°C for 35 minutes. The bags were removed from water bath, cooled to room temperature, cut open and drained off the cookout fluid (fat, water soluble solids) and final sample weight was recorded. The emulsion stability (N=6) was calculated and expressed as percentage of the cooked meat. Cooking yield was calculated by noting and dividing the weights of raw and cooked chicken meat croquettes before and after cooking respectively, multiplied by 100.

The pH was determined (Trout *et al.*, 1992) with digital pH meter (SAB 5000, LABINDIA, New Delhi, India). For this, 10 g of sample was homogenized with 50 ml of distilled water and the electrode was dipped into the suspensions to note down the pH.

Water activity was determined using hand held potable digital water activity meter (Rotronix HYGRO Palm AW1 Set/40, 60146499). Finely ground chicken meat croquettes is filled up (80%) in a moisture free sample cup over which the sensor was placed for five min and reading was noted.

Texture profile analysis (TPA) was calculated using Texture Analyzer (TMS-PRO, Food Technology Corporation, USA). Each chicken meat croquette was subjected to preset speed (30mm/sec), post-test speed (100mm/sec) and test speed (100mm/sec) to a single Warner-Bratzler shear blade with load cell of 2500 N. The TPA was performed as per the procedure outlined by Bourne (1978).

Colour profile was measured using Lovibond Tintometer (Lovibond RT-300, Reflactance Tintometer, United Kingdom) set at 2° of cool white light (D_{65}) and known as *L*, *a**, and *b** values. *L* value brightness (100) or lightness (0), *a** (+ redness/- greenness), *b** (+ yellowness/-blueness) values were recorded on restructured chicken meat slices kept in a plate. The instrument was calibrated using light trap (black hole) and white tile provided with the instrument. Then the above colour parameters were selected. The instrument was directly put on the surface of individual restructured chicken meat slice. Mean and standard error for each parameter were calculated.

Sensory analysis of chicken meat croquettes was conducted by a six member (n=18) experienced panel of judges using an 8 point descriptive scale (Keeton 1983), where 8=excellent and 1=extremely poor. Experiment was replicated thrice in duplicates (n=6) and data were analysed on SPSS-16.0 software package (SPSS Inc.

Chicago, IL,USA) as per standard procedures (Snedecor and Cochran, 1994) for analysis of variance using Duncan's Multiple Range Tests and Homogenity tests to test the significance of difference between means at 5% level (P<0.05) of significance.

RESULTS AND DISCUSSION

Physico-chemical properties

It is revealed from Table 3 that all the treatments i.e. T_1, T_2 and T_3 had significantly (P<0.05) lower a_w than the control indicating that addition of acidulants while lowering the pH of the emulsion as well as of cooked product, also lowered the a_w of the product. Among the treatments T_3 had significantly (P<0.05) lower water activity as compare to other treatments and control. As the pH of the emulsion decreased from 6.08 to 5.20 the water activity also show the decreasing trend. It is well established that decrease in the pH approaching the isoelectric point of meat proteins reduce its water binding capacities (Hedrick *et al*., 1993; Pearson and Gillet, 1997). Wismer-Pedersen (1971) also reported that with addition of acidulants water bindig capacity of meat products decreases which consequently lower the water activity.

In general it was observed that pH of cooked product was higher than the emulsion. Babu *et al*. (1994) attributed the increase in pH on cooking to increased salt concentration due to loss of moisture and the change in the net charge of proteins due to denaturation. The emulsion stability and cooking yield decreased significantly (P<0.05) in T_3 than in other treatments and control. There was no significant difference between T_2 and control. The emulsion stability and cooking yield of T_1 was significantly (P<0.05) higher than T_2, T_3 and control. These variations in emulsion stability and cooking yield might be due to presence of humectants texturized soy-protein and carrageenan combination in all the treated batches. Papadima and Bloukas (1999) reported that at lower pH levels denaturation of muscle proteins might have occurred which resulted in lower cooking yield and emulsion stability in sausages. Offer and Trinick (1983) suggested that shrinkage of meat myofibrils due to lower intracellular pH caused drip loss by reducing the space between the three-dimensional networks of myofibrils that are able to retain water. Barbut (2006) reported that addition of liquid lactic acid caused immediate pH drop and separation of moisture and fat, which in turn resulted in lower cooking yield in salami type products.

Table 3: Effect of lactic acid on the physico-chemical properties of hurdle treated chicken meat croquettes

Parameters	Treatment			
	C	T_1	T_2	T_3
Water activity	0.977±0.04[d]	0.931±0.06[c]	0.928±0.03[b]	0.896±0.05[a]
Emulsion stability	89.28±0.15[b]	89.93±0.08[c]	89.14±0.14[b]	82.06±0.21[a]
Product pH	6.12±0.04[c]	6.10±0.04[c]	5.80±0.07[b]	5.31±0.05[a]
Cooking yield	88.67±0.01[b]	89.54±0.06[c]	88.73±0.05[b]	81.68±0.05[a]

Mean±S.E. with different superscripts in the same row indicate significant difference (P<0.05)

C=Control (without lactic acid), T_1= 0.14 % 2M Lactic acid, T_2= 1.62% 2M Lactic acid, T_3= 2.16% 2M Lactic acid

Texture profile analysis

It is revealed from Table 4 that T_3 had significantly (P<0.05) lower values for all textural parameters as compared to other treatments and control. There was no significant difference between T_2 and control for hardness, springiness and stringiness values but these values were significantly (P<0.05) higher for T_1 as compared to control. This might be due to the presence of humectants like texturized soy-protein and carrageenan in all the treatments. Thomas *et al.* (2008) reported that all the textural parameters of the pork sausages decreased with decrease in emulsion pH. Sheard and Tali (2004) also reported that decrease in pH below or above of isoelectric point of myofibrillar protein decrease the hardness.

Barbut (2005) observed decrease in springiness in salami type product with decrease in pH. Cohesiveness was significantly (P<0.05) lower in T_3 sample as compared to control, T_1 and T_2 products. Chewiness, gumineess and resilience were significantly (P<0.05) higher for T_1 as compare to control and T_2, T_3. According to Gou *et al.* (1996) reduction in chewiness, guminees and hardness in fermented sausages was due to decrease in pH. Feng and xiong (2002) observed that the quality of gel matrix had an important role in determining textural properties of cooked frankfurters.

Table 4: Effect of lactic acid on the texture profiles of hurdle treated chicken meat croquettes

Texture profiles	Treatment			
	Control	T_1	T_2	T_3
Hardness	8.84 ± 0.05^b	10.43 ± 0.06^c	8.49 ± 0.08^b	6.45 ± 0.07^a
Springiness	27.46 ± 0.04^d	27.20 ± 0.05^c	26.64 ± 0.06^b	24.54 ± 0.08^a
Stringiness	22.47 ± 0.15^d	21.93 ± 0.01^c	21.21 ± 0.05^b	19.47 ± 0.10^a
Cohesiveness	0.56 ± 0.03^b	0.58 ± 0.01^b	0.55 ± 0.04^b	0.51 ± 0.01^a
Chewiness	152.08 ± 0.57^b	167.06 ± 0.53^d	154.63 ± 0.36^c	138.18 ± 0.50^a
Guminess	5.34 ± 0.43^b	6.74 ± 0.01^c	6.18 ± 0.04^c	4.38 ± 0.09^a
Resilience	0.65 ± 0.06^c	0.55 ± 0.09^b	0.51 ± 0.05^a	0.49 ± 0.01^a

Mean±S.E. with different superscripts in the same row indicate significant difference (P<0.05).

C=Control (without lactic acid), T_1= 0.14 % 2M Lactic acid, T_2= 1.62% 2M Lactic acid, T_3= 2.16% 2M Lactic acid

Colour profile analysis

Table 5 shows that with the decrease in pH the *L* value and *b** value decreased and *a** value increased. T_3 had significantly (P<0.05) lower *L* value as compared to other treatments and control group. As pH decreases the colour of meat lightens due to reduced water holding capacity and a corresponding increase in light scattering properties in muscle fibre (Warriss, 2000). Arganosa and Marriott (1989) reported that restructured steaks treated with acid were whiter when compared to controls due to enhance conversion of myoglobin to metmyoglobin, which has lower colour intensity.

The *a** value was significantly (P<0.05) higher for all treatments than control but there was no significant difference among the treatments. According to Maca *et al.* (1999) decrease in pH effect the conversion of myoglobin to metmyoglobin in the cooked meat products and also lead to the concentration of meat pigments due to higher moisture loss in sauasges. The *b** value of T_1 and control were significantly higher than T_2 and T_3. An increase of *a** value and decrease of *b** values was observed with decrease of pH in cooked meats (Papadopoulos *et al.*, 1991). Thomas *et al.* (2008) also reported the decrease in *L* and *b** value and increase in *a** value with the decrease in pH with the addition of lactic acid.

Table 5: Effect of lactic acid on the colour profile of hurdle treated chicken meat croquettes

Colour profiles	Treatment			
	C	T_1	T_2	T_3
L	50.10±0.45^d	49.37±0.30^c	46.12±0.36^b	42.45±0.54^a
*a**	13.18±0.15^a	15.09±0.84^b	14.49±0.61^b	15.83±0.57^b
*b**	26.73±0.38^b	26.74±0.54^b	23.81±0.29^a	22.96±0.30^a

Mean±S.E. with different superscripts in the same row indicate significant difference (P<0.05).

C=Control (without lactic acid), T_1= 0.14 % 2M Lactic acid, T_2= 1.62% 2M Lactic acid, T_3= 2.16% 2M Lactic acid

Sensory attributes

All the sensory parameters of T_3 was significantly (P<0.05) lower than control and other treatments (Table 6). T_2 scored higher for flavor, juiciness and overall acceptability as compared to control, T_1 and T_3. Rao and Gault (1990) observed that changes in the structural organization of the myofibrillar proteins increase the water holding capacity of acid marinated meat are of major importance in influencing meat tenderness and subsequently juiciness. Desmond and Troy (2001) reported that lactic acid had a more beneficial effect in improving texture, flavor and acceptability in comparison to the citric acid.

Table 6: Effect of lactic acid on the sensory attributes of hurdle treated chicken meat croquettes

Sensory parameters	Treatment			
	Control	T_1	T_2	T_3
Colour	6.61±0.10^b	6.69±0.09^b	6.66±0.09^b	5.40±0.08^a
Flavor	6.58±0.10^b	6.50±0.09^b	6.86±0.09^b	5.30±0.08^a

Texture	6.75±0.10[b]	6.47±0.10[b]	6.55±0.09[b]	5.36±0.01[a]
Juiciness	6.58±0.09[b]	6.63±0.10[b]	6.83±0.08[b]	5.30±0.07[a]
Overall acceptability	6.63±0.10[b]	6.61±0.11[b]	6.66±0.10[b]	5.38±0.05[a]

Mean±S.E. with different superscripts in the same row indicate significant differenc (P<0.05).

C=Control (without lactic acid), T_1= 0.14 % 2M Lactic acid, T_2= 1.62% 2M Lactic acid, T_3= 2.16% 2M Lactic acid

CONCLUSION

Based on above study, pH of 5.6 was selected suitable for the preparation of hurdle treated chicken croquettes with improved physic-chemical parameters by using lactic acid. The developed croquettes scored highest in juiciness, flavour and overall acceptability than control and other treatments.

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