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Quality Analysis of Vacuum Packed Super Chilled Chicken Breast at 24 hour Storage

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A B S T R A C T

The present study was conducted to compare the quality of vacuum packed superchilled (-1.5 to -2.5ºC) chicken breast with the chilled and frozen chicken breast at 24 h of storage. The result showed improvement in moisture content of superchilled meat with reduction in protein content as compared to fresh meat. There were no significant difference (P>0.05) in fat content of treated samples. The pH and WHC % showed no significant effect of cooling treatments. The ERV was good in treated samples except in chilled samples wherein it was decreased significantly. There was significant (P<0.05) reduction of drip loss in superchilled meat compared to chilled and frozen samples which is significant for superchilling industry. The a_w in frozen and superchilled fillets were found to be reduced significantly (P<0.05) as compared to fresh meat. Microbiological analysis indicated non significant (P>0.05) increase in TPC of superchilled and frozen fillets where as in chilled samples the increase in TPC was significant (P<0.05) indicating significance of superchilling technique in improving meat quality. However, psychrophillic count was increased significantly (P<0.05) in both chilled and superchilled fillets. The texture of superchilled fillets was comparable to chilled fillet and found to be improved. Lightness (L*), redness (a*) and yellowness (Hunter b*) value were affected markedly due to superchilling temperature. There was reduction in L* and b* in superchilled breast fillet against frozen and chilled fillet. The study indicated that superchilling could be a good way to preserve freshness of vacuum packed chicken breast fillet with improving the quality characteristics.

Introduction

Consumption of meat is continuously increasing worldwide. Although consumption of meat is increasing world wide the significant portion of meat and meat products are spoiled every year. The significant portion of this loss is due to microbial spoilage (Heinz and Hautzinger, 2007). Chilling is critical for meat hygiene, safety, shelf life, appearance and nutritional quality (Zhou *et*

al,, 2010). Chilling also helps to prevent denaturing of proteins which may lead to bacterial attack as they are more susceptible to denatured protein than native protein. On the other hand, cold-shortening and toughening may result from ultra-rapid chilling of pre-rigour meat (Ockerman and Basu, 2004).

Freezing is one of the best methods for preserving food and extending its shelf life. However, food qualities such as texture, color and water holding capacity decreases after freezing and thawing. Meat contains about 50-75% by weight water, depending on the species and the process of freezing converts most of water into ice (Heinz and Hautzinger, 2007). Freezing rate (slow and fast) affects the quality of frozen meat significantly. Fast freezing produce better quality meat than slow freezing (Garthwaite, 1997).

Superchilling is a different concept than refrigeration and freezing having potential to reduce storage and transport costs (Reynolds, 2007). Super-chilling refers to the temperature zone below its initial freezing point (1-2°C) but where ice crystals are not generated. In this process, instead of adding external ice to the food product, part of the internal water is frozen and works as a refrigeration reservoir, ensuring its refrigeration during distribution and transportation (Bahuaud *et al.,* 2008). The main advantage of this method of preservation over traditional methods is that it increases the shelf life of meat for up to 4 times. Although most microbial activities are stopped or inhibited, chemical and physical changes may progress and in some cases are even accelerate (Magnussen *et al.,* 2008).

The superchilling process was described as early as 1920 by Le Danois, and the terms "superchilling", "partial freezing" and "deep chilling" are used to describe a process by which food products are stored between their initial freezing point (−0.5 °C to−2.8 °C for most food) and 1–2 °C below this temperature in most reports (Chang *et al.,* 1998; Duun and Rustad, 2007; Magnussen *et al.,* 2008). Compared with traditional chilling technology, superchilling can retain better food quality and prolong the shelf life of most stored food by at least 1.5 − 4 times (Kaale *et*

al., 2011). It can also reduce the use of freezing/thawing and thereby a lower energy cost was involved in superchilling in terms of transportation and retailing compared with freezing technology (Zhou, *et al.,* 2010). Previous studies have investigated the effects of superchilling on the shelf life and quality parameters of aquatic products only at a special temperature (Gallart-Jornet *et al.,* 2007; Kaale *et al.,* 2014; Fernandez *et al.,* 2009; Olafsdottir *et al.,* 2006). The formation and growth of intra- and extracellular ice crystals during superchilling storage are significant. These crystals accelerate the extent of myofiber detachment and breakage (Bahuaud *et al.,* 2008; Kaale *et al.,* 2013). However there are few published studies on effect of superchilling on shelf of livestock products (Jeremiah and Gibson, 1997 in pork cuts; Jeremiah and Gibson, 2001 in beef steaks) and meat (Gill and McGinnis, 1995 in beef; Liu *et al.,* 2012 in beef; Lan *et al.,* 2016 in rabbit meat) and only few literature concerning chicken breast (Lawrence *et al.,* 2010) has been published.

Since the studies describing the effect of superchilling temperature on the physicochemical and microbiological quality of chicken breasts not yet been published, the present study was conducted to focus effect of superchilling process on vacuum packed chicken breast fillet and compared with chilled and frozen breast fillet at 24 h of storage.

Materials and Methods

Meat procurement and treatment

The live broiler birds weighing 1.25 to 1.5 kg weight were procured from Indian Broiler, Nagpur and then freshly dressed poultry carcass were kept in refrigerator for 12 h for ageing which were deboned. Breast fillets were vacuum packed in Low density

Polyethylene (LDPE) pouches and shifted to freezer (-20^OC) for cooling until the core temperature was approximately -0.5^OC (about 1h and 40 min.) was reached and then two samples were immediately transferred to store at chilling (0 to 4^OC) and superchilling (-1.5 to -2.5^OC) temperature for 24 h. The fresh meat was analyzed on the day of processing.

Physico-chemical analysis

The proximate composition (moisture, fat and protein) of all treated samples were determined by using the standard methods of AOAC (1995).

The pH of a product was determined by method of AOAC (1995). Ten g sample was added in 50 ml distilled water and fine suspension was prepared. Then glass with combined electrode of digital pH meter was immersed in the suspension (Model: Systronics Digital pH meter 802).

The water holding capacity (WHC) of meat determined as described by Wardlaw *et al.,* (1973) with slight modification. 20g of minced meat sample was blended with 30ml chilled NaCl (0.6M) in centrifuge tube which was stirred for 1 min with the help of glass rod which was then hold at 40C for 15 min, after that sample was allowed to centrifuge at 5000 rpm for 15 min (REMI- R- 24). The supernatant obtained was measured and amount of water retained by sample was expressed in percentage.

The ERV was estimated according to the procedure described by Strange *et al.,* (1977). Twenty five gram of minced meat was blended with 100 ml distilled water and homogenate was filtered through a Whatman filter paper No. 1. The volume of filtrate collected in first 15 min was recorded as ERV of the respective sample.

Drip loss of meat samples were determined by the method (AOAC, 1995) from the known weights of before and after thawing and expressed as:

$$\% \text{ Drip loss} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Water activity was measured by Rotronic hygropalm-HP23-AW by putting 1 g sample in sample cup and aw was recorded after 1 min, at the specific temperature (25ºC).

Instrumental colour

The colour was determined using Hunter Lab Miniscan XE Plus Colorimeter (Hunter Associates Laboratory Inc., Reston, VA, USA) at National Research Centre on Meat, Hyderabad using illuminant D65 and the 10º standard observer angle. Meat colour was measured at the surface of breast fillet 30 min after pack opening in order to allow colour stabilization on exposure to air and then L* (Lightness), a* (redness) and b* (yellowness) values were measured.

Texture (shear force value) analysis

To measure shear force (N), breast fillet were cooked and six subsamples in a cylindrical shape (diameter 8mm) were taken from each sample, longitudinally and in the direction of the muscle fibers using tissue borer. The Warner – Bratzler shear force (WBSF) of the cores were measured using texturometer (Tinius Olsen, Model H1KF, 6 Perrywood Business park, Redhill, RH1 5DZ, England) with V shaped stainless steel Blade (60° angle) and triangular whole in the middle. The cores were sheared perpendicular to the muscle fibre orientation with 75 Newton load range and a cross head speed set at 200 mm/minute. The force required to shear the samples were recorded in Newton (N).

Determination of microbiological quality

The determination of total plate count, pychrophillic count and coliform count were determined following the standard method of APHA (1992).

Sample preparation

Ten g of meat sample was taken near flame in a sterile mortar with the help of sterilized forceps and scissor. To it 90 ml of sterile 0.1% peptone water was added and fine suspension was prepared using a sterile pestle for 2 min. to get 10^{-1} dilution. One ml of this dilution was transferred to 9 ml of sterile 0.1% Peptone water in a test tube and mixed uniformly to get 10^{-2} dilution. Subsequent dilutions were made as per the requirement using the same procedure.

Total plate count

Plate count agar (23.5 g) was suspended in one liter distilled water, boiled to dissolve the medium completely and pH was adjusted to 7.0 + 0.2. It was sterilized by autoclaving at 15 lbs pressure (1210C) for 15 min. About 20 ml of molten media at 45^{0}C was poured to each sterile Petridish in duplicate after dropping of 1 ml inoculum of suitable dilution. The plate were kept for solidification and incubated at $37+1^{0}$C for 24 hrs. Plates showing 30 - 300 colonies were counted and expressed as $\log_{10}$cfu/g of meat sample.

Psychrophilic count

The procedure of similar to TPC was used for determination of psychrophillic count, except that the plates were incubated at $4+1^{0}$C for 7 days. Colonies were counted and results were expressed as $\log_{10}$ cfu/g of sample.

Coliform count

For coliform estimation Mac Conkey agar was prepared and 1 ml of inoculum of each dilution was placed in duplicate Petridishes. The sterile molten and cooled (45^{0}C) medium was poured and mixed thoroughly in Petridishes. After solidification of medium, the Petridishes were incubated at $37+1^{0}$C for 24 hrs. Pink coloured colonies were counted and expressed as $\log_{10}$cfu /g of meat sample.

Statistical analysis

The experiment was repeated on three separate occasions and the reading was taken in duplicate using duplicate subsamples. The data obtained was analyzed using online data analysis package WASP (Web Agri Stat Package) developed by ICAR-Central Costal Agricultural Research Institute, Goa. The significance was defined at a level of P<0.05.

Results and Discussion

The effect of superchilling process on vacuum packed breast fillet was analyzed after temperature equalization (24 h storage) for various physicochemical and microbiological qualities has been summarized in table 1.

Proximate composition

The mean moisture value of fresh and superchilled breast fillet was found to be 74.96+0.25 and 75.74+0.53 respectively which did not differ significantly (P>0.05). However, chilled meat showed significantly higher moisture content compared to frozon and superchilled breast fillet indicating that the superchilling may reduce the moisture content in the meat. This reduction could be due to evaporation of moisture from meat during storage (Arief *et al.,* 1989) and sublimation of surface water of the meat to colder surface in the vicinity of freezer (Taylor *et al.,* 1990).

The results indicated that these different cooling treatments have significant effect on protein content which was decreased (P<0.05)

as compared to fresh meat which might be due to protein denaturation, as also exhibited in drip loss in this study and proteolysis induced by enzymatic activities of psychographs (Peterson and Gunderson, 1960) as well as increased microbial growth resulted from higher water activity (aw) and enzymatic autolysis (Rao *et al.,* 1998).

The fat content of chilled (4°C), frozen (-18°C), superchilled (-1.5 to -2.5°C) and fresh breast fillet showed no significant difference.

pH, WHC and ERV

Though the pH of superchilled breast fillet is reduced compared to fresh meat, all the treated samples showed no significant differences. This decreased pH in the treated samples, though non significant, could be due to the post mortem conversion of muscle glycogen to lactic acid which has an important bearing on keeping quality of meat (Gracy, 1981).

The water holding capacity (WHC) and thus the liquid loss (LL), of muscle is regarded as an essential quality parameter and a high WHC is of great importance both to the industry and the consumer (Dunn and Rustad, 2007). It influences the appearance of the muscle before cooking, its behavior during cooking and its juiciness when consumed (Olsson, 2003). The per cent WHC of chilled (4°C), frozen (-18°C) and superchilled (-1.5 to -2.5°C) breast fillet was 61.49+0.88, 63.16+0.72 and 62.82+0.45 respectively showing no significance which is in agreement with Kaale *et al.,* (2014) who also reported non significant difference in Liquied Loss (LL) in superchilled Atlantic salmon (Salmo *salar*) muscle as compared to chilled and frozen samples. However, the WHC values are much lower than the WHC of fresh breast fillet. This decrease in WHC in treated

samples could be attributed to the rate of post mortem pH decline, high ionic strength, and protein denaturation and enhanced movement of water into extracellular space (Kondaiah *et al.,* 1986).

The ERV (ml) of chilled (4°C), frozen (-18°C), superchilled (-1.5 to -2.5°C) and fresh breast fillet was 27.26+0.48, 29.5+0.50, 29.0 +0.42 and 29.46+0.37 ml respectively indicating significant (P<0.05) decrease in the chilled sample where as ERV of frozen and superchilled breast fillet was as good as for fresh breast fillet. This decrease in ERV in the chilled sample might be due to bacterial growth (Miller and Price, 1971).

Drip loss %

The per cent drip loss of chilled (4°C), frozen (-18°C), superchilled (-1.5 to -2.5°C) breast fillet at 24 h storage was 1.66+0.14, 2.23+0.29 and 1.72+0.12 respectively indicating significant reduction in drip loss in superchilled sample compared to chilled and frozen sample. The results are in agreement with the Kaale *et al.,* (2014) who studied superchilling effect on WHC and drip loss of Atlantic salmon (Salmo *salar*) muscle. These findings are significant for the superchilling industry because they provide beneficial information on the quality of food products and this reduction in drip loss due to superchilling might be due to small amount of water in frozen from as compared to frozen samples resulting in less enzymes and salt concentration in the remaining water (Kaale and Eikevik, 2014). When water form ice, there is an increased concentration of enzymes and builds up of salt concentration in the remaining water causing protein denaturation and therefore effect the protein functionality (George, 1993; Shenouda, 1980) Moreover, high drip loss in frozen sample could be due to the mechanical damage to cell membranes caused by destruction of muscular

tissue due to freezing resulting in low WHC (Anese *et al.,* 2012; Srinivasan, Xiong, Blanchard and Tidwell, 1997).

Water activity (a_w)

The a_w of chilled (4°C), frozen (-18°C), superchilled (-1.5 to -2.5°C) and fresh breast fillet at 24 h storage was 0.944+0.07, 0.906+0.06, 0.928+0.05 and 0.966+0.05 respectively indicating significant reduction of a_w in frozen and superchilled fillet which could be due to the fact that the freezing lowers water activity (Warris, 2010). It is also observed that there is no significant difference in the a_w of chilled and superchilled fillet as well as frozen and superchilled fillet.

Microbiological analysis

In the present study, total plate count (TPC) increased significantly (P<0.05) in chilled fillet as compared to fresh meat. However, increase in TPC of frozen (-18°C) and superchilled (-1.5 to -2.5°C) breast fillet was found to be non significant. This could be due to the damage caused to the cells through the formation of ice crystals (Warris, 2010) preventing the growth of bacteria by reducing the availability of water as it forms ice. However, Release of drip which has provided excellent medium for microbial growth (Nirmal and Benjakul, 2010) may be the reason for increase in TPC in superchilled breast fillet as compared to fresh meat.

Table.1 Effect of superchilling treatment on physicochemical qualities of vacuum packed chicken breast fillets (n=6)

Sr. No.	Parameters	Temperatures			Fresh meat
		Chilling (0-4°C)	Freezing (-20°C)	Superchilling (-1.5 to -2.5°C)	
1	Moisture (%)	75.85+0.50	74.38 + 0.26	75.54 + 0.55	74.96 + 0.15
2	Protein (%)	19.09 + 0.21[a]	19.17+ 0.29[a]	19.20+ 0.26[a]	20.56+ 0.24[b]
3	Fat (%)	4.39+ 0.19	4.31+ 0.21	4.49+ 0.12	4.39+ 0.11
4	pH	5.99 +0.07[a]	6.17+0.02[b]	5.99+ 0.05[a]	6.18+ 0.03[b]
5	WHC (%)	62.85+1.72	65.94+ 1.16	65.84+0.57	66.07+0.45
6	Water activity (a_w)	0.92+0.04[b]	0.90+0.05[c]	0.92+0.06[bc]	0.97+0.05[a]
7	Drip loss (%)	1.63+0.05	2.18+0.27	1.69+0.07	-
8	TPC (Log_{10}cfu/g)	4.40+0.25	3.80+0.26	4.18+0.22	4.02+0.29
9	PPC (Log_{10}cfu/g)	2.25+0.08[a]	1.54+0.12[b]	1.83+0.07[c]	1.44+0.03[b]
10	Coliforms (Log_{10}cfu/g)	ND	ND	ND	ND

Different superscripts in a row differ significantly (P<0.05)

Table.2 Effect of superchilling treatment on colour and texture of vacuum packed
chicken breast fillets (Colour n=3 and Texture n=5)

Sr. No.	Treatment	Colour Parameters			Texture Shear Force Value (N)
		Lightness L*	Redness a*	Yellowness b*	
1	Chilling (0-4ºC)	30.82±0.30	-1.03±0.52	6.31±0.57	8.12±0.84
2	Freezing (-20ºC)	35.11±1.13	-0.30±0.53	6.49±0.88	8.83±0.97
3	Superchilling (-1.5 to -2.5ºC)	32.43±0.63	-1.81±0.36	3.83±0.56	8.83±0.75

Different superscripts in a row differ significantly (P<0.05)

Psychrophillic count increased significantly in chilled and superchilled breast fillet when compared with fresh and frozen fillet. This increased Psychrophillic count in chilled and superchilled breast fillet could be due to increased enzymatic activity of psychrotrophs at low temperature which might have contributed to deterioration of meat quality (Kandeepan and Biswas, 2007).

Warner – Bratzler shear force (WBSF)

The table 2 indicated reduction in shear force value of superchilled meat as compared to frozen fillet, though there is no significance. Compared with the shear force measured for chilled breast fillet, lower values were observed for superchilled fillet. These results are in agreement with Lan *et al.,* (2016) who also observed lower values of shear force for superchilled hind rabbit hind leg than chilled rabbit hind leg. This reduction in shear force value could be due to the loss of membrane strength caused by ice crystal formation (Laygonie *et al.,* 2012).

Changes in colour

Color plays an important role in the appearance, presentation and acceptability of

meat. Lightness (L*), redness (a*) and yellowness (Hunter b* value) were affected markedly due to superchilling temperature. The result indicated significant reduction in lightness (Hunter L* value) and yellowness (Hunter b* value) score in superchilled breast fillet against frozen and chilled fillet. The redness score (Hunter a* value) increased significantly suggesting the beneficial effect of superchilling in improving the redness of breast fillet. These results can be corroborated with the results of Lan *et al.,* (2016) who reported significant decrease of L* in rabbit hind legs when stored at superchilled temperature of −4 °C and −2.5 °C temperature. Duun and Rustad (2008) also obtained a lower L* in salmon filets stored at −1.4 °C than in filets stored at −3.6 °C.

In conclusion, the study indicated that super chilling could be a good alternative to preserve freshness of vacuum packed breast fillet with improvement in the quality characteristics representing an advantage over traditional chilling and freezing. It could be a good way to preserve freshness of fresh poultry meat before processing and also could have great effect on improving the quality characteristics of poultry meat and shelf life.

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