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Storage Stability of Chicken *Momo* at Super Chilling Temperature

A.A. Pawade, K.S. Rathod* and R.K. Ambadkar

Department of Livestock Products Technology, Nagpur Veterinary College, Nagpur (M.S.), India

**Corresponding author*

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A B S T R A C T

The present study was conducted to compare the quality of superchilled (-2 ±0.5ºC), frozen (-20±1ºC) and chilled (4±1ºC) chicken *momos*, aerobically packaged in LDPE pouches. The products stored at chilling (4±1ºC) temperature spoiled on day 12. There was significant decrease in moisture and fat content of both frozen and superchilled samples with progress in storage period where as the protein content of chicken momo did not affect. The pH of all the samples increased gradually during the storage period. However, the pH of superchilled samples increased significantly at the end of storage. TBA and Tyrosine values of the superchilled samples were significantly lower than chilled samples during the storage period. Furthermore, superchilled products showed significantly lower TPC and PC as compared to chilled product and none of the samples revealed coliforms throughout the period of storage. Superchilled samples had the yeast and molds on day 24 onwards.However, frozen sample did not reveal any yeast and mold throughout the study period of 32 days. Sensory evaluation also revealed significantly high scores for superchilled product than chilled momos indicating usefulness of superchilling in extension of shelf life. The study indicated that the shelf life of chicken momos could be extended up to 32 days under superchilling (-2 ±0.5ºC) temperature.

Introduction

Due to rapidly increasing economy, population, industrialization and urbanization, there is a fast development of meat industries over recent decades. Processed, convenient and value added meat products sector particularly snack industry has very good opportunities in developed and developing countries like India due to changing consumer lifestyle, working women trends, increase in income of families, singles/professionals staying away from home, nuclear families. Snacks are available in variety of packaged as well as processed foods like Chicken chips (Sharma and Nanda, 2002), chicken meat rings (Mishra *et al.*, 2015), fish curls (Raja *et al.*, 2014), *momos* (Tanuja *et al.*, 2014), *Chakali* (Hiwarkar, 2017) etc. *Momos* (type of dumpling), native to Tibet and was brought to Nepal by Newari traders of Kathmandu before 1930s, are famous street food throughout the world. It is very popular in the Himalayan states of India especially in Sikkim and Ladakh. They were introduced from Han China, as one of the most popular fast food.

There are two types of *momos* fried and steamed *momos*. *Momos* that are pan fried after steaming are known as *kothey momo* and steamed *momo* served in hot sauce are referred *C-momo* (Tanuja, 2013).

The storage temperature of chilled fresh foods is normally 4 to10°C and in the distribution chain the storage temperatures also vary a lot (Hemmingsen, 2002). Most of the foods are perishable and require refrigeration in order to achieve an acceptable length of shelf life and to minimise the risk of food borne diseases. The ability to supply sufficient amounts of fresh food to a growing population is currently a major worldwide challenge. In this context, superchilling is considered as the best technology for ensuring a greater exploitation of fresh food. Superchilling is a method for conserving foods by holding the product at a temperature between -0.5 to -4°C (Fennema, 1973) and results in better quality compared to conventional chilling (Einarsson, 1988) for many food products. The ice stored in super-chilled products will protect from temperature rises in poor cold chains (Magnussen *et al.*, 2008). However, most of the studies on superchilling has been conducted on seafoods (Kaale *et al.,* 2013; Erikson *et al.,* 2011; Olafsdottir *et al.,* 2006; Sivertsvik *et al.,* 2002 and 2003; Zeng *et al.,* 2005, Duun and Rustad, 2007, 2008;) and fresh meats (Rathod *et al.,* 2017a and Rathod *et al.,* 2017b).

Since, scanty literature on superchilling of meat products like pork roast (Duun *et al*, 2008), Chicken nuggets (Kanle, 2017) is available, the present study was undertaken to investigate the effects of superchilling temperature on storage stability of chicken *momo*.

Materials and Methods

Fresh boneless meat from chicken, slaughtered by traditional halal method was procured from the local market. All the body fat, tendons and separable connective tissue were trimmed off from the breast fillets. These fillets were then packaged in LDPE bags, kept at refrigeration temperature (4 ± 1^0C) overnight (12 h) and subsequently used for product preparation.

Boneless chilled meat was cut into small pieces and minced in a mixer. Firstly salt (1.6%) and MSG (0.4%) were added in minced meat and mixed for 2 min with addition of condiments (10%) and spice mix (2%) and mixed for 2 min. Then vegetable oil (5.5%) along with chopped onion (15%) and green coriander (5%) were added and mixed properly. Chicken *momos* were prepared from *momo* mix according to the method of Vanramhlimpuii (2015) with slight modifications. The dough was prepared by proper kneading of refined wheat flour (95.5%), refined oil (4%), salt (0.5%) and lukewarm water as per requirement in a bowl. 5 g of dough was taken, rolled in a round shape and filled with 15 g of *momo* mix and then the edges were closed properly. The chicken *momo* were shaped manually at ambient temperature followed by cooking in steamer for 30 min.

The product was evaluated on the basis of the physico-chemical properties viz., pH, TBA number, tyrosine value and microbiological analysis viz., total plate count, psychrophilic plate count, coliform count and yeast and mold count as well as sensory scores at an interval of 4 days during the study period of 32 days. The pH, moisture (%), fat (%) and protein (%) content of chicken nuggets were determined as per the method of AOAC (2012). Thiobarbituric acid number and tyrosine value of chicken *momo* samples were determined as per the method suggested by Witte *et al.,* (1970) and strange *et al.*,(1977) with slight modifications. The microbiological quality of chicken *momo* was assessed on the basis of total plate count (TPC), psychrophilic

count (PC),coliform count and yeast and mold count as per the procedure of APHA (1984).

The sensory evaluation of steamed chicken *momos* were conducted by semi-trained sensory panelists and the product was evaluated on the basis of various sensory attributes viz., appearance, flavor, texture, juiciness and overall acceptability by using 8 point Hedonic scale (Keeton *et al.,* 1983) and the data generated was analyzed by Analysis of Variance following the procedure described by Snedecor and Cochran (1989).

Results and Discussion

Physicochemical properties

The moisture content of superchilled sample was significantly low during the entire storage period of 32 days than frozen samples. However, the moisture of both the samples decreased significantly with progress in storage period. This reduction in moisture content might be co-related with the decrease in pH (Huff- Lonergan and Lonergan, 2005) during storage. The results Corroborated with the findings of Rathod (2017) who reported significant reduction in moisture of frozen (-20±1ºC) and superchilled (-1.5 to -2.5ºC) chicken breast samples throughout storage period of 20 days under aerobic conditions. Similar observations were also reported by Kanle (2017) in aerobically packed superchilled chicken nuggets stored at two different superchilling (- 2 ± 0.5ºC and -0.5±0.5ºC) temperatures.

Storage temperatures did not affect the protein content of chicken momo. There was marginal reduction in protein content of chicken momos stored at different temperatures during storage periods. Nevertheless the protein content of superchilled sample (17.43± 0.06) was slightly lower than that of the frozen sample (17.66± 0.07).Similar results were also reported by Tanuja (2013) who observed non significant differences in protein content of chicken momos stored at chilling temperature. Similarly, there was no significant variation in the fat content of samples between 0 and 4 days of storage. However, significant variations in the fat content of the products were observed between superchilled and frozen samples at the end of storage. The decrease in fat content during frozen storage at the end of storage might be due to lipid oxidation caused by loss of triglyceride fraction during frozen storage whereas intermediately activities of endogenous enzymes also resulted in disintegration of meat lipids (Agnihotri, 1988). Similar results were also reported by Kanle (2017) in superchilled nuggets.

The pH of sample differed significantly between the superchilled and frozen samples. The pH of all the samples increased gradually during the storage period and was significantly higher in chilled sample (6.31± 0.01) than superchilling (6.02± 0.01) and frozen (6.01± 0.01) samples on 12^{th} day of storage. However, superchilled samples showed significant increase in pH than frozen samples at the end of storage. This consistent increase in pH during storage under superchilling temperature could be due to liberation of protein metabolites by bacterial enzymes, during autolysis (Strange *et al.,* 1977) and microbial spoilage (Dainty *et al.,* 1975) of meat.

The TBA values of chicken *momos* increased significantly ($P<0.05$) from day 8 of the storage period irrespective of treatments. TBA values of different treatments on day 4 indicated significant increase in TBA value of chilled product while there was no significant variation of TBA values of superchilled and frozen product. This pattern was observed upto day 12 where the chilled samples were unacceptable sensorily (Table 1).

Table.1 Physico-chemical changes in aerobically packed superchilled Chicken momos during storage

Treatment	Storage period (Days)									Treatment mean
	0	4	8	12	16	20	24	28	32	
	Moisture(%)									
T_1	62.67± 0.30$_a$	^{A}61.70± 0.26$_b$	^{A}60.85± 0.18$_c$	^{A}59.18± 0.16$_d$	^{A}58.04± 0.41$_{ef}$	^{A}58.37± 0.13$_f$	^{A}55.89± 0.31$_g$	^{A}54.53± 0.28$_{hi}$	^{A}53.91± 0.14$_i$	^{A}58.35± 0.40
T_2	62.67± 0.30$_a$	^{B}60.59± 0.33$_b$	^{B}55.76± 0.57$_c$	^{B}52.67± 0.18$_d$	Spoiled	-	-	-	-	-
T_3	62.67± 0.30$_a$	^{C}62.43± 0.14$_a$	^{C}62.07± 0.22$_a$	^{C}60.74± 0.14$_b$	^{B}60.43± 0.11$_{bc}$	^{B}59.12± 0.17$_d$	^{B}59.10± 0.22$_{de}$	^{B}58.22± 0.16$_f$	^{B}57.74± 0.26$_{fg}$	^{B}60.28± 0.25
Days mean	62.67± 0.17$_a$	61.57± 0.23$_b$	59.56± 0.69$_c$	57.53± 0.85$_d$	-	-	-	-	-	
	Protein (%)									
T_1	17.94± 0.20$_a$	17.88± 0.06$_{ac}$	17.84± 0.05$_{ac}$	17.80± 0.03$_{ab}$	17.79± 0.10a$_b$	17.6± 0.10$_{bcd}$	17.60± 0.08$_{bcd}$	17.48± 0.05$_d$	17.43± 0.06$_d$	17.71± 0.04
T_2	17.94± 0.20$_a$	17.78± 0.25$_{ab}$	17.65± 0.16$_a$	17.55± 0.11$_b$	Spoiled	-	-	-	-	-
T_3	17.94± 0.20	17.91± 0.12	17.86± 0.04	17.82± 0.06	17.79± 0.06	17.75± 0.06	17.73± 0.09	17.70± 0.09	17.66± 0.07	17.80± 0.03
Days mean	17.94± 0.11	17.86± 0.09	17.78± 0.06	17.72± 0.05	-	-	-	-	-	
	Fat (%)									
T_1	10.66± 0.01	10.65± 0.01	^{A}10.65± 0.01	^{AB}10.63± 0.01	10.64± 0.01	^{A}10.64± 0.01	^{A}10.65± 0.01	^{A}10.65± 0.01	^{A}10.65± 0.01	^{A}10.65± 0.01
T_2	10.66± 0.01$_a$	10.63± 0.02$_a$	^{B}10.60± 0.01$_b$	^{B}10.60± 0.01$_{bc}$	Spoiled	-	-	-	-	-
T_3	10.66± 0.01$_a$	10.65± 0.01$_a$	^{AC}10.64± 0.01$_a$	^{AC}10.64± 0.01$_a$	10.61± 0.01$_b$	^{B}10.55± 0.02$_{cd}$	^{B}10.54± 0.02$_{de}$	^{B}10.52± 0.01$_e$	^{B}10.48± 0.01$_f$	^{B}10.59± 0.01
Days mean	10.66± 0.01$_a$	10.64± 0.01$_{ab}$	10.63± 0.01$_b$	10.62± 0.01$_{bc}$	-	-	-	-	-	
	pH									
T_1	5.98± 0.01$_a$	^{A}6.02± 0.01$_b$	^{AC}5.99± 0.01$_a$	^{AC}6.02± 0.01$_{bc}$	^{A}6.09± 0.01$_d$	^{A}6.17± 0.01$_e$	^{A}6.21± 0.01$_f$	^{A}6.21± 0.01$_g$	^{A}6.25± 0.01$_h$	^{A}6.10± 0.01
T_2	5.98± 0.01$_a$	^{B}6.04± 0.01$_b$	^{B}6.16± 0.01$_c$	^{B}6.31± 0.01$_d$	Spoiled	-	-	-	-	-
T_3	5.98± 0.01$_a$	^{C}5.99± 0.01$_a$	^{C}5.99± 0.01$_a$	^{C}6.01± 0.01$_b$	^{B}6.05± 0.01$_c$	^{B}6.10± 0.01$_d$	^{B}6.12± 0.01$_e$	^{B}6.14± 0.01$_f$	^{B}6.19± 0.01$_g$	^{B}6.06± 0.01
Days mean	5.98± 0.01$_a$	6.02± 0.01$_b$	6.05± 0.02$_c$	6.11± 0.03$_d$	-	-	-	-	-	

Treatment	Storage period (Days)									Treat-ment mean
	0	4	8	12	16	20	24	28	32	
	TBA (mg malanoaldehyde/kg)									
T_1	0.30± 0.01$_a$	^{AC}0.32± 0.01$_{ab}$	^{AC}0.34± 0.01$_b$	^{AC}0.37± 0.01$_c$	0.39± 0.01$_{cd}$	0.44± 0.01$_e$	0.48± 0.01$_f$	^{A}0.55± 0.02$_g$	^{A}0.62± 0.01$_h$	0.42± 0.01
T_2	0.30± 0.01$_a$	^{B}0.39± 0.01$_b$	^{B}0.59± 0.01$_c$	^{B}0.66± 0.01$_d$	Spoiled	-	-	-	-	-
T_3	0.30± 0.01$_a$	^{C}0.32± 0.01$_{ab}$	^{C}0.33± 0.01$_b$	^{C}0.38± 0.01$_c$	0.38± 0.01$_{cd}$	0.42± 0.01$_e$	0.47± 0.01$_f$	^{B}0.52± 0.01$_g$	^{B}0.58± 0.01$_h$	0.41± 0.01
Days mean	0.30± 0.01$_a$	0.34± 0.01$_b$	0.42± 0.03$_c$	0.47± 0.03$_d$	-	-	-	-	-	
	Tyrosine (mg/100g)									
T_1	11.29± 0.31$_a$	^{AC}12.21± 0.28$_a$	^{AC}13.42± 0.21$_b$	^{AC}14.25± 0.20$_c$	^{A}14.96± 0.12$_d$	^{A}15.75± 0.37$_e$	^{A}16.88± 0.33$_f$	^{A}18.83± 0.41$_g$	^{A}23.21± 0.78$_h$	^{A}15.64± 0.48
T_2	11.29± 0.31$_a$	^{B}14.13± 0.58$_b$	^{B}18.54± 0.47$_c$	^{B}24.42± 0.62$_d$	Spoiled	-	-	-	-	-
T_3	11.29± 0.31$_a$	^{C}11.38± 0.42$_{ab}$	^{C}12.08± 0.30$_a$	^{C}12.38± 0.46$_b$	^{B}12.92± 0.46$_c$	^{B}13.04± 0.46$_d$	^{B}14.25± 0.50$_e$	^{B}14.75± 0.40$_f$	^{B}16.54± 0.68$_g$	^{B}13.18± 0.26
Days mean	11.29± 0.17$_a$	12.57± 0.37$_b$	14.68± 0.70$_c$	17.01± 1.31$_d$	-	-	-	-	-	

Values are Mean± S.E. of three replications (n=6)

Means ± S.E with different superscripts in a column (Capital letters) or row (Small letters) differ significantly (P < 0.05).

Table.2 Microbiological changes in aerobically packed superchilled chicken momos during storage

Treatment	Storage period (Days)									Treatment mean
	0	4	8	12	16	20	24	28	32	
	TPC (Log_{10}cfu/g)									
T_1	1.55± 0.69$_a$	^{AC}2.68± 0.54$_b$	^{AC}3.30± 0.11$_{bc}$	^{AC}3.70± 0.16$_{cd}$	3.92± 0.13$_{de}$	4.14± 0.13$_{ef}$	4.37± 0.11$_{fg}$	4.57± 0.05$_{ghi}$	4.83± 0.10$_i$	^{A}3.67± 0.16
T_2	1.55±0.69$_a$	^{B}3.59±0.08$_b$	^{B}4.58±0.05$_c$	^{B}5.02±0.06$_{cd}$	Spoiled	-	-	-	-	-
T_3	1.55± 0.69$_a$	^{C}2.10± 0.67$_{ab}$	^{C}2.72± 0.55$_b$	^{C}3.10± 0.06$_{bc}$	3.57± 0.20$_{cd}$	3.77± 0.08$_{de}$	4.03± 0.13$_{ef}$	4.36± 0.11$_{gh}$	4.47± 0.10$_h$	^{B}3.30± 0.18
Days mean	1.55±0.38$_a$	2.79±0.31$_b$	3.53±0.26$_c$	3.94±0.20$_d$	-	-	-	-	-	
	PPC (Log_{10}cfu/g)									
T_1	ND	ND	ND	ND	ND	2.68± 0.54$_a$	^{A}3.50± 0.07$_a$	^{A}3.53± 0.06$_{bc}$	3.69± 0.03$_{cd}$	^{A}1.49± 0.24
T_2	ND	ND	3.25± 0.10	3.71± 0.05	Spoiled	-	-	-	-	-
T_3	ND	ND	ND	ND	ND	ND	^{B}2.60± 0.52$_a$	^{B}2.65± 0.53$_a$	3.46± 0.06$_b$	^{B}0.97± 0.20
Days mean	ND	ND	1.08±0.37	1.24±0.42	-	-	-	-	-	
	Yeast and mold count (Log_{10}cfu/g)									
T_1	ND	ND	ND	ND	ND	ND	0.95± 0.60$_a$	1.90± 0.60$_{bc}$	2.03± 0.65$_c$	0.54± 0.16
T_2	ND	1.40± 0.63$_a$	1.93± 0.61$_{ab}$	2.68± 0.54$_b$	spoiled	-	-	-	-	-
T_3	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00
Days mean	-	-	-	-	-	-	-	-	-	

Values are Mean± S.E. of three replications (n=6)

Means ± S.E with different superscripts in a column (Capital letters) or row (Small letters) differ significantly (P < 0.05).

ND=Not Detected

Table.3 Sensory changes in aerobically packed superchilled chicken momos during storage

Treatment	Storage period (Days)								Treatment mean
	0	4	8	12	16	20	24	28	
	Overall palatability								
T_1	7.57± 0.12$_a$	^{AB}6.77± 0.12$_{bg}$	^{AC}6.77± 0.12$_{bgcf}$	6.53± 0.23$_{bd}$	6.67± 0.12$_{befg}$	6.40± 0.17$_{fdh}$	^{A}6.93± 0.15$_{ge}$	6.23± 0.21$_{hd}$	6.73± 0.06
T_2	7.57± 0.12$_a$	^{A}6.40± 0.14$_{bc}$	^{B}6.13± 0.24$_c$	Spoiled	-	-	-	-	-
T_3	7.57± 0.12$_a$	^{B}6.90± 0.13$_b$	^{C}6.90± 0.16$_c$	6.53± 0.23$_{dc}$	6.87± 0.13$_{ec}$	6.60± 0.11$_{fcg}$	^{B}6.40± 0.13$_{gdh}$	6.38± 0.20$_{hdf}$	6.77± 0.06
Days mean	7.57± 0.07$_a$	6.69± 0.08$_{bc}$	6.60± 0.11$_c$	-	-	-	-	-	

Treat-ment	Storage period (Days)								Treatment mean
	0	4	8	12	16	20	24	28	
	Appearance								
T_1	7.23± 0.15$_a$	6.97± 0.09$_{ab}$	7.13± 0.12$_{abc}$	6.87± 0.10$_{bc}$	6.87± 0.10$_{bc}$	6.87± 0.09$_{bc}$	7.07± 0.07$_{abc}$	6.80± 0.10$_c$	^{A}6.98± 0.04
T_2	7.23± 0.15$_a$	6.87± 0.11$_b$	6.87± 0.17$_b$	Spoiled	-	-	-	-	-
T_3	7.23± 0.15$_a$	6.97± 0.11$_{ab}$	6.80± 0.11$_{bc}$	6.87± 0.10$_{bd}$	6.73± 0.10$_{beh}$	6.90± 0.07$_{bfh}$	6.87± 0.09$_{bgh}$	6.77± 0.11$_{cdh}$	^{B}6.89± 0.04
Days mean	7.23± 0.08$_a$	6.93± 0.06$_b$	6.93± 0.08$_{bc}$	-	-	-	-	-	
	Flavour								
T_1	7.37± 0.16$_{ac}$	^{AC}6.93± 0.11$_{bc}$	^{AC}6.97± 0.09$_{cde}$	6.67± 0.14$_{bd}$	6.63± 0.11$_{beh}$	6.50± 0.14$_{bfe}$	6.50± 0.22$_{bge}$	6.30± 0.21$_{dh}$	6.73± 0.06
T_2	7.37± 0.16$_a$	^{B}6.40± 0.16$_b$	^{B}6.40± 0.24$_b$	Spoiled	-	-	-	-	-
T_3	7.37± 0.16$_a$	^{C}6.90± 0.18 $_{bc}$	^{C}6.77± 0.23$_{cd}$	6.67± 0.19$_{bde}$	6.80± 0.11$_{bce}$	6.80± 0.11$_{bce}$	6.60± 0.20$_{bfe}$	6.07± 0.20$_g$	6.75± 0.07
Days mean	7.37± 0.09$_a$	6.74± 0.09$_b$	6.71± 0.12$_{bc}$	-	-	-	-	-	
	Juiciness								
T_1	7.17± 0.19	^{A}7.28± 0.11	^{A}7.35± 0.10	^{A}7.53± 0.10	^{A}7.45± 0.10	^{A}7.42± 0.11	^{A}7.33± 0.09	^{A}7.47± 0.12	^{A}7.38± 0.04
T_2	7.17± 0.19$_a$	^{B}6.43± 0.15$_{bc}$	^{B}6.33± 0.27$_c$	Spoiled	-	-	-	-	-

T_3	7.17± 0.19$_a$	^{C}6.63± 0.16$_{bd}$	^{C}6.43± 0.28$_{bc}$	^{B}6.70± 0.15$_{dce}$	^{B}6.63± 0.09$_{bef}$	^{B}6.60± 0.16$_{bfd}$	^{B}5.77± 0.16$_g$	^{B}6.07± 0.16$_{hc}$	^{B}6.50± 0.07
Days mean	7.17± 0.11$_a$	6.78± 0.10$_b$	6.71± 0.15$_c$	-	-	-	-	-	
	Texture								
T	7.27± 0.14$_{ab}$	^{AC}6.90 ± 0.11$_a$	^{A}6.87± 0.10$_{bc}$	6.43± 0.19$_d$	6.43± 0.13$_d$	^{A}6.37± 0.16$_{de}$	6.57± 0.20$_{df}$	6.23± 0.17$_{dg}$	6.63± 0.06
T_2	7.27± 0.14$_a$	^{B}6.33± 0.15$_b$	^{B}6.07± 0.19$_{bc}$	Spoiled	-	-	-	-	-
T_3	7.27± 0.14$_{ac}$	^{C}6.83± 0.15$_{be}$	^{C}6.37± 0.23$_{cdg}$	6.43± 0.23$_d$	6.37± 0.14$_{cdg}$	^{B}6.87± 0.12$_e$	6.23± 0.15$_{fd}$	6.40± 0.16$_{dg}$	6.60± 0.07
Days mean	7.27± 0.08$_a$	6.69± 0.09$_b$	6.43± 0.11$_c$	-	-	-	-	-	

Values are Mean± S.E. of three replications (n=15)

Means ± S.E with different superscripts in a column (Capital letters) or row (Small letters) differ significantly (P < 0.05).

Thereafter TBA values in superchilling and frozen samples increased consistently throughout the storage period. However, this increase was significantly higher in superchilled samples as compared to frozen samples. The increase in TBA value during storage period was mainly attributed to the oxygen permeability of packaging material (Sen, 1996) and/or due to lipid oxidation (Strange *et al.,* 1977). Present findings were in agreement with the findings of Vanramhlimpuii (2015) in chicken *momo* stored at 4±1°C and Kanle (2017) for superchilled nuggets.

Similar pattern was also observed in tyrosine value of chilled, superchilled and frozen samples. The tyrosine value was significantly lower in frozen sample than superchilled samples throughout the study. However, it was consistently highest in chilled samples upto day 12 which might be due to intrinsic (autolysis) changes in chicken *momo* and bacterial action (Agnihotri, 1988; Dainty *et al.,* 1975; Strange *et.al.,* 1977). The findings of Vanramhlimpuii (2015) in chicken *momo* stored at 4±1°C and Kanle (2017) for superchilled nuggets also supported the present results.

Microbiological analysis

There was gradual increase in total plate count (TPC) of all the samples during entire storage period (Table 2). However, superchilled and frozen samples had significantly lower TPC than chilled samples upto day 12. This reduction in TPC of superchilled and frozen samples could be attributed to the temperature effect due to which microbes became dormant and did not multiply (Leygonie *et al.,* 2012) and in both the samples damage caused to the cells through the formation of ice crystals (Warris, 2010). A linear increase in total plate counts of chicken nuggets stored under superchilled and frozen conditions was also reported by Kanle (2017).

The Psychrophillic count (PPC) in chicken *momos* were absent in superchilled and frozen samples upto 16 days and in chilled samples upto 4 days. The PPC were recorded in superchilled sample on day 20 and onwards, which was significantly higher than frozen samples. This increase in Psychrophillic count 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). Similar trends were also reported by Rathod (2017) and Kanle (2017) for superchilled breast fillets and chicken nuggets respectively. The yeast and molds were not detected in chicken *momos* on day 0. However it was gradually increased in chilled sample from day 4 onwards while superchilled samples had the yeast and mold on day 24 onwards. This might be due to post processing contamination and handling. Das *et al.,* (2013) and Singh *et al.,* (2011) also reported similar results in chicken nuggets and chicken snacks, respectively. However, frozen sample did not reveal any yeast and mold count. Sutherland *et al.,* (1975) and Babji and Murthy (2000) also recorded very low yeast and mould counts during storage of beef and for minced goat meat at low temperature respectively.

Further, none of the samples revealed coliforms in chicken *momos* throughout the period of storage. It could be either due to the destruction of these bacteria during cooking at high temperature, much above their death point of 57°C or no contamination during post processing handling of chicken *momos*. Tanuja (2013) also reported similar findings who reported no coliform count for the chicken *momos* throughout storage study at chilling temperature. Similar results were also reported by Rathod (2017) in chicken breast fillets at superchilling temperature.

Sensory scores

It was observed that the sensory scores of appearance, juiciness and overall palatability were higher for superchilled samples than frozen samples throughout the study (Table 3). However overall palatability scores of superchilled samples significantly reduced on day 28 and the sample was subsequently spoiled on day 32 whereas chilled samples were spoiled on day 12. The sensory score of all samples were decreased gradually during entire storage period. Moreover, there was no significant variation in appearance of chicken *momo* in all treatments. The flavor scores increased marginally in superchilled samples during initial storage which were then reduced gradually by the end of storage. However this decrease in flavor scores of superchilled sample was non significant as compared to frozen sample. The juiciness and texture scores of superchilled samples were improved indicating beneficial effect of superchilling in stored products. In case of frozen product, juiciness was reduced significantly during storage period as compared to superchilled samples. Kanle (2017) also reported improvement in juiciness of chicken nuggets when stored under superchilling (2±0.5°C) temperature. Similarly, Olafsdottir *et al.,* (2006) also reported improvement in juiciness in superchilled cod during storage.

This improvement in overall palatability of superchilled sample was improved which could be due to improved juiciness and texture of the product. Similar results were also reported by Kanle (2017) in chicken nuggets and Olafsdottir *et al.,* (2006) in superchilled whole cod. Thus it was concluded that the chicken *momos* superchilled at -2±0.5ºC could be stored conveniently up to 28 days under aerobic conditions.

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