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Research Paper

Physico-Chemical, Microbiological and Sensory Properties of Chicken Meat Balls incorporated with Soy-Protein Concentrate

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ABSTRACT

The physico-chemical, microbiological and sensory parameters of soy protein concentrate (SPC) incorporated (10, 20 and 30%)chicken meat balls were studied at different storage intervals under refrigeration (4±1°C). Cooking yield and gain in weight was highest while shrinkage was less for 30% SPC added chicken meat balls, Proximate composition revealed an increased protein and ash percent and decreased ether extract with significant variation in moisture content with increased incorporation levels of SPC. TBA value decreased significantly while pH showed no significant variation with increasing levels of SPC. However,total viable counts, coliforms, yeast and mould were observed only on 7th day of storage. Moreover, all the three counts increased significantly ($p<0.05$) with the advancement of storage period. Sensory evaluation of meat balls (appearance, flavor, texture and juiciness) exhibited non significant variation up to 30% incorporation level of SPC. While over all acceptability for 20% SPC incorporated meat balls was significantly higher ($p<0.05$) when compared with other treatments. All sensory parameters decreased significantly ($p<0.05$) as the storage period progressed.

Keywords : *Soy Protein concentrate, Chicken meat balls, Cooking yield, Refrigerated storage*

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INTRODUCTION

Consumer demands for healthier meat products have increased recently. Meeting consumer demands is stimulating the development of meat products formulated with various amounts and types of healthier bioactive compounds. In this regards, several ingredients of plants and plant products such as oat, soy, wheat, sunflower and rosemary are commonly used in meat products formulations to provide beneficial components such as phytochemicals to improve product quality, enhanced binding properties and to reduce manufacturing cost (Pennington, 2002). Plant-based proteins are used as non-meat ingredients for bringing bioactive components into meat products (Jimenez-Colmenero, 2007). Soy proteins have an important role in human health since they are good source of essential amino acids. Soy protein also plays an important role for production of foods with health-enhancing activity. In addition to improving protein quantitatively and qualitatively soy proteins are effective for preventing cardiovascular disease, cancer and osteoporosis.Soy also contain another group of bioactive components such as isoflavones which is thought to be effective for reducing risk of cancer in women by binding estrogen receptors (Hasler, 1998; Arihara, 2006; Messina and Wood, 2008). In addition, contain a range of vitamins and minerals including vitamin A, vitamin B12, vitamin B2 (riboflavin) and vitamin D, as well as calcium, phosphorus and magnesium (Das *et al.* 2008). Thus, soy proteins are becoming one of the most commonly used non-meat ingredient in the meat industry (Feiner, 2006). Soy proteins can be obtained from soy flour, soy concentrate and soy isolate. There have been several studies about the effects of soy protein incorporation on quality of different types of meat products (Sofos and Allen, 1977; Dexter *et al.* 1993; Matulis *et al.* 1995; Feng *et al.* 2003; Lin and Mei, 2000). It was reported that the addition of soy proteins improves texture and moisture retention in meat products and provide a juicy and meaty mouth-feeling (Feiner, 2006). Interaction between myofibrillar and soy proteins during heating encourages the formation of agel matrix which improves the quality characteristics of meat products (Haga and Ohashi, 1984; Nagano *et al.* 1996; Feng and Xiong, 2002; Ramirez-Suarez and Xiong, 2003). An attempt has been made to incorporate SPC into chicken meat balls with an objective to investigate the effect of SPC incorporation on some quality characteristics of chicken meat balls.

MATERIALS AND METHODS

Method of manufacture of protein enriched chicken meat balls: Adult broilers of 14weeks of age were selected and slaughtered in the Department of Livestock Products Technology, College

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of Veterinary Science, Rajendranagar, adopting standard procedure. The carcasses were chilled and subsequently deboned and meat (lean) and fat were separated and packed separately in LDPE bags (150g) and frozen in a deep freezer at -18^{0}C ±5^{0}C.

Table1: Basic formula of protein enriched chicken meat balls

Ingredients	Control	T1	T2	T3
Lean Meat (Chicken)	85 parts	75 parts	65 parts	55 parts
Fat	15	15	15	15
Soy protein concentrate (SPC)	-	10	20	30
	100	100	100	100
Non meat ingredients				
Water %	10.00	10.00	10.00	10.00
Salt %	2.00	2.00	2.00	2.00
Sugar %	1.00	1.00	1.00	1.00
Phosphate %	0.30	0.30	0.30	0.30
Wet condiments Ginger + Garlic (2:1) %	3.00	3.00	3.00	3.00
Dry spice mix	1.75	1.75	1.75	1.75
Red chilli powder %	0.25	0.25	0.25	0.25
Binder (Refined wheat flour) %	3.00	3.00	3.00	3.00

The frozen chicken lean was thawed overnight and minced using 8 mm sieve followed by 4 mm sieve in a meat mincer (Sirrman, Model TC 12E). The minced meat was then used for making emulsion using a bowl chopper (MADO, Mod.No: TC 11, Germany) for the preparation of meat balls. Meat balls were prepared using the following above recipe.The meat balls thus prepared were analyzed for estimation of physicO chemical properties *viz.*, Cooking yield, pH, proximate composition, microbiological and organoleptic quality at weekly interval for a period of 21 days.

Estimation of cooking yield: The weight of samples was recorded before (raw weight) and after cooking of chicken meat balls. Percent cooking yield was determined by calculating differences in weight before and after cooking according to Murphy *et al.* (1975).

Estimation of pH: The pH of raw and cooked chicken meat balls were determined by homogenization of 10 g of sample with 90 ml distilled water using a tissue homogenizer (DaihanScientifics, WiseMix, HG-15D, Korea) for 1 min. The pH of suspension was recorded in a digital pH meter (Thermo Orion, Model 420A+, USA) (Trout *et al.* 1992) which was pre calibrated against buffer of pH 4, 7 and 10.

Estimation of proximate composition: The percent content ofprotein and total ash were determined in accordance with the procedure laid downby AOAC (2002). The crude fiber was determined according to the method of Prosky*et al.* (1988).

Estimation of moisture and fat retention: The moisture and fat retention values representing the amount of moisture and fat retained in the cooked product per 100 g of raw sample were calculated according to the procedure described by El-Magoli*et al.* (1996).

Thiobarbituric acid reacting substance (TBARS): Thiobarbituric acid reactive substance (mg malonaldehyde/kg) value was determined as per the method described by Witte *et al.* (1970).

Microbiological profile: Samples of Chicken meat balls (10 g) were grounded in a sterile pestleand mortar with 90 ml sterile 0.1% peptone water. Appropriate serial dilutions of samples were prepared in sterile 0.1%peptone water. The desired dilutions were inoculated in duplicates in appropriate media using pour plate method. The plates were incubated at appropriate temperatures for enumeration of Total plate count (TPC), Coliform counts, and Yeast and mould counts as per APHA (1984) and the counts were expressed aslog10 cfu/g.

Sensory evaluation: The cooked meat balls were subjected to organoleptic evaluation by subjecting to a sensory panel which consists of ten members of postgraduate students and faculty of department of Livestock Products Technology. Sensory attributes like color, flavor, juiciness, tenderness and overall acceptability of the soy protein enriched meat balls were evaluated using a 8 point hedonic scale (Keeton 1983) where 8 = extremely good and 1 = extremely poor.

Statistical analysis: Data obtained in the study was analysed statistically on 'SPSS-16.0' software package as per standard methods (Snedecor and Cochran 1994). Duplicate samples were drawn for each parameter and the experiment was replicated three times (n=6). Means for various parameters were analyzed using two-way ANOVA. Duncan's multiple range tests and critical difference were determined at the 5% significance level for comparing the means to find the difference between treatments and storage period.

RESULTS AND DISCUSSION

pH: The average pH value of meat balls was 6.14±0.04 (Table 2). It was observed that pH increased with addition of SPC into meat emulsion ($p<0.05$). However, pH differences among groups containing various levels of SPC were not significant statistically. An increase in pH due to SPC addition into meat product formulation was reported previously byRao*et al.*(1984). As expected, there was a strong correlation between meat ball pH and cooking loss. In general, pH of raw meat was significantly and positively correlated with moisture retention in the product.These results agree with the findings of Das *et al.* (2008). Cooking also increased pH in all the groups ($p<0.05$). Although, cooked meat ball samples with SPC had a higher pH than control ($p<0.05$), the differences were not significant statistically.

Cooking yield: Various vegetable proteins such as soy protein have been used in manufacture of meat products to enhance

Table 2: Mean ± S.E values of physico-chemicalcharacteristics of chicken meat balls incorporated with soy protein concentrate during refrigerated storage at (4±1ºC)

	Control	T1	T2	T3
pH				
	Control	T1	T2	T3
Day 0	6.14 ± 0.04	6.12 ± 0.02	6.17 ± 0.03	6.13 ± 0.01
Day 7	6.12 ± 0.06	6.14 ± 0.04	6.14 ± 0.04	6.16 ± 0.03
Day 14	6.10 ± 0.04	6.11 ± 0.02	6.18 ± 0.05	6.11 ± 0.03
Day 21	6.11 ± 0.05	6.17 ± 0.04	6.12 ± 0.07	6.10 ± 0.03
Cooking yield				
Day 0	$91.53^{a} \pm 0.48$	$94.82^{b} \pm 0.78$	$96.37^{bc} \pm 0.58$	$97.85^{c} \pm 0.35$
Proximate Composition				
Parameter	Control	T1	T2	T3
Moisture (%)	64.23b ± 0.40	64.20 b ± 0.55	61.90 a ± 0.63	61.05 a ± 0.38
Protein (%)	17.23± 0.37	18.45 ± 0.58	19.93± 0.40	20.17± 0.31
Fat (%)	11.52± 1.46	12.32 ± 1.36	12.58 ± 1.37	12.90± 0.87
Ash (%)	3.37 ± 0.28	3.63 ± 0.21	3.82 ± 0.25	3.73± 0.22
Dietary fibre (%)	1.19 a ± 0.03	1.36 b ± 0.01	1.43 c ± 0.02	1.93 d ± 0.01
TBARS Value (mg malonaldehyde/kg)				
Days	Control	T1	T2	T3
Day 0	0.16 ± 0.01	0.20 ± 0.01	0.18 ± 0.01	0.18± 0.02
Day 7	$0.33^{a} \pm 0.03$	$0.33^{ab} \pm 0.04$	$0.26^{a} \pm 0.03$	0.28 ± 0.04
Day 14	$0.41^{a} \pm 0.05$	$0.37^{a} \pm 0.04$	$0.32^{a} \pm 0.04$	0.35 ± 0.04
Day 21	$0.52^{a} \pm 0.03$	$0.52^{a} \pm 0.03$	$0.46^{a} \pm 0.11$	0.52 ± 0.18

Mean ± SE with different superscripts differ significantly ($P < 0.05$)

the products functional characteristics like improving cooking yield and slicability. In the present study, the addition of 10 and 20% SPC in meat ball formulation significantly reduced cooking loss ($p<0.05$) (Table 2). The lower cooking loss may be the result of an increased number of charged polar amino and carboxylic groups due to cleavage of peptidewhich leads to a stronger protein water interaction (Pena-Ramos and Xiong, 2003) and Kassama *et al.*(2003).

Proximate composition: Effect of hydrated SPC incorporation (10, 20 and 30%) on the moisture, protein, fat and ash content of chicken meat balls compared to the meat balls without SPC (control) is presented in (Table 2). No significant differences were observed in percent content of moisture, protein, ether extract and ash in both control and treatment groups. However there is a slight but non significant increase in protein and crude fat content of the treated products. Hydration of SPC (@ 1:2.5) might have a reduction of protein content from 60% to20% (Rakosky. 1974)whereas slight increase of protein contentcould be attributed to low levels of lean replacement with hydrated SPC (10, 20 and 30%) and it also increased the crude fat content in the chicken meat balls due to fat binding ability of SPC. Various authors reported non-significant differences in proximate composition of soy protein incorporated meat products *viz.*, Chicken sausages (Jindal and Bawa, 1988), and chicken meat patties Chowdhury*et al.*(1994).

Thiobarbituric acid reacting substance (TBARS): The effect of SPC incorporation on TBARS values of cooked meat balls stored at 4°C during 21 days of storage was ranged from 0.16 ± 0.01to 0.52 ± 0.18 mgmalonaldehyde per kg during 21 days of storage. In general, lipid oxidation increased during storage as indicated by increased TBARS values ($p<0.05$). However, TBARS values of meatballs with SPC were significantly lower than that of control during storage ($p<0.05$). The increase in the amount of added SPC in meatball formulation inhibited the lipid oxidation measured in terms of TBARS (Table 2). Pena-Ramos and Xiong (2003) reported that Soy protein Isolate (SPI) hydrolysates were effective in inhibiting lipid oxidation in cooked pork patties.

Microbial Quality: All microbial counts of chicken meat balls determined during refrigeration storage were low and can be categorized as satisfactory and within the acceptable values for cooked meat products as presented in (Table3) Soy protein extended products had slightly higher microbial counts than that of the control. This could be due to higher pH and available nutrients favourable for microbial growth. There was no significant change in total viable counts (TVC) during

Table 3: Mean ± S.E values of microbiological characteristics of chicken meat balls incorporated with soy protein concentrate during refrigerated storage at (4±1ºC)

		Total plate count (log10 cfu/g)		
Days	Control	T1	T2	T3
Day 0	$2.27^{ac} \pm 0.09$	$2.41^{ab} \pm 0.14$	$2.67^{a} \pm 0.14$	$2.96^{a} \pm 0.10$
Day 7	$3.84^{b} \pm 0.12$	$4.59^{c} \pm 0.20$	$4.23^{aC} \pm 0.20$	$3.45^{ab} \pm 0.16$
Day 14	$4.31^{b} \pm 0.08$	$4.33^{bc} \pm 0.20$	$3.78^{ba} \pm 0.14$	$3.79^{b} \pm 0.21$
Day 21	$4.46^{c} \pm 0.15$	$5.02^{b} \pm 0.13$	$4.40^{cd} \pm 0.14$	$4.86^{da} \pm 0.14$
		Coliforms (log10 cfu/g)		
Day 0	ND	ND	ND	ND
Day 7	ND	ND	ND	ND
Day 14	ND	ND	ND	ND
Day 21	ND	ND	ND	ND
		Yeast and mould (log10 cfu/g)		
Day 0	ND	ND	ND	ND
Day 7	$3.13^{ba} \pm 0.18$	$2.89^{b} \pm 0.23$	$1.73^{ab} \pm 0.57$	$1.81^{ab} \pm 0.58$
Day 14	$3.43^{cd} \pm 0.21$	$3.97^{dc} \pm 0.40$	$3.17^{cd} \pm 0.24$	$3.24^{cd} \pm 0.18$
Day 21	$3.24^{ba} \pm 0.41$	$3.98^{bc} \pm 0.10$	$3.44^{ba} \pm 0.13$	$3.45^{bc} \pm 0.06$

Mean ± SE with different superscripts differ significantly ($P < 0.05$)

the period ($p<0.01$) of storage. However, TVC of chicken meat balls had not exceeded the permissible level of microbial standards (log 106 cfu/g of sample) in cooked meat products as reported by Jay (1996). The yeast and mould counts were not detected on day 0 and thereafter following a significant ($p<0.05$) increasing trend with storage period, However the counts did not exceed the limit of 4.6 log cfu/g. The coliform counts were not present in the entire study. The occurrence of coliform counts during storage was very rare, indicating better sanitary measures adopted during processing. Das *et al.* (2008) also reported similar results.

Sensory evaluation: Meat balls samples were evaluated for appearance, flavor, juiciness, texture and overall acceptability. Sensory evaluationof meat balls showed that addition of SPC significantly affected some of the sensory attributes compared to control group (Table 4). The appearance scores weresignificantly different ($P<0.05$) at 0% to 10% except 20% and 30%. However, the value for appearance of 0% SPC inclusion was lowest while 20% washighest. In processing, colour has been identified as single most important factor of meat products which influences consumer perceptionof the product (Boles and Pegg, 2005). Meat ball prepared with 20%

Table 4: Mean ± S.E values of sensory attributes of chicken meat balls incorporated with soy protein concentrate during refrigerated storage at (4±1ºC)

		Appearance		
Days	**Control**	**T1**	**T2**	**T3**
Day 0	7.12±0.10	7.08±0.08	7.12±0.10	7.12±0.10
Day 7	7.00±0.08	7.00±0.08	7.06±0.08	7.04±0.08
Day 14	6.95^{a}±0.08	6.98 ±0.08	6.95±0.08	6.93±0.08
Day 21	6.81±0.11	6.90±0.08	6.81^{a}±0.11	6.81±0.11
		Flavour		
Day 0	7.02±0.07	6.98±0.09	7.00±0.09	7.01^{a}±0.09
Day 7	7.02±0.08	6.94^{a}±0.04	6.95±0.04	6.88±0.04
Day 14	6.98±0.07	6.90^{a}±0.12	6.90^{a}±0.12	6.83±0.12
Day 21	6.83^{ac}±0.09	6.86±0.09	6.88±0.09	6.80±0.09
		Juiciness		
Day 0	7.01 ± 0.31	7.33^{b} ± 0.15	7.97^{b} ± 0.14	7.49^{a}± 0.25
Day 7	6.72 ± 0.26	7.08^{a} ± 0.24	7.71^{c} ± 0.15	7.06^{a} ± 0.17
Day 14	6.56 ± 0.43	7.13 ± 0.35	7.68 ± 0.20	7.09 ± 0.17
Day 21	6.19^{a} ± 0.26	6.56 ± 0.23	7.11± 0.13	6.55 ± 0.18
		Texture		
Day 0	7.06^{a} ± 0.24	7.63 ± 0.12	7.86^{b} ± 0.08	7.50 ± 0.15
Day 7	6.61^{a} ± 0.32	7.16± 0.14	7.69^{c} ± 0.14	7.23^{b}± 0.16
Day 14	6.96^{ab} ± 0.39	7.17^{a} ± 0.22	7.56^{b} ± 0.14	7.25 ± 0.21
Day 21	6.40^{a} ± 0.44	6.62^{a} ± 0.29	7.07 ± 0.17	6.51^{a} ± 0.27
		Overall Acceptability		
Day 0	7.36^{b} ± 0.25	7.15^{a} ± 0.20	7.94^{b} ± 0.16	6.87^{a} ± 0.26
Day 7	6.93^{a} ± 0.22	6.89^{ab} ± 0.10	7.58^{c} ± 0.15	6.58^{a} ± 0.28
Day 14	6.92^{a} ± 0.25	7.08^{ab} ± 0.23	7.59^{bc} ± 0.23	6.51^{a} ± 0.41
Day 21	6.50^{ab} ± 0.30	6.72^{bc} ± 0.36	7.18^{bc} ± 0.36	5.75^{a}± 0.36

Mean ± SE with different superscripts differ significantly ($P < 0.05$)

SPC recorded the most desirable flavor ($p<0.05$) scores followed by samples with 10% SPC, 30% SPC and control respectively. Juiciness scores increased with addition of SPC in meatball formulation ($p<0.05$). Generally, the texturescores decreased though there were no significant difference between 10% and 20% SPC inclusion. 30% incorporation had thelowest texture score. The products were generally accepted. However, up to 20% SPC inclusion wasliked very much. In the study, results indicated that meat balls contained 10% and 20% SPC recorded higher for the overall acceptability scores by panelists ($p<0.05$). The overall acceptability scores of control were lower than the treatment groups.This may indicate that SPC inclusion up to 20% was acceptable. There were nosignificant differences between 0%, 10% and 20% SPC inclusion in terms of overall acceptability up to 20%inclusion of SPC in meatball formulation wouldtherefore be most appropriate in product preparation. There are several studies in agreement with our results. It was reported that addition of SPC up to 25% can be used in meat product preparation without affecting consumer acceptability Odiase *et al.*(2013).

CONCLUSION

The results showed that the soy protein concentrate incorporation into meat balls increased pH and decreased cooking loss. The addition of soy protein concentrate changed physical appearance and over all acceptability scores for meat balls. Sensory panel revealed that meat balls prepared with soy protein concentrate upto 20% were well accepted. The results of this study concluded that up to 20% soy protein concentrate addition into meat balls formulation may be applied to improve the quality of meat balls without any adverse effects on the final product.

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