JOURNAL OF PURE AND APPLIED MICROBIOLOGY, June 2016. Vol. **10**(2), p. 1341-1349

Effect of Clove Oil on the Oxidative Stability and Microbial Quality of Almond and Walnut Enriched Chevon Nuggets

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(Received: 15 March 2016; accepted: 20 April 2016)

The aim of this study was to evaluate the efficacy of clove oil on the oxidative stability and microbial quality of almond and walnut fortified chevon nuggets. The chevon nuggets were aerobically packaged in low density polyethylene pouches along with control and storage quality was evaluated for 21 days under refrigerated conditions (4±1°C). The products were analyzed for oxidative stability, microbiological and sensory parameters. A non significant (P>0.05) effect of clove oil was recorded on pH on day 0 of storage and pH values of all chevon nuggets increased significantly (P<0.05) at the progressive storage intervals. An increasing trend in FFA and TBARS values was observed in all preparations at the subsequent storage intervals but optimized chevon nuggets containing clove oil (0.1%) maintained a significantly (P<0.05) lower FFA and TBARS values throughout the storage period than other treatments. Clove oil (0.1%) treated preparations also recorded significantly lower total plate count, psychrotropic counts and yeast and mould counts than without clove oil preparations. The chevon nuggets without clove oil treatment showed deterioration on 14th day of refrigerated storage. However, clove oil treated nuggets were found acceptable upto 14th days of refrigeration storage (4±1°C).

Keywords: Chevon, Nuggets, Oxidative stability, Clove oil, Refrigerated Storage.

The constant rise of food borne infections is a consequence of consumption of food contaminated with bacteria and/or their toxins. This has initiated considerable research interest towards the discovery of potent antimicrobial agents. Today one more concern regarding food safety is presence of chemical residue in foods and the demand for non-toxic natural preservatives is increasing everyday because of harmful effects of food preservatives. The recent negative consumer perception against artificial preservatives, has led to a paradigm shift in the efforts towards the development of alternatives that consumers perceive as naturals (Kaur, 2015). Antimicrobial properties of herbs and spices have been recognized and used since ancient times for food preservation as well as in medicinal use (Zaika, 1988; Conner, 1993; Dorman, 2000). Clove oil is one of the plant based antioxidant used in the meat products. Cloves (*Syzygium aromaticum*) are the aromatic dried flower buds of a tree in the family *Myrtaceae* (Srivastava and Malhotra, 1991; Chaieb *et al*., 2007a). Cloves are used in Ayurveda, Chinese medicine and Western herbalism. The anti-mutagenic (Miyazawa & Hisama, 2003), anti-inflammatory (Kim *et al.*, 1998), antioxidant (Chaieb

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et al., 2007b), anti-ulcerogenic (Bae *et al*., 1998; Li *et al.*, 2005), anti-thrombotic (Srivastava & Malhotra, 1991) and anti-parasitic (Yang *et al.*, 2003) effect of cloves is well documented. Besides, clove extract is effective against almost all of the food borne microbes. *Staphylococcus aureus* is the most sensitive to clove extract and *Pseudomonas aeruginosa* is resistant (Gupta *et. al.* 2008). The inhibitory activity of clove is due to the presence of several constituents, mainly eugenol, eugenyl acetate, beta-caryophyllene, 2-heptanone (Chaieb *et al*., 2007b), acetyl- eugenol, alpha-humulene, methyl salicylate, iso-eugenol, methyl-eugenol (Yang *et al*., 2003), phenyl propanoides, dehydrodieugenol, trans-confireryl aldehyde, biflorin, kaempferol, rhamnocitrin, myricetin, gallic acid, ellagic acid and oleanolic acid (Cai & Wu, 1996). Considering the extensive proof of clove being an antioxidant and antimicrobial and more importantly being safe as a plant derived food preservative, the present study was conducted with an objective to evaluate the efficacy of clove oil in maintaining the oxidative stability and microbial quality of chevon nuggets treated with standardized levels of almond and walnut during refrigeration storage (4±1°C).

MATERIALS AND METHODS

Preliminary trials were conducted to optimize the levels of almond and walnut for the preparation of reformulated chevon nuggets. Based on preliminary trials 5% levels of almond and 10% levels of walnut were recorded as optimum for the preparation of almond and walnut enriched chevon nuggets. These optimized almond and walnut incorporated chevon nuggets were selected for storage study and oxidative stability and microbial quality was studied with and without addition of clove oil (0.1%).

Analytical procedures

pH

The pH of chevon nuggets was determined by the method of Keller *et al.* (1974) using a digital pH meter (Systronics Digital pH Meter 803).

Free fatty acid value and Thiobarbituric acid reactive substances (TBARS) value

Free fatty acid value was determined by method of US Army laboratories (Natick) described by Koniecko (1979). Thiobarbituric acid reactive substances (TBARS) value of cooked products during storage was determined as per Witte *et al.* (1970).

Microbiological profile

Total plate count, psychrophillic count, coliform count and yeast and mold count were determined by methods of APHA (1984).

Sensory Evaluation

The sensory evaluation of the products was carried for colour and appearance, flavour, juiciness, texture and overall acceptability by a panel of seven trained members based on a 8-point hedonic scale, wherein 8 denoted "extremely desirable" and 1 denoted "extremely undesirable" (Keeton *et al*., 1983).

Analysis

The results were analyzed statistically for analysis of variance and least significant difference tests as per Snedecor and Cochran (1980). In significant effects, least significant differences were calculated at appropriate level of significance for a pair wise comparison of treatment means.

RESULTS AND DISCUSSION

Storage studies

Oxidative stability

The mean values of various oxidative stability parameters of cooked chevon nuggets incorporated with 5% levels of almond and 10% levels of walnut with and without addition of clove oil (0.1%) along with control during refrigerated storage (4±1°C) are presented in Table 1.

pH

A non significant ($P>0.05$) effect of clove oil was recorded on pH on day 0 of storage. Clove oil treated almond and walnut enriched chevon nuggets recorded comparable pH values with respect to control. Again, during the subsequent days of refrigerated storage a non-significant ($P>0.05$) effect of clove oil treatment was observed on the pH. However, pH values of all chevon nuggets increased significantly ($P<0.05$) at the progressive storage intervals. A non-significant ($P>0.05$) effect of clove powder incorporation in chicken nuggets on pH during storage studies was also reported earlier by Kumar and Tanwar (2012). Koplay and Sezer (2013) recorded the same results of clove essential oil on shelf life of beef. The

increase in pH value during storage period suggests that, there was significant breakdown of meat protein on storage of the product. The increase in pH during storage is also reported elsewhere (Yadav and Sanyal, 1999).

Free fatty acid (FFA)

An increasing trend in FFA value was observed in all preparations at the subsequent storage intervals but optimized chevon nuggets containing clove oil maintained a significantly ($P<0.05$) lower FFA values throughout the storage period than other treatments.

The significant ($P<0.05$) increase in FFA content of meat products during storage might be due to growth of lipolytic microorganisms (Das, *et al*., 2008). Alasnier *et al.* (2000) studied lipolysis in muscle during refrigerated storage and reported that FFA formation is due to the breakdown of triglycerides and phospholipids. Sahoo and Anjaneyulu (1997) reported similar trend but with higher value of FFA content in buffalo meat nuggets. Similar trend was observed by Nayak and Tanwar (2004) and Nagamallika *et al.* (2006) in chicken patties. The decrease in FFA content in clove oil treated optimized chevon nuggets may be attributed to lesser lipolytic count in the product as reported earlier by Kumar and Tanwar (2010) in clove powder treated chicken nuggets.

Thiobarbituric acid reactive substances (TBARS) value (mg malonaldehyde/kg)

Clove oil (0.1%) recorded an appreciable influence on the TBARS values during our storage study. Optimized chevon nuggets treated with 0.1% clove oil maintained significantly ($P<0.05$) lower TBARS values throughout the storage period. However, TBARS values increased significantly ($P<0.05$) in all nugget preparations with the advancement of storage period irrespective of various treatments. On day 21st of storage TBARS values greater than 1 were recorded in products without clove oil treatment However, clove oil treated products maintained

Table 1. Effect of clove oil (0.1%) on the physico-chemical characteristics of chevon nuggets incorporated with optimum levels of almond and walnut aerobically packaged in LDPE films and stored in refrigerator. (Mean ±SE)*

Treatment	Storage period in days			
	0	7	14	21
pH				
Control	6.17 ± 0.027^{Aa}	6.26 ± 0.021^{Ab}	6.36 ± 0.015^{Ac}	6.47 ± 0.034^{Ad}
AL	6.20 ± 0.018^{Aa}	6.37 ± 0.022^{Cb}	6.48 ± 0.021^{Cc}	6.60 ± 0.020^{Cd}
ALC	6.19 ± 0.013^{Aa}	6.27 ± 0.013^{ABb}	6.37 ± 0.016^{Ac}	6.49 ± 0.012^{ABd}
WL	$6.20\pm .016^{Aa}$	$6.31\pm .107^{Bb}$	6.43 ± 0.010^{BCc}	6.53 ± 0.01^{Bd}
WLC	6.20 ± 0.021^{Aa}	6.27 ± 0.013^{Ab}	6.40 ± 0.014^{Ac}	6.51 ± 0.02^{Ac}
	TBARS (mg malonaldehyde/kg)			
CONTROL	0.347 ± 0.001^{Aa}	0.722 ± 0.002^{Ab}	1.03 ± 0.016^{Ac}	1.29 ± 0.016^{Ad}
AL	0.320 ± 0.008^{Aa}	0.709 ± 0.005^{Bb}	0.977 ± 0.020^{Ac}	1.22 ± 0.020^{Bd}
ALC	0.258 ± 0.016^{Ba}	0.375 ± 0.002^{Cb}	0.558 ± 0.014^{Bc}	0.698 ± 0.010^{Cd}
WL	0.335 ± 0.008^{Aa}	0.708 ± 0.005^{Bb}	$1.01\pm .032^{Ac}$	1.21 ± 0.020^{Bd}
WLC	0.253 ± 0.020^{Ba}	0.379 ± 0.001^{Cb}	0.566 ± 0.009^{Bc}	0.704 ± 0.011^{Cd}
	FFA(% oleic acid)			
Control	0.087 ± 0.001^{Aa}	0.127 ± 0.001^{Ab}	0.211 ± 0.001^{Ac}	0.363 ± 0.001^{Ad}
AL	0.071 ± 0.001^{ABa}	0.108 ± 0.004^{Bb}	0.198 ± 0.001^{Bc}	0.354 ± 0.001^{Bd}
ALC	0.038 ± 0.001^{Ca}	0.076 ± 0.000^{Cb}	0.132 ± 0.001^{Cc}	0.234 ± 0.001^{Cd}
WL	0.074 ± 0.001^{Ba}	0.116 ± 0.001^{Db}	0.201 ± 0.001^{Bc}	0.356 ± 0.001^{Bd}
WLC	0.040 ± 0.003^{Ca}	0.077 ± 0.001^{Cb}	0.134 ± 0.001^{Cc}	0.236 ± 0.001^{Cd}

*****Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly ($P<0.05$).AL= Optimized almond incorporated nuggets, ALC= optimized almond incorporated nuggets with clove oil(0.1%), WL= Optimized walnut incorporated nuggets WLC= Optimized walnut incorporated nuggets with clove oil(0.1%)

TBARS values lesser than 1 even on day 21 of storage. Saumya *et al.* (2006) in their studies reported that 0.1% was the optimum level at which clove can be used to significantly reduce TBARS values in ground beef. TBARS values greater than 1 are usually associated with rancid flavour/odour by sensory panelists (Tarladgis *et al.*, 1960; Jayasingh and Cornforth, 2003). Lower TBARS values in clove treated optimized product were due to antioxidant properties of clove oil. As reported earlier, clove powder at 0.2% w/w significantly ($P<0.05$) reduced oxidative rancidity measured by TBARS, and improved acceptability of oysters. The oysters remained acceptable for 278 days and 237 days when treated with cloves and untreated samples, respectively (Jawahar *et al.,* 1994). Clove oil has been shown to inhibit the increase of secondary oxidation products formed during refrigerated storage of cooked meat and to affect the extent of non-heme iron release during cooking, which is believed to be the primary catalyst accelerating lipid oxidation (Jayathikalan et al 1997). The antioxidant effect of clove has further been reported elsewhere (Gulcin *et al.,* 2004; Shobana and Naidu, 2000)

Microbiological characteristics

The mean values of various microbiological characteristics of cooked chevon nuggets incorporated with 5% levels of almond and 10% levels of walnut with and without addition of clove oil (0.1%) along with control during refrigerated storage (4±1°C) are presented in Table 2.

Table 2. Effect of clove oil (0.1%) on the microbiological characteristics ofchevon nuggets with optimum levels of almond and walnut aerobically packaged in LDPE films and stored in refrigerator. (Mean ±SE)*

Treatment	Storage Period In Days			
	0	7	14	21
		Total plate count(log_{10} cfu/g)		
Control	2.59 ± 0.082^{Aa}	3.64 ± 0.152^{Ab}	4.79 ± 0.145^{Ac}	6.33 ± 0.205^{Ad}
AL	2.67 ± 0.199^{Aa}	3.81 ± 0.177^{Ab}	4.48 ± 0.170^{Ac}	$6.02 \pm 0.0.093^{Ad}$
ALC	2.13 ± 0.075^{Ba}	2.48 ± 0.096^{Bb}	2.78 ± 0.138^{Bb}	3.20 ± 0.112^{Bc}
WL	2.66 ± 0.095^{Aa}	3.41 ± 0.143^{Ab}	4.65 ± 0.181^{Ac}	6.033 ± 0.191^{Ad}
WLC	2.09 ± 0.054^{Ba}	2.74 ± 0.091^{Bb}	3.00 ± 0.160^{Bb}	3.60 ± 0.142^{Bc}
		Psychrotrophic count (log_{10} cfu/g)		
Control	ND	ND	2.23 ± 0.141^{Aa}	2.33 ± 0.199^{ABa}
AL	ND	ND	2.34 ± 0.165^{Aa}	2.76 ± 0.168^{Aa}
ALC	ND	ND	1.56 ± 0.145^{Ba}	1.99 ± 0.197^{BCa}
WL	ND	ND	2.46 ± 0.302^{Aa}	2.78 ± 0.115^{Aa}
WLC	ND	ND	1.43 ± 0.315^{Ba}	1.68 ± 0.114^{Ca}
		Coliform count (log_{10}cfu/g)		
Control	ND	ND	ND	ND
AL	ND	ND	ND	ND
ALC	ND	ND	ND	ND
WL	ND	ND	ND	ND
WLC	ND	ND	ND	ND
		Yeast and Mould count (log_{10}cfu/g)		
Control	ND	ND	ND	2.17 ± 0.130^{A}
AL	ND	ND	ND	1.94 ± 0.209^{A}
ALC	ND	ND	ND	0.32 ± 0.080^{B}
WL	ND	ND	ND	2.25 ± 0.145^{A}
WLC	ND	ND	ND	0.311 ± 0.106^{B}

*Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly ($P<0.05$).AL= Optimized almond incorporated nuggets, ALC= optimized almond incorporated nuggets with clove oil(0.1%), WL= Optimized walnut incorporated nuggets WLC= Optimized walnut incorporated nuggets with clove oil (0.1%)

Total plate count (log cfu/g)

Total plate count recorded a progressive increase from day 0 to 21 in all preparations. This could be due to availability of the nutrients favourable for microbial growth. Similar results were obtained by Siddique *et al.* (2013) on quality and shelf life of fish sausage and fish balls prepared from Bombay duck and by Kumar *et al.* (2007) in chicken meat patties and according to them total plate count increased at each storage interval both in control and treatment patties. Singh *et al.* (2011) and Sagar Chand (2011) also reported an increase in total plate count at each storage interval in meat snacks.

However, total plate count of clove oil treated almond and walnut enriched chevon nuggets had comparable counts on day 7 and 14 days of storage period. Total plate count of clove oil treated optimized chevon nuggets were significantly ($P<0.05$) lower than other treatments during entire period of storage. Lower total plate count observed in chevon nuggets containing clove oil suggested antimicrobial properties of clove oil. Essential oils are capable of inducing

Table 3. Effect of clove oil (0.1%) on the sensory characteristics of chevon nuggets with optimum levels of almond and walnut aerobically packaged in LDPE films and stored in refrigerator. (Mean ±SE)*

Treatments	Storage period (days)			
	0	7	14	21
		Appearance		
Control	6.33±0.098^{Aa}	6.05±0.113^{Ab}	5.25±0.127^{Ac}	4.38±0.152^{Ad}
AL	6.89 ±0.088^{Ba}	6.36±0.094^{Bb}	5.74±0.137^{Bc}	4.76±0.185^{Ad}
ALC	7.06 ± 0.089^{Ba}	6.71 ± 0.108^{Cb}	6.22 ± 0.104^{Cc}	5.26±0.126^{Bd}
WL	6.92±.073^{Ba}	6.48±0.097^{BCb}	5.77±0.091^{Bc}	4.63±0.151^{Ad}
WLC	7.09 ± 0.077^{Ba}	6.64± 0.076^{BCb}	5.97±0.103^{BCc}	5.25 ± 0.123^{Bd}
		Flavour		
Control	6.75± 0.123^{ABa}	6.15± 0.148^{ABb}	3.97 ± 0.116^{Ac}	Not tasted
AL	7.07 ± 0.069^{Ca}	6.01 ± 0.083^{Ab}	4.64 ± 0.142^{Bc}	Not tasted
ALC	7.09 ± 0.096^{Ca}	6.44 ±0.095^{BCb}	4.75 ± 0.163^{Bc}	Not tasted
WL	6.61±0.112^{Aa}	5.98±0.092^{Ab}	3.82±0.118^{Ac}	Not tasted
WLC	6.96±0.102 ^{BCa}	6.58 ± 0.119^{Cb}	4.93 ± 0.117^{Bc}	Not tasted
		Texture		
Control	6.61 ± 0.136^{Aa}	6.30 ± 0.119^{Aa}	6.26±0.121^{Aa}	5.13 ± 0.135^{Ab}
AL	6.75 ± 0.107^{Aa}	6.41 ± 0.138^{Aab}	6.15±0.162^{Ab}	5.53 ± 0.113^{Bc}
ALC	6.80 ± 0.095^{Aa}	6.34 ± 0.138^{Ab}	5.87±0.137^{ABc}	5.70± 0.121^{Bc}
WL	6.71±0.069^{Aa}	6.27±0.113^{Ab}	6.01±0.124^{ABb}	5.60±0.121^{Bc}
WLC	6.53 ± 0.136^{Aa}	6.03 ± 0.174^{Ab}	5.71±0.157^{Bbc}	5.54 ± 0.153^{Bc}
		Juiciness		
Control	6.39 ± 0.096^{Aa}	6.00 ± 0.079^{Ab}	5.76±0.093^{ABb}	Not tasted
AL	6.76 ± 0.095^{Ba}	6.11± 0.062^{ABb}	5.77±0.111^{ABc}	Not tasted
ALC	6.99± 0.089^{BCa}	6.41 ± 0.095^{Ca}	5.98 ± 0.077^{Ba}	Not tasted
WL	6.92 ±0.090^{BCa}	6.08 ±0.091^{ABb}	5.62 ±0.108^{Ac}	Not tasted
WLC	7.05 ± 0.080^{Ca}	6.32±0.088^{BCb}	5.90±0.092^{ABc}	Not tasted
		Overall acceptability		
Control	6.48 ± 0.108^{Aa}	6.03 ± 0.081^{Ab}	5.30±0.145^{Ac}	3.78 ± 0.05^{Ad}
AL	6.82 ± 0.059^{Ba}	6.33± 0.071^{BCb}	5.22±0.135^{Ac}	4.34 ± 0.165^{Bd}
ALC	7.10 ± 0.069^{Ba}	6.54 ± 0.070^{Cb}	6.03± 0.060^{Bc}	4.97 ± 0.188^{Cd}
WL	6.9 ± 0.065^{ABa}	6.30 ±0.076^{Bb}	5.19±0.121^{Ac}	4.37 ±0.171^{Bd}
WLC	7.08 ± 0.065^{Ba}	6.54 ± 0.070^{Cb}	6.10± 0.070^{Bc}	5.05 ± 0.169^{Cd}

*****Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly ($P<0.05$).AL= Optimized almond incorporated nuggets, ALC= optimized almond incorporated nuggets with clove oil(0.1%), WL= Optimized walnut incorporated nuggets WLC= Optimized walnut incorporated nuggets with clove oil(0.1%)

bacterial cell lysis, damaging both cell wall and membrane (Rhayour *et al.,* 2003). The antimicrobial activity of clove was also reported earlier by Abdel Moneim *et al.* (2007), Arora and Kaur (1999), Yadav (2005) and Rajkumar and Berwal (2003). Rakshit and Ramalingam (2010) reported higher antibacterial activity of clove even at the temperatures as high as 360 ^{0}C which provides the explanation that cooking temperature of chevon nuggets does not alter the bioactive constituents of clove oil.

Psychrotropic count (log cfu/g)

Psychrotrophs were not detected on day 0 and 7 days in any of the preparations of chevon nuggets. But it was observed on day 14 in all clove treated groups, without clove treated groups as well as control and the count increased at day 21 of refrigeration storage. Clove oil treated optimized chevon nuggets maintained significantly ($P<0.05$) lower counts both at day 14 and 21 days of storage period. This appearance of Psychrotrophs after such a long gap might be caused by sufficient heat treatment during cooking, which drastically injured and killed the psychrotrophic population (Jay, 1996) reducing the number of surviving injured and resistant ones to a non countable limits. A detectable count on day 14 onwards while nil on preceding observations might be attributed to the fact that bacteria generally need some lag phase before active multiplication is initiated (Jay, 1996). A gradual increase in psychrotrophic counts during storage of meat products had earlier been reported by Sen (1993), Nag (1998) and Kalaikanan (1998). Naveena *et al.* (2006) in their studies also reported significantly ($P<0.05$) lower psychrotropic count in clove oil treated buffalo meat steaks. De Oliveira *et al.* (2013) reported a significant ($P<0.05$) activity of clove oil against *Listeria monocytogenes*, a commonly found meat spoiling psychrotroph during storage.

Coliform count (log cfu/g)

No coliform colonies were detected in any of the preparations on any interval of storage period. The absence of coliforms during storage depicts that heat processing and subsequent hygienic handling and packaging was effective to control coliform growth in chevon nuggets. Bhat *et al*. (2015) reported that presence of high concentration of coliforms in food is indicative of failures during processing, heat treatment or inadequate hygiene.

Yeast and mould count (log cfu/g)

The yeast and mould count was detected on day 21. Clove oil treated optimized chevon nuggets maintained significantly ($P<0.05$) lower counts than other preparations. The yeast and mould count in control was comparable to walnut and almond enriched chevon nuggets without clove oil incorporated in them. The detection of yeast and mould counts on day 21st possibly could be due to contamination which might have occurred during post processing. Singh *et al.* (2011) reported that yeast and mold appeared during the last day of storage of chicken snacks due to the availability of nutrients in meat. The activity of clove oil against Yeast (*Candida albicans*) and moulds (*Rhizopus nigricans*) has previously been indicated by Abdel Moneim *et al*. (2007). Arora and Kaur (1999) also reported anti-yeast activity of clove oil extract. The inhibitory effect of clove on toxigenic mould has been also reported by Rajkumar and Berwal (2003).

Sensory parameters

Mean sensory scores of aerobically packaged clove oil (0.1%) treated walnut and almond enriched optimized chevon nuggets along with respective controls are presented in the table 14. Appearance and colour, flavour, juiciness and overall acceptability decreased significantly ($P<0.05$) with the advancement of storage period in all preparations. However, the reduction in appearance and colour value in clove oil treatments was significantly ($P<0.05$) lower than other preparations on day 7 and day 21 of storage. In clove oil treated nuggets, texture scores remained unaffected statistically. Juiciness scores in clove treated almond enriched chevon nuggets were recorded comparable to control on day 7 and 14. Clove treated nuggets scored significantly ($P<0.05$) higher in overall acceptability than other preparations at all storage intervals except on day 0. The better appearance and colour scores in clove oil treated optimized chevon nuggets at later stage of storage might be attributed to slight reddish tint imparted by clove oil. Previously, similar effects on sensory parameters due to incorporation of clove powder in chicken nuggets have been reported (Kumar and Tanwar, 2012). Decrease in flavour scores during the subsequent storage intervals might be due to development of oxidative rancidity and microbial deterioration. Biswas *et al.*

(2006) also reported that all sensory quality values decreased significantly with the advancement of storage period. Further, in support to the present results, Saumya *et al.* (2006) reported that clove treatment effectively lowered ($P < 0.05$) rancid odour and rancid flavour of stored, cooked ground beef samples compared with control. The control samples without added clove had the highest scores for rancid odour and flavour intensity. Naveena *et al.* (2006) reported that clove in combination with lactic acid and Vitamin C maintained significantly ($P<0.05$) higher hunter colour values during display and there was improvement in sensory colour and odour as well.

CONCLUSIONS

The present study showed that in the preparation of chevon nuggets, clove oil (0.1%) can be used in meat emulsion with beneficial effects on oxidative and microbiological qualities of the product. Addition of clove oil (0.1%) in optimized chevon nuggets depicted significantly ($P < 0.05$) lower microbial profile, TBARS, FFA values and better sensory acceptability on 14st day of refrigeration storage (4 ± 1^0C).

ACKNOWLEDGEMENTS

The authors wish to express sincere thanks to the Dean, F.V.Sc and A.H. SKUAST Jammu for providing the support and technical assistance in completion of this study.

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