J.Meat Sci., 2011, 7(1) : 17-22 Research Paper

Effect of Carrot and Sweet Potato on the Storability of Chicken Nuggets during Refrigeration Storage

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ABSTRACT

Chicken meat nuggets were prepared with ground raw carrot (10%) and mashed sweet potato (10%), individually aerobic packaged and stored at 4±1°C. Samples were evaluated for pH, free fatty acid (FFA) contents, 2-thiobarbituricacid reacting substances (TBARS), microbiological quality and sensory profiles at 5 days intervals during 25 days storage. Nuggets formulated with carrot and sweet potato affected ($P<0.05$) pH between control and treated samples. For each kind of sample, the pH values decreased ($P<0.05$) with storage days. Lipid oxidation products (FFA contents and TBARS numbers) though increased with the increase of storage days, they were well below the acceptable limits at the end of the storage. Control samples had highest TBARS values. Both the formulated samples had a positive impact on product safety and quality, in respect to microbiological and sensory quality. In general, carrot and sweet potato is helpful to prevent lipid oxidation, improving microbiological quality as well as sensory attributes of the chicken nuggets.

Key words: *Lipid oxidation, carrot, sweet potato, chicken nuggets.*

INTRODUCTION

Precooked meat products are susceptible to lipid oxidation, which leads to rapid formation of rancid or stale flavor, denoted as warmed-over flavor (WOF). Lipid oxidation in meat products is initiated when polyunsaturated fatty acids react with molecular oxygen, via free radical chain mechanism, forming peroxides which adversely affect quality and safety (Gray, 1978). It is now established fact that addition of salt or grinding of meat greatly influences the lipid oxidation of finished products.

Inclusion of raw carrot and sweet potato to chicken meat products could help in retardation of lipid per-oxidation process besides their inherent functional properties. The antioxidant activity of these components is due to presence of vitamin C and E, carotenoids (mainly â-carotene), glutathione, flavonoids and phenolics, as well as other unidentified compounds (Eberhardt et al., 2000). Flavonoids are effective antioxidants because of their scavenging properties, chelators of metal ions and may protect tissues against free oxygen radicals and lipid per-oxidation. In contrast to anti-oxidative properties, addition of carrot in meat products affects the sensory properties during storage (Eim et al., 2008). The present study was envisaged to investigate the effects of raw carrot and sweet potato on lipid stability, microbial quality and sensory properties of chicken nuggets.

MATERIALS AND METHODS

Preparation of carrot paste and mashed sweet potato: The raw carrot after thorough cleaning were manually washed with clean water and peeled off outer most thin layer by using a knife. The peeled off carrots were then sliced and made into a paste in a spice grinder. The clean and washed sweet potato was boiled for 5 min, cooled to room temperature, and then peeled off to make fine paste.

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Preparation of chicken nuggets: Meat of spent male broilers was minced twice through an 8 mm plate followed by 6 mm plate in a meat mincer. The ground meat was divided into three different batches. The first batch (control), contained neither carrot nor sweet potato. The second and third batches consisted of ground raw carrot and mashed sweet potato at 10% level each. Ingredients were weighed and added on the basis of meat emulsion. All batches of minced meat samples were mixed separately with other ingredients (Table 1) in an Inalsa food mixer/ grinder for 1 min. Salt and tetra sodium pyrophosphates were added first and egg white and refined vegetable oil were added slowly at the time of mixing. Sugar was not added in treated samples because both carrot and sweet potato contained high amount of sugar residues in them. After complete mixing, emulsions were filled up in rectangular shape aluminium moulds, cooked in an autoclave at 15lb pressure (121°C) for 20 min. The cooked molds were cooled to room temperature, packed in colourless low density polyethylene bags (150-200 gauges, 83 × 63), sealed and then kept at 4±1°C temperature before slicing them into nuggets. The nuggets samples were packaged aerobically in polyethylene pouches and stored at refrigerated temperature (4±1°C).

Table 1. Formulation of chicken meat nuggets incorporated with raw carrot and mashed sweet potato

	Control	T_1	T_2
Minced chicken meat	1139.07	996.57	996.57
Carrot /sweet potato paste	-	150	150
Textured soy protein (TSP)	75	75	75
Refined vegetable oil	75	75	75
Refined wheat flour (Maida)	60	60	60
Liquid egg white	45	45	45
Condiments	45	45	45
Spice mix	26.25	26.25	26.25
Table salt	24	24	24
Sugar	7.5	-	-
Tetra sodium pyrophosphates	3	3	3
Sodium nitrite	0.18	0.18	0.18

Control= without carrot or sweet potato; T_1= Carrot, 10% ; T_2= Sweet potato, 10%

Three separate batches of nuggets were prepared for analysis of all quality parameters.

Analytical procedure: The pH of cooked nuggets was measured with a digital (Elico make, Model: LI 127) pH following Trout et al.(1992). Lipid stability was measured using TBARS test of Witte et al. (1970) with suitable modifications. TBA value was expressed as mg malonaldehyde per kg of sample by multiplying O.D. with K factor 5.2. The free fatty acid (FFA) content was determined following the method as described by Koniecko (1979).

Conventional methods recommended by American Public Health Association (1984) were used to enumerate microbial lead of nugget samples. Standard plate counts were determined on Plate Count Agar (PCA), Coliforms on Violet Red Bile Agar, and *Staphylococcal* spp. were counted on Baird Parker Agar. In all cases, plates were incubated at 37 ± 2 °C for 48 hrs. Psychrotrophic plate counts were determined on PCA, and the plates were incubated at 4 ± 1°C for 14 days. Yeast and moulds were determined on Potato Dextrose Agar and plates were incubated at 25±2°C for 7 days. Pour plate methods in duplicate were used to analyze the samples. Cultural media were from HiMedia, Mumbai, India. Samples were analyzed at 5 days interval and experiment was repeated three times (n=6).

Sensory evaluation: Nuggets were evaluated by a seven member experienced panel of judges consisted of teachers and postgraduate students of College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University for appearance and colour, texture, flavour, juiciness and overall acceptability using 8 point descriptive scale (Keeton, 1983), where 8=extremely desirable and 1=extremely undesirable. Potable water at room temperature was provided to clean the palate between samples. The tests were carried out one hour before or two hours after the midday meal.

Statistical analysis: Data were analysed by two way analysis of variance (ANOVA) with Duncans

multiple range tests using SPSS-12.0 software packages as per standard methods (Snedecor & Cochran, 1994). Statistical significance was expressed at the 5% level.

RESULTS AND DISCUSSION

pH: Chicken meat nuggets formulated with carrot and sweet potato significantly (P<0.05) reduced the pH of treated samples as compared to the control (Table 2). On the other hand, for each kind of sample, pH value decreased (P<0.05) in all the samples as storage time increased. Amongst the treated samples, differences in pH value were significant (P<0.05) up to day 15. Similar observations were also reported by Devatkal et al. (2004) in buffalo meat loaves added with carrot paste.

Free fatty acids (FFA): The FFA content of control samples containing carrot and sweet potato increased as the storage progressed but differences were not significant (P>0.05) up to day 10 (Table 2). However, the FFA values were well within the acceptable limit (Das et al., 2008). Sahoo and Anjaneyulu (1997) reported similar trend but with higher value of FFA content in buffalo meat nuggets.

TBARS value: TBARS values are indicator for development of oxidative rancidity in meat products. Initial TBARS value indicated no differences (P>0.05) among formulations (Table 2). In general, TBARS values for all treatments increased during storage. Control, as well as sweet potato incorporated samples, had higher TBARS value than carrot incorporated products, but significant differences were observed only after 10th day of storage. A general trend of increased TBARS value during refrigerated and frozen storage of meat products had been reported (Devatkal et al., 2004). The results obtained in the present study were within the acceptable limits. The threshold value of TBARS is around 1-2 mg malonaldehyde per kg of meat as reported by Witte et al. (1970). Among the three types of chicken nuggets, lower TBARS value was observed in treated products as compared to control which might be attributed to antioxidant activity of carotenoids present in carrot and sweet potato. Similarly, Pizzocaro et al. (1998) reported that addition of 2% carrot and 10% spinach improved the oxidative stability of poultry hamburgers.

Microbial quality: Microbiological evaluation was performed until day 25 (Table 3). Non-significant differences were found between control and vegetable (carrot and sweet potato) formulated samples with regards to standard plate counts. For both type of samples, significant increase (P<0.05)

Table 2. Effect of carrot and sweet potato on the pH, FFAs and TBARS values of chicken nuggets during refrigeration (4±1ºC) storage

	Storage days					
Parameter	**0**	**5**	**10**	**15**	**20**	**25**
				pH		
Control	6.23^{dA}±0.011	6.11^{cdB}±0.011	6.04^{dB}±0.014	5.97^{cA}±0.007	5.86^{bA}±0.009	5.63^{aB}±0.016
RC (10%)	6.18^{dA}±0.014	6.08^{cAB}±0.062	6.01^{cA}±0.007	5.96^{cA}±0.015	5.80^{bA}±0.011	5.43^{aA}±0.017
MSP (10%)	6.14^{dA}±0.018	6.11^{cB}±0.008	6.04^{aA}±0.015	5.91^{bA}±0.008	5.80^{bA}±0.008	5.39^{aA}±0.022
				Free Fatty Acid		
Control	0.095^{aAB}±0.002	0.099^{aA}±0.002	0.101^{abA}±0.005	0.106^{bA}±0.001	0.167^{cA}±0.001	0.223^{dA}±0.002
RC (10%)	0.093^{aA}±0.008	0.095^{aA}±0.004	0.095^{aA}±0.004	0.103^{bA}±0.002	0.166^{cA}±0.001	0.234^{dB}±0.003
MSP (10%)	0.095^{aB}±0.009	0.096^{aA}±0.005	0.096^{aA}±0.002	0.104^{bA}±0.001	0.167^{cA}±0.003	0.231^{dB}±0.004
				TBARS value		
Control	0.148^{aA}±0.014	0.163^{aA}±0.011	0.208^{abB}±0.05	0.260^{bA}±0.18	0.317^{bB}±0.074	0.435^{dC}±0.006
RC (10%)	0.124^{aA}±0.012	0.141^{aA}±0.020	0.142^{aA}±0.030	0.248^{bA}±0.015	0.267^{bA}±0.012	0.321^{bA}±0.014
MSP (10%)	0.149^{aA}±0.06	0.182^{aA}±0.011	0.185^{aA}±0.014	0.244^{bB}±0.01	0.261^{bA}±0.014	0.377^{dB}±0.009

Mean with different superscripts (small case letters row wise, upper case letter column-wise) differ significantly at (P<0.05).
Control=without addition RC or MSP, RC= Raw carrot and MSP=Mashed sweet potato.

Table 3. Effect of carrot and sweet potato on microbiological qualities* of chicken nuggets during refrigeration (4±1ºC) storage

	Storage period(days)					
Treatment	**0**	**5**	**10**	**15**	**20**	**25**
			Standard Plate Count (log_{10}cfu/g)			
Control	1.76±0.56^{a}	1.97±0.39^{a}	3.03±0.29^{b}	3.47±0.28^{bc}	4.60±0.39^{cd}	5.08±0.34^{d}
RC (10%)	1.70±0.54^{a}	2.03±0.41^{a}	2.64±0.57^{ab}	3.48±0.30^{bc}	4.56±0.13^{cd}	4.85±0.35^{d}
MSP (10%)	1.69±0.52^{a}	1.99±0.54^{a}	2.73±0.57^{a}	3.48±0.21^{b}	4.38±0.15^{cd}	4.82±0.25^{d}
			Psychrotropic plate count (log_{10}cfu/g)			
Control	N.D	N.D	2.25±0.03^{a}	2.50±0.19^{a}	3.07±0.17^{b}	3.25±0.01^{b}
RC (10%)	N.D	N.D	2.21±0.03^{a}	2.22±0.04^{a}	2.29±0.48^{a}	3.16±0.05^{b}
MSP (10%)	N.D	N.D	2.39±0.11^{a}	2.19±0.04^{a}	2.45±0.17^{a}	2.87±0.21^{b}

Means with different superscripts row -wise indicated significant difference (P<0.05).
Control=without addition of RC or MSP, RC= Raw carrot and MSP=Mashed sweet potato.

of standard plate count was found as storage days progressed. But differences were non-significant from day 0 to day5. The highest standard plate counts were observed in control samples. Psychrotrophic plate counts (PPC) were not detected during initial period of storage up to day 5. The counts were increased with increase of storage periods but differences were significant (P<0.05) only after 15th and 20th days of storage in control and treated products, respectively. Total coliforms, *Staphylococcus* spp. and Yeast and mold counts were not detected at any point of storage. The absence of these groups of bacteria during entire storage periods might be due to destruction of microbes during cooking as nuggets were cooked at temperature of 121ºC, at 15 psi for 20 min. Good hygienic conditions at the time of processing as well as careful post processing handling might be responsible for absence of all these organisms.

Sensory attributes: Addition of raw carrot and boiled sweet potato in the formulation significantly (P<0.05) affected sensory attributes of chicken nuggets. At initial day of storage, nuggets formulated with sweet potato had higher (P<0.05) colour and appearance score as compared to control (Table 4). The colour and appearance values decreased linearly and significantly at each storage interval up to day 15, but differences were non- significant among control and carrot formulated samples. Decrease in colour scores with advancement of storage days could be attributed to non-enzymatic browning reaction between lipid oxidation products and amino acids (Che Man et al., 1995). At the end of the storage, control had higher appearance and colour scores, and this could be attributed to rapid decrease in moisture content of the treated nuggets, which caused more myoglobin concentration in meat products. In general, flavor score decreased significantly and linearly with increase in storage period and off-flavour were detected on 25th day of storage. Control samples exhibited higher flavor score compared to treated products. The reduction of flavour score during storage could be attributed to the increased lipid oxidation, liberation of fatty acid and increased microbial load (Sahoo and Ajaneyulu, 1997). The control samples were juicier and release more moisture on first bite, and as the storage day progresses, all the products become drier. Lower juiciness in formulated products might be attributed due to reduction of fat content by the addition of carrot and sweet potato. The textural score for control and treated nuggets significantly decreased on 5th day onwards, however, treated nuggets had textural score as good as control nuggets. Eim et al. (2008) reported addition of more than 3% carrot fiber in sobrassada (dry

Table 4. Effect of carrot and sweet potato on the sensory attributes* of chicken nuggets under refrigeration (4±1°C) storage

Treatment	Storage period (Days)					
	0	5	10	15	20	25
			Colour and Appearance			
Control	7.28±0.09 ^{cB}	6.78±0.07 ^{bA}	6.78±0.05 ^{bA}	6.71±0.06 ^{bA}	6.71±0.07 ^{bB}	6.14±0.06 ^{a}
RC (10%)	7.16±0.05 ^{dA}	7.07±0.09 ^{cB}	6.97±0.07 ^{cB}	6.95±0.06 ^{cB}	6.41±0.05 ^{bA}	6.04±0.06 ^{a}
MSP (10%)	7.45±0.10 ^{eC}	7.32±0.09 ^{dC}	7.04±0.07 ^{cB}	6.50±0.06 ^{bA}	6.47±0.05 ^{bA}	5.95±0.06 ^{a}
			Flavour			
Control	7.36±0.06 ^{dB}	7.28±0.06 ^{cB}	7.11±0.06 ^{cB}	6.42±0.06 ^{b}	6.26±0.06^{aA}	6.21±0.06^{aB}
RC (10%)	7.21±0.06^{dA}	7.19±0.06^{dA}	6.73±0.06^{cA}	6.65±0.06^{ab}	6.54±0.06^{bB}	6.02±0.06^{aA}
MSP (10%)	7.11±0.06^{cA}	6.91±0.05 ^{A}	6.75±0.05^{bcA}	6.43±0.04 ^{b}	6.26±0.04^{aA}	6.14±0.05^{aA}
			Texture			
Control	7.41±0.06^{eA}	7.16±0.06^{dA}	6.86±0.06 ^{c}	6.65±0.05^{c}	6.41±0.06^{b}	6.01±0.05^{a}
RC (10%)	7.45±0.05^{eB}	7.21±0.05^{dA}	6.95±0.05 ^{c}	6.71±0.05^{b}	6.59±0.05^{b}	6.12±0.05^{a}
MSP (10%)	7.50±0.04^{eB}	7.41±0.04^{dB}	6.98±0.04 ^{c}	6.68±0.05^{b}	6.49±0.04^{b}	6.09±0.05^{a}
			Juiciness			
Control	7.30±0.06^{dA}	7.07±0.06^{c}	6.80±0.05 ^{b}	6.76±0.07^{b}	6.51±0.05^{b}	6.11±0.05^{aA}
RC (10%)	7.28±0.05^{dA}	7.01±0.05^{c}	6.79±0.05 ^{b}	6.66±0.05^{b}	6.59±0.05^{b}	6.21±0.05^{aB}
MSP (10%)	7.23±0.05^{dB}	7.01±0.04^{c}	6.78±0.06 ^{b}	6.64±0.05^{b}	6.58±0.06^{b}	6.18±0.05^{aA}
			Overall Acceptability			
Control	7.28±0.05 ^{c}	7.14±0.05 ^{c}	6.86±0.05 ^{b}	6.76±0.05 ^{b}	6.65±0.05 ^{b}	6.04±0.05 ^{a}
RC (10%)	7.21±0.04 ^{d}	7.14±0.04 ^{d}	6.91±0.05 ^{c}	6.71±0.05 ^{b}	6.61±0.03 ^{b}	6.14±0.03 ^{a}
MSP (10%)	7.31±0.03 ^{d}	7.26±0.03 ^{d}	6.92±0.02 ^{c}	6.73±0.03 ^{b}	6.59±0.03 ^{b}	6.16±0.02 ^{a}

Means with different superscripts (lower case letters row wise, upper case letter column-wise) differ significantly at (P<0.05).
Control=without addition RC or MSP, RC= Raw carrot and MSP=Mashed sweet potato

fermented sausage) affected sensory quality on storage. Similar trend was found for juiciness. Non-significant differences were observed in overall acceptability scores amongst control and treated nuggets at any point of storage interval, except on day 10. However, these values were decreased over storage periods. Gradual decrease of overall acceptability scores was due to decrease in the scores of other sensory attributes. The products were acceptable up to 20th day of storage period as rated by taste panel members.

The results of this study indicate that the use of carrot and sweet potato as extenders for chicken meat nuggets has positive influence on products quality parameters as incorporation of these vegetables in chicken meat nuggets is helpful to prevent lipid oxidation, improving microbiological quality of the products.

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