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DETERMINING THE FORMULATION AND REFRIGERATED STORAGE QUALITY OF MUTTON NUGGETS ENRICHED WITH WALNUT KERNELS (*Juglans regia*) AND SAFFRON PETALS (*Crocus sativus* L)

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ABSTRACT

The negative effects associated with meat have turned the attention of meat scientists towards the development of functional meat products. A study was thus designed to evaluate the effect of health promoting walnut kernels and antioxidant rich saffron petals in mutton nuggets. After preliminary trials, three combinations of walnut kernel paste (WKP) and saffron petal powder (SPP) viz., 15+1, 15+2 and 15+3 were incorporated in mutton nuggets. The mutton nuggets were evaluated for various physico-chemical and sensory parameters. The combination of 15+2 (WKP+SPP) was selected as optimum level and thus studied under aerobic refrigerated conditions to ascertain its storage life. The functional nuggets were compared with control (without WKP and SPP). It was observed that during storage, the lipid oxidation [measured as TBARS (mg malonaldehyde/kg)] and protein degradation (measured by tyrosine value) was slower in functional mutton nuggets. Also, antioxidant potential (measured as DPPH-RSA) and microbiological quality (measured by total plate count, coliform count and yeast and mould count) was better in functional mutton nuggets. Sensory quality decreased during storage, but the product of was acceptable quality even on 21th day of storage. It was concluded that walnut kernels and saffron petals are a very good natural sources for improving the quality of mutton nuggets, by acting as natural preservatives during refrigerated storage of mutton nuggets.

Key words : Functional, Mutton nuggets, Quality, Saffron petal powder, Shelf life, Walnut kernel paste.

Introduction

Meat is an excellent source of essential nutrients with high-quality proteins, fat and minerals (Stadnik, 2024). Nowadays, consumers show increased interest towards healthier, safer and stable food products without compromising their nutritional and organoleptic profile (Ramandeep *et al.*, 2021). This trend has stimulated interest in developing functional meat products enriched with bioactive ingredients of plant origin, such as nuts, seeds, and dietary fibers, which can enhance both the sensory characteristics and the nutritional value of traditional formulations (Domínguez *et al.*, 2019). The incorporation of natural ingredients aligns with the growing

consumer preference for clean-label, additive-free foods that support health without compromising taste or texture (Cirstulescu *et al.*, 2025).

Fruits, vegetables, different herbs and spices have been used as functional ingredients in different meat products throughout the world (Skwarek and Karwowska, 2023). Among fruits, walnut is one of the most important locally available sources in Kashmir and among spices, saffron petals as byproduct can be exploited for their functional role in different meat products. The walnut kernels contain abundant amount of desirable and health promoting mono-unsaturated fatty acids (18% oleic acid) and PUFAs (58% linoleic and 12% α -linolenic acid)

(Nguyen and Danh, 2021). Their inclusion in meat systems has demonstrated improvements in the fatty acid profile, lipid oxidation resistance, and overall nutritional quality (Pintado *et al.*, 2016). Moreover, walnuts have been shown to exert beneficial effects on oxidative stability and sensory performance in various meat matrices, including restructured beef steaks and emulsified sausages (Florowski *et al.*, 2022). However, formulation challenges remain, particularly concerning texture, moisture retention, and flavor balance, which must be optimized for consumer acceptance. Beyond product-specific benefits, the nutritional implications of walnut incorporation extend to public health. Spence *et al.* (2023) demonstrated that substituting part of the dietary meat intake with walnuts significantly improved overall nutrient quality, increasing omega-3 fatty acid, magnesium, and fiber intake while reducing cholesterol and saturated fat. Such findings support the concept that integrating walnuts into popular meat products can contribute to healthier dietary patterns without requiring radical changes in consumption habits (Spence *et al.*, 2023). Walnut exhibits antioxidant and antimicrobial capacity due to presence of phenolic compounds especially hydrolysable tannins, tocopherol, melatonin and indoleamin (Wu *et al.*, 2023).

During the harvesting of saffron, the petals are generally thrown away as waste. However, these petals are rich in biologically active compounds like phenolics, flavonoides and anthocyanin; hence can be exploited as functional ingredients in different meat products especially for their antioxidant potential (Rahmani *et al.*, 2017), thereby developing novel meat products with improved shelf life, quality and enhanced health benefits. Keeping in view the above mentioned facts, the combination of walnut kernel paste and saffron petal powder can be incorporated in the formulation of meat products to improve their functional quality and thereby enhance storage life.

Materials and Methods

Procurement of materials for the preparation of mutton nuggets

Mutton was procured from local market of Shuhama, Kashmir and deboned manually. The lean meat obtained after deboning and trimming of fat manually was packed in low density polyethylene (LDPE) pouches (50-100µ) and stored at standard freezing temperature ($-18 \pm 2^{\circ}\text{C}$) until used. Condiment paste used contained fresh onion, garlic and ginger in the ratio of 3:2:1. The shells from dried walnuts were removed manually and the kernels were ground in powder form and packed in polythene bags and refrigerated at $4 \pm 1^{\circ}\text{C}$. Saffron petals were

dried in an oven at $50-60^{\circ}\text{C}$ (overnight) to a moisture content of less than 8%, followed by grinding to form saffron petal powder (SPP) and stored in air tight container for further use. WKP+SPP was incorporated in mutton nuggets at three different levels replacing lean meat in the formulation (Table 1).

Preparation of mutton nuggets

Thawed mutton was cut into pieces and minced in a mincer (Sirman, Italy) after passing through 8mm plate and 4mm plate. Minced meat was transferred to bowl chopper, salt was added along with half of chilled water and mixed for 1 minute. Vegetable oil (Dhara brand) was gradually added and thoroughly mixed for 1 minute followed by addition of whole egg liquid, dry spice mix and condiment paste and mixed for 1-2 minutes till proper emulsion was formed. This formulation served as control. Throughout the preparation, the combination of walnut kernel paste (WKP) and saffron petal powder (SPP) in different levels (15+1%, 15+2% and 15+3%) was added by replacing lean meat from the basic formulation of the product. The emulsion prepared was then weighed and filled in stainless steel moulds. Moulds were covered with lid and tied with thread and cooked in steam without pressure for 35 minutes to an internal temperature of around 80°C . Mutton loaves so obtained were cooled to room temperature and cut into nuggets of approx 1cm^3 size. Samples were evaluated for various quality parameters to select the optimum level of WKP+SPP.

Table 1 : Formulation of nuggets.

Ingredients	Percentage (w/w)			
	Control	15+1% WKP +SPP	15+2% WKP +SPP	15+3% WKP +SPP
Lean mutton	78.00	62.00	61.00	60.00
Walnut kernel paste (WKP)	0.00	15.00	15.00	15.00
Saffron petal powder (SPP)	0.00	1	2	3
Ice/Chilled water	8.70	8.70	8.70	8.70
Vegetable oil	5.00	5.00	5.00	5.00
Condiments	3.00	3.00	3.00	3.00
Salt	1.50	1.50	1.50	1.50
Whole egg	2.00	2.00	2.00	2.00
Dry spices	1.50	1.50	1.50	1.50
STPP (Sodium Tripolyphosphate)	0.30	0.30	0.30	0.30
Total	100			

Mutton nuggets containing optimum level of WKP+SPP (15+2%) along with control were packed aerobically in LDPE pouches and stored at refrigerated temperature ($4\pm1^\circ\text{C}$) for 21 days. During the refrigerated storage, nuggets were evaluated at an interval of 7 days on 0th, 7th, 14th, and 21th day for physio-chemical, antioxidant, microbiological and sensory parameters.

Analytical procedures

The emulsion stability was determined as per the method of (Anjaneyulu *et al.*, 1989). The pH of mutton nuggets was estimated by using digital pH meter (Model CP 901, Century Instrument Ltd. India). The proximate composition was determined by using standard procedures of AOAC (2000). Tyrosine value was measured by the procedure put forward by Strange *et al.* (1977) with slight modifications. Thiobarbituric acid reactive substances (TBARS) value of cooked products was determined using standard procedure of Witte *et al.* (1970). The DPPH assay was done according to the method of Brand *et al.* (1995) with some modifications. Total plate count, coliform count and yeast and mould count were determined by methods of APHA (1984). The sensory evaluation of all sample products was performed by a panel of seven semi-trained members consisting of scientists and post-graduate scholars of the Division of Livestock Products Technology, based on 8-point hedonic scale, wherein 8 denoted “extremely desirable” and 1 denoted “extremely undesirable” (Keeton *et al.*, 1984).

The data generated was analyzed by analysis of variances using SPSS software and the significance was checked at 5% level of confidence.

Results and Discussion

Optimisation of walnut kernel paste and saffron petal powder

The physico-chemical properties like pH of treated mutton nuggets was non-significantly ($P>0.05$) affected as compared to control (Table 2). Ayo *et al.* (2007) also reported that the incorporation of walnut did not influence ($p > 0.05$) the pH of the walnut frankfurters (6.37), as compared with low-fat frankfurters and traditional frankfurters. There was significant ($p<0.05$) increase in cooking yield, emulsion stability, moisture, ash and fat content with increase the level of walnut kernel paste and saffron petal powder. Overall, slightly increased ash percentage of WKP+SPP treated mutton nuggets might be attributed to higher mineral

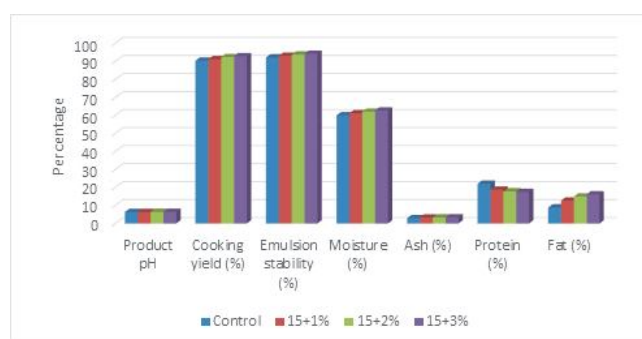


Fig. 1 : Physico-chemical quality of mutton nuggets.

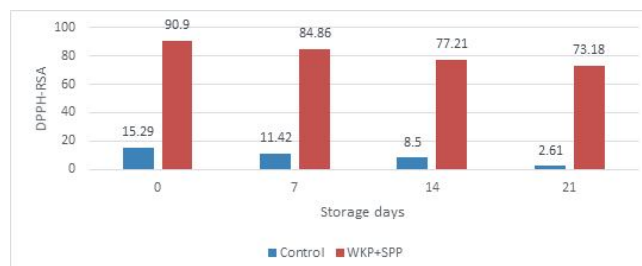


Fig. 2 : Physico-chemical and antioxidant quality of mutton nuggets during refrigerated storage.

content of SPP. Protein content of WKP+SPP treated mutton nuggets was significantly ($P<0.05$) lower than control. Similar type of results was reported by Bhat and Kumar (2014) in chicken nuggets treated with *Aloe-vera* pulp.

The sensory evaluation revealed that up to 15+2% addition of WKP+SPP, the product remained acceptable for all parameters included overall acceptability (Table 3). However, the panellists rejected the product containing 15+3% level of WKP+SPP. Based on the physico-chemical properties and sensory evaluation of the products, 15+2% of WKP+SPP was selected as optimum level for use in mutton nuggets. Therefore, the 15+2% WKP+SPP treated product along with control were stored in low density polyethylene (LDPE) pouches and

Table 2 : Physico-chemical quality of mutton nuggets (Mean ± SE).

Parameters	Treatments			
	Control	15+1%	15+2%	15+3%
Product pH	6.36±0.02 ^a	6.37±0.02 ^a	6.39±0.03 ^a	6.39±0.02 ^a
Cooking yield (%)	90.35±0.17 ^a	91.09±0.36 ^{ab}	92.31±0.65 ^{bc}	92.73±0.12 ^c
Emulsion stability (%)	92.11±0.58 ^a	92.99±1.20 ^a	93.73±0.61 ^{ab}	94.10±0.56 ^b
Moisture (%)	60.00±0.41 ^a	61.09±0.31 ^b	62.02±0.37 ^{bc}	62.62±0.33 ^c
Ash (%)	2.90±0.08 ^a	3.28±0.11 ^b	3.33±0.08 ^b	3.36±0.07 ^b
Protein (%)	21.99±0.65 ^c	18.77±0.18 ^b	17.78±0.18 ^{ab}	17.46±0.16 ^a
Fat (%)	8.84±0.35 ^a	12.70±0.21 ^b	14.97±0.38 ^c	16.10±0.18 ^d

Row-wise group means with different superscript differ significantly ($P<0.05$)

* N = 6

Table 3 : Sensory attributes of mutton nuggets (Mean $\pm$ SE).

Sensory attributes	Treatments			
	Control	15+1%	15+2%	15+3%
Appearance	7.24 $\pm$ 0.14 ^c	7.09 $\pm$ 0.12 ^c	6.71 $\pm$ 0.10 ^b	6.29 $\pm$ 0.12 ^a
Flavour	7.09 $\pm$ 0.14 ^b	6.86 $\pm$ 0.78 ^{ab}	6.81 $\pm$ 0.11 ^{ab}	6.62 $\pm$ 0.15 ^a
Texture	6.81 $\pm$ 0.09 ^a	6.62 $\pm$ 0.13 ^a	6.67 $\pm$ 0.13 ^a	6.71 $\pm$ 0.14 ^a
Juiciness	7.19 $\pm$ 0.13 ^b	7.00 $\pm$ 0.15 ^{ab}	6.90 $\pm$ 0.14 ^{ab}	6.67 $\pm$ 0.16 ^a
Mouth coating	7.57 $\pm$ 0.13 ^b	7.43 $\pm$ 0.13 ^b	7.24 $\pm$ 0.2 ^{ab}	6.95 $\pm$ 0.16 ^a
Saltiness	7.43 $\pm$ 0.11 ^b	7.24 $\pm$ 0.09 ^{ab}	7.24 $\pm$ 0.09 ^{ab}	6.95 $\pm$ 0.16 ^a
Overall acceptability	7.29 $\pm$ 0.13 ^b	7.01 $\pm$ 0.11 ^{ab}	6.89 $\pm$ 0.13 ^{ab}	6.48 $\pm$ 0.15 ^a

Row-wise group means with different superscript differ significantly ($P < 0.05$)

* 8-point descriptive scale (8 = extremely desirable, 1 = extremely undesirable)

**N = 21

Table 4: Physico-chemical and antioxidant quality of mutton nuggets during refrigerated storage (Mean $\pm$ SE).

Treatments	Storage period (days)			
	0	7	14	21
pH				
Control	6.16 $\pm$ 0.01 ^{aA}	6.19 $\pm$ 0.00 ^{aAB}	6.23 $\pm$ 0.01 ^{aB}	6.33 $\pm$ 0.02 ^{aC}
WKP+SPP	6.19 $\pm$ 0.01 ^{bA}	6.21 $\pm$ 0.19 ^{bAB}	6.25 $\pm$ 0.01 ^{bB}	6.34 $\pm$ 0.02 ^{aC}
Moisture (%)				
Control	61.15 $\pm$ 0.61 ^{aC}	60.19 $\pm$ 0.06 ^{aB}	59.76 $\pm$ 0.25 ^{aB}	59.03 $\pm$ 0.39 ^{aA}
WKP+SPP	61.77 $\pm$ 0.22 ^{aB}	61.09 $\pm$ 0.50 ^{bB}	60.07 $\pm$ 0.32 ^{aA}	59.99 $\pm$ 0.01 ^{aA}
TBARS				
Control	0.16 $\pm$ 0.01 ^{bA}	0.28 $\pm$ 0.01 ^{bB}	0.38 $\pm$ 0.02 ^{bC}	0.50 $\pm$ 0.01 ^{bD}
WKP+SPP	0.12 $\pm$ 0.01 ^{aA}	0.17 $\pm$ 0.00 ^{aB}	0.20 $\pm$ 0.00 ^{aC}	0.28 $\pm$ 0.00 ^{aD}
Tyrosine				
Control	0.52 $\pm$ 0.01 ^{bA}	0.79 $\pm$ 0.04 ^{aB}	1.01 $\pm$ 0.04 ^{aC}	1.37 $\pm$ 0.01 ^{bD}
WKP+SPP	0.45 $\pm$ 0.00 ^{aA}	0.74 $\pm$ 0.00 ^{aB}	1.03 $\pm$ 0.32 ^{aC}	1.31 $\pm$ 0.00 ^{aD}
DPPH-RSA				
Control	15.29 $\pm$ 0.77 ^{aD}	11.42 $\pm$ 0.48 ^{aC}	8.50 $\pm$ 0.38 ^{aB}	2.61 $\pm$ 0.26 ^{aA}
WKP+SPP	90.90 $\pm$ 0.91 ^{bD}	84.86 $\pm$ 1.90 ^{bC}	77.21 $\pm$ 1.59 ^{bB}	73.18 $\pm$ 1.47 ^{bA}

Mean $\pm$ SE with lower case letter column-wise and upper case letter row-wise with different superscript differ significantly ($P < 0.05$)

* N = 6

kept at refrigerated temperature for a period of 21 days to ascertain their storage stability.

Storage study

During storage, an overall increase in pH of products could be due to production of basic amines from protein breakdown by micro-organisms. The loss of moisture might be due to degradation of proteins responsible for water holding (Das *et al.*, 2008). Ahmad (2014) found

similar trend for moisture in aerobically packaged restructured buffalo meat fillets stored at refrigeration temperature. Significantly lower ($P < 0.05$) TBARS and tyrosine values for treatment products could be due to the presence of phenolic compounds in walnut kernel paste and saffron petal powder. Kumar and Tanwar (2011) reported that chicken nuggets containing clove powder (optimized product) maintained significantly ($P < 0.05$) lower TBA values throughout the storage period. DPPH radical scavenging activity (DPPH-RSA) values of WKP+SPP treated mutton nuggets were significantly ($P < 0.05$) higher than control. The significantly ($P < 0.05$) higher DPPH-RSA value might be due to the addition of antioxidant rich saffron petals. These results (increased DPPH-RSA and reduced TBARS and tyrosine values) indicated that saffron petal powder is an excellent natural antioxidant source.

During storage, an overall increase in microbial counts (TPC, CC and YMC) was observed, however a comparatively slow increase in WKP+SPP treated mutton nuggets might be attributed to the possible antimicrobial activity of the WKP and SPP. Similar observation was reported by Ahmad (2014) in buffalo meat fillets, Bhat *et al.* (2013a) in chicken *seekh kababs*, Bhat *et al.* (2013b) in chicken meat balls; Kumar and Tanwar (2011) in chicken nuggets treated with different natural ingredients. During storage, coliform counts were not detected during initial period upto 7th day and yeast and mould count were not detected up to 14th day of storage, probably due to thorough cooking, good hygiene and absence of post processing contamination.

The sensory attributes decreased significantly ($P < 0.05$) as the storage progressed, however the products were acceptable even on 21st day of storage. The decreasing in sensory attributes might be due to lipid and protein oxidation and enzymatic activity happening during the storage period. Similar observations were also reported by Bhat *et al.* (2013a, 2013b) and Kumar and Sharma (2004).

Table 5 : Microbiological quality of mutton nuggets during refrigerated storage (Mean $\pm$ SE).

Treatments	Storage period (days)			
	0	7	14	21
Total plate count (logcfu/g)				
Control	0.93 $\pm$ 0.16 ^{ba}	2.15 $\pm$ 0.06 ^{bb}	2.97 $\pm$ 0.01 ^{ac}	3.59 $\pm$ 0.09 ^{ad}
WKP + SPP	0.76 $\pm$ 0.18 ^{aA}	1.83 $\pm$ 0.02 ^{aB}	2.46 $\pm$ 0.20 ^{aC}	3.29 $\pm$ 0.16 ^{aD}
Coliform count (logcfu/g)				
Control	N.D	N.D	0.34 $\pm$ 0.06 ^{bA}	0.85 $\pm$ 0.02 ^{bB}
WKP+SPP	N.D	N.D	0.21 $\pm$ 0.09 ^{aA}	0.66 $\pm$ 0.01 ^{aB}
Yeast and mould count (logcfu/g)				
Control	N.D	N.D	N.D	1.00 $\pm$ 0.03 ^b
WKP+SPP	N.D	N.D	N.D	0.40 $\pm$ 0.05 ^a

Mean $\pm$ SE with lower case letter column-wise and upper case letter row-wise with different superscript differ significantly (P<0.05)

* N = 6

Table 6 : Sensory quality of mutton nuggets during refrigerated storage (Mean $\pm$ SE).

Treatments	Storage period (days)			
	0	7	14	21
Appearance				
Control	7.76 $\pm$ 0.95 ^{bc}	7.52 $\pm$ 0.11 ^{bc}	6.95 $\pm$ 0.11 ^{bb}	6.49 $\pm$ 0.11 ^{ba}
WKP+SPP	6.62 $\pm$ 0.11 ^{ac}	6.48 $\pm$ 0.13 ^{aC}	6.00 $\pm$ 0.17 ^{aB}	5.33 $\pm$ 0.14 ^{aA}
Flavour				
Control	7.67 $\pm$ 0.10 ^{ac}	7.28 $\pm$ 0.14 ^{bc}	6.52 $\pm$ 0.16 ^{bB}	5.86 $\pm$ 0.19 ^{aA}
WKP+SPP	7.43 $\pm$ 0.11 ^{ad}	6.67 $\pm$ 0.10 ^{aC}	6.14 $\pm$ 0.14 ^{aB}	5.24 $\pm$ 0.70 ^{aA}
Texture				
Control	7.57 $\pm$ 0.11 ^{ad}	7.09 $\pm$ 0.12 ^{bc}	6.48 $\pm$ 0.13 ^{bb}	5.62 $\pm$ 0.11 ^{aA}
WKP+SPP	7.33 $\pm$ 0.12 ^{ac}	6.33 $\pm$ 0.14 ^{aB}	6.00 $\pm$ 0.17 ^{aB}	5.28 $\pm$ 0.14 ^{aA}
Juiciness				
Control	7.71 $\pm$ 0.10 ^{aB}	7.43 $\pm$ 0.11 ^{bb}	6.71 $\pm$ 0.10 ^{aA}	6.43 $\pm$ 0.11 ^{ba}
WKP+SPP	7.39 $\pm$ 0.11 ^{ad}	6.71 $\pm$ 0.10 ^{aC}	6.14 $\pm$ 0.16 ^{aB}	5.33 $\pm$ 0.14 ^{aA}
Mouth Coating				
Control	7.81 $\pm$ 0.88 ^{bc}	7.48 $\pm$ 0.11 ^{bc}	7.00 $\pm$ 0.12 ^{bb}	6.33 $\pm$ 0.16 ^{ba}
WKP+SPP	7.24 $\pm$ 0.95 ^{ad}	6.76 $\pm$ 0.09 ^{aC}	5.95 $\pm$ 0.15 ^{aB}	5.24 $\pm$ 0.15 ^{aA}
Saltiness				
Control	7.86 $\pm$ 0.08 ^{bd}	6.71 $\pm$ 0.10 ^{bc}	6.81 $\pm$ 0.11 ^{bb}	6.28 $\pm$ 0.16 ^{ba}
WKP+SPP	7.05 $\pm$ 0.15 ^{aC}	6.14 $\pm$ 0.16 ^{aB}	5.81 $\pm$ 0.13 ^{aB}	5.28 $\pm$ 0.12 ^{aA}
Overall Acceptability				
Control	7.81 $\pm$ 0.09 ^{aC}	7.48 $\pm$ 0.11 ^{bc}	6.90 $\pm$ 0.12 ^{aB}	6.23 $\pm$ 0.15 ^{ba}
WKP+SPP	7.19 $\pm$ 0.15 ^{aC}	6.33 $\pm$ 0.14 ^{aB}	6.00 $\pm$ 0.17 ^{aB}	5.28 $\pm$ 0.14 ^{aA}

Conclusion

Incorporation of walnut kernel paste and saffron petal powder (WKP+SPP) are an excellent and accessible source of bioactive compounds, including polyunsaturated fatty acids, phenolic compounds, tocopherols and antioxidants, making them an ideal functional ingredient for food products. Walnut kernel paste and saffron petal powder owing to its high nutritional value and strong bioactive potential, represents a valuable nonconventional material for improving the functional and health-promoting quality of foods. Therefore, it can be concluded that premium mutton nuggets with improved refrigerated storage quality could be developed lipid profile, antioxidant activity and antimicrobial effects could be developed with incorporation of walnut kernels and saffron petals.

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