

Original Research Article

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Development and Quality of Fiber Enriched Functional Spent Hen Nuggets Incorporated with Hydrated Wheat Bran

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ABSTRACT

In the present investigation, the effect of hydrated wheat bran on physico-chemical, textural, color and sensory qualities of spent hen meat nuggets were studied. Moisture, protein, fat and a_w decreased significantly ($P < 0.05$), while ash, fiber, water holding capacity, emulsion stability and cooking yield increased significantly ($P < 0.05$) with incorporation of wheat bran. It was found that addition of hydrated wheat bran significantly ($P < 0.05$) increased moisture retention and fat retention. Instrumental color profile, lightness (L^*) and yellowness (b^*) increased while redness (a^*) decreased ($P < 0.05$) with addition of hydrated wheat bran. The effect of addition of hydrated wheat bran was also observed on instrumental textural properties of nuggets. Hardness, chewiness and gumminess of spent hen meat nuggets were higher, whereas springiness, stringiness, cohesiveness and resilience were lower in treated products as compared to control. All the sensory properties decreased significantly ($P < 0.05$) with the addition of hydrated wheat bran however, sensory panelists rated the nuggets to be of 'very good to excellent' quality. It is concluded that fiber enriched spent hen meat nuggets can be successfully developed with the incorporation of pre-hydrated 8 % wheat bran.

Keywords

Wheat bran, Fiber enriched nuggets

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Introduction

Functional meat can be produced by either nutritional or processing interventions. Processing interventions are more precise, repeatable and provide opportunities to develop strategies for the improvement of functionality of meat and meat products.

Functional meat products can be developed by various strategies like reduction of fat, saturated fatty acids, salt and nitrite as well as

by the incorporation of functional ingredients like fibres (Barros *et al.*, 2018). Consumption of diet containing dietary fiber is linked with control of body weight, reduction of cardiovascular diseases risk and decrease in chronic health problems (WHO/FAO, 2003; Slavin, 2005). Dietary fiber has various beneficial effect like it increase bulkiness of diet, form gel during digestion, slowing of glucose absorption, trapping of carbohydrates, regulate blood pressure and lowering LDL cholesterol (Dhingra *et al.*, 2012).

Daily dietary fibre requirement recommended by National Academy of Sciences (USA) is 30-38 g and 21-26 g for men and women, respectively. Meat products formulated with optimal levels of dietary fibre gain interest in the design of new functional foods along with the increase in product yield (Cappa *et al.*, 2015). Cereal agro-industry by-products viz., wheat bran, rice bran etc the potential of imparting health benefits to consumers and reduces the overall cost of production of meat products. Cereal brans containing dietary fiber act as a functional ingredient as stabilizer, fat replacer, binder, volume enhancer in emulsion based meat products (Kumar *et al.*, 2011).

Byproduct from milling industry like wheat bran contains 11.58% crude fiber, 48.69% total dietary fiber, 46.59% insoluble dietary fiber and 2.10% soluble dietary fiber (Yadav and Malik, 2016). Wheat bran is good source of fiber, protein and minerals therefore recommended for prevention and treatment of constipation and diabetes with cancer reducing risk (Haripriya and Premakumari, 2010). Several studies have been reported for dietary fiber enrichment from cereal brans in chicken sausages (Yadav *et al.*, 2016), pork sausages (Khate, 2007), meat balls (Yasarlar *et al.*, 2007) and beef patties (Saricoban *et al.*, 2009).

Difference in composition and structural properties of dietary fiber, directs the nutritional and technical properties of meat products. Hence, this study was carried out to evaluate whether hydrated wheat bran as a dietary fiber could be successfully incorporated in spent hen meat nuggets with an effort to improve our understanding of how physico-chemical, textural, color and sensory qualities affected by addition.

Materials and Methods

Layer bird of white leghorn (WLH) breed of age 72 weeks procured from poultry farm of

GADVASU, Ludhiana were slaughtered and dressed in the experimental slaughter house of the Department of Livestock Products Technology, COVS, GADVASU, Ludhiana as per standard procedures and guidelines for animal welfare and ethics. Dressed carcasses were packed in LDPE bags and stored overnight at $4\pm 1^{\circ}\text{C}$ temperature. The dressed birds were manually deboned and meat free from visible fat and connective tissue, was packed in LDPE bags and frozen for 24 hrs. Wheat bran procured from Bagrry's India Ltd. New Delhi. Other material including spices, condiments and refined wheat flour used in the present study were procured from local market.

Preparation of spent hen meat nuggets

Spent hen meat nuggets (SHMN) were prepared as per standardized formulation in our laboratory mentioned in Table 1. Emulsion was prepared with the incorporation of different levels of hydrated wheat bran (0, 4, 8 and 12 %). Wheat bran levels mentioned earlier were selected on the basis of available literature and preliminary experiments. Frozen deboned meat was thawed at $4\pm 1^{\circ}\text{C}$ and minced using meat mincer (Eskimo grinder, MEW-714-H82, MADDO, Dornhan, Germany). Chopping of minced meat was done in bowl chopper (Model: TC11, Scharfen, Germany) along with salt, sodium nitrite and sodium tripolyphosphate for three minutes. Thereafter, chilled water and refined oil were added slowly and chopped for 2 minutes to develop emulsion. The wheat bran was hydrated in the added chilled water of the formulation for 30 min. Thereafter, it was thoroughly mixed in the chopper along with other emulsion additives. The spent hen meat emulsions were filled compactly in aluminum molds (18 x 12 x 4 cm) with 600 gm of meat emulsion. The air bubbles were removed by tapping molds for 4-5 times on plain surface and closed tightly. The molds filled with emulsion were

subjected to steam in an autoclave and cooked at 121⁰ C, 15 psi for 15 minutes followed by cooling to room temperature. The cooked products after removing from molds cut in to rectangular meat nuggets and subjected for analysis.

Analysis

pH

pH of samples was determined as per the method of Trout *et al.*, (1992) using digital pH meter (Elico, Model LI 127, Elico Limited Hyderabad, India). After blending 10 g of cooked product(s) with 100 ml of deionized water for 2 min to get suspension, the pH was measure by placing combined glass electrode.

Water activity

Water activity was measured by using portable digital water activity meter at 25⁰ C (Rotronix HYGRO Palm AW1 Set, Rotronix Instrument (UK) Ltd., West Sussex and UK). All the tests were performed in duplicate.

Proximate analysis

Proximate parameters viz., moisture, protein, fat and ash measurement were done according to the methods described by AOAC (1995). To determine the moisture percent, 10-g sample was dried at 100 ± 5⁰ C to constant weight. After analysis of total nitrogen using Kjeldahl method, a factor of 6.25 was used to derive total protein (%). Fat percent was estimated using Soxhlet apparatus. Total ash was determined by using muffle furnace (550 ± 5⁰ C for 6 h). The crucible with residue was oven dried (105 ± 5⁰ C) overnight and weighed. The crucible and its content were then transferred into a muffle furnace and ashing was done at 550 ± 5⁰ C for 4 h, cooled and reweighed. The weight of ash was then calculated as g/100 g of original sample.

Fiber

Crude fiber was estimated as per AOAC (1995) method using Fibra Plus Automatic Fibre Estimation System (Model no FES 6, Pelican equipment manufactured by Chennai, India) by alternate acid (1.25 % H₂SO₄) and alkali (1.25 % NaOH) digestion followed by washing with deionized water.

Carbohydrate

Carbohydrate percentage in product was determined by numerical formula as follows
Carbohydrate % = 100 – (Moisture % + Protein % + Fat % + Ash % +Fiber %).

Energy

Total calories content of cooked products were calculated as per the methods used by Verma *et al.*, (2016). For 100-g portion using at water values for fat (9 kcal/g), protein (4.02 kcal/g) and carbohydrate (4 kcal/g).

Shear force values

Shear press of nuggets were conducted by Texture Analyzer (TMS-PRO, FTC, Maries Road, Sterling, VA, USA). The nuggets cube of uniform size (1.0 X 1.0 X 1.0 cm) was subjected to double compression cycle to 50% of their original height. The protocol described by the manufacturer was followed.

Emulsion stability

Emulsion stability was determined as per the method of Baliga and Madaiah (1970). 20 g of meat emulsion were packed in polyethylene bags, sealed and cooked at 80⁰ C in a thermostatically controlled stirred water bath (Equitron, Model: 8414, Medica Instrument Mfg. Co., Mumbai, India) for 20 min. Thereafter bags were removed from water bath, cooled to room temperature, cut open,

cooked out fluid (fat, water and water soluble solids) was drained. The cooked emulsion mass weighed and expressed as percent emulsion stability.

Cooking yield

It is measured and expressed in percentage as the weight differ of cooked product and initial raw weight with the help of following formula

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked nuggets}}{\text{Weight of uncooked nuggets}} \times 100$$

Moisture retention

Values of moisture retention indicate the amount of moisture retained in the cooked product per 100 g and calculated as per the equation used by Kumar *et al.*, (2007) as follows

$$\text{Moisture retention (\%)} = \frac{(\text{Percent cooking yield}) \times (\text{Percent moisture in nuggets})}{100}$$

Fat retention

Retention of fat was calculated as per the equation used by Kumar and Sharma (2003) as follows.

$$\text{Fat retention (\%)} = \frac{(\text{Cooked weight} \times \% \text{ Fat in cooked nuggets})}{(\text{Uncooked weight} \times \% \text{ Fat in uncooked nuggets})} \times 100$$

Water holding capacity

Water holding capacity (WHC) was calculated per the method prescribed by Wardlaw *et al.*, (1973). In a 100 mL polycarbonate centrifuge bottle, finely minced sample (20 g) was taken and then 30 mL of 0.6 M NaCl solution was

added to it, mixed with glass rod and stirred for 2 min on a mechanical shaker. After holding for 15 min at 4°C in order to allow the effect of salt to reach equilibrium, the meat slurry was again stirred for 1 min on a shaker and immediately centrifuged at 5000 rpm for 10 min at -9°C in a centrifuge.

The supernatant volume was measured and difference between the added and decanted solution was expressed as percentage of the initial weight of sample.

Instrumental color profile

Color profile (L*, a* and b* values) of cooked nuggets was measured using a Minolta Camera Co., Osaka, Japan. The colorimeter was calibrated with a white standard plate (mod CR-A43) and six measurements was taken on different surface of nuggets (3 x 3 x 3 cm size) at room temperature and. Color scores were expressed as L* (lightness), a* (redness) and b* (yellowness).

Texture Profile Analysis (TPA)

Texture profile analysis (TPA) of spent hen meat nuggets were recorded using a texture analyzer (TMS-PRO, Food Technology Corporation, Maries Road, Suite 120 Sterling, VA, USA) following the procedures of Bourne (1978).

Nuggets were cut uniformly (1.0 x 1.0 x 1.0 cm) were subjected to double-compression cycle reducing their size to half the original height using pretest speed of 5 mm/s, test speed of 1 mm/s, posttest speed of 1 mm/s, distance 10 mm and exposure time 3 s. Texture profile parameters viz., hardness (N), springiness (mm), stringiness (mm), cohesiveness, chewiness (J), gumminess (N) and resilience were estimated using in-built software (TMS-Pro) in the equipment from the force time plot.

Sensory evaluation

Sensory evaluation for all the batches was carried out as per the international standards (ASTM, 1986). The sensory panelists were selected from the pool of Post-Graduate students and faculty of the department. All the panelists have very good knowledge about different meat quality attributes. Two sessions were conducted to detail about all the product characteristics and evaluation proforma of scale. A 8-point descriptive scale (where 1 = extremely undesirable and 8 = extremely desirable) was used to evaluate sensory attributes of spent hen meat chicken nuggets. The coded samples were served to each panelist at room temperature for evaluation. Drinking water was provided to cleanse the palate between successive evaluations.

Statistical analysis

Each experiment was conducted thrice to assure consistency of the results. The parameters for each sample were carried out in duplicate (n=6). In case of color profile and instrumental texture analysis, triplicate (n=9) observations were drawn for analysis whereas for sensory parameter seven panelists analyzed sample (n=21). The data obtained were subjected to statistical analysis for one-way analysis of variance (ANOVA). Duncan's multiple range test at 5% significance level was applied to find out significant difference in mean (Snedecor and Cochran, 1989) and results were expressed as mean \pm standard error using SPSS-20 (SPSS Inc., Chicago, IL, USA).

Results and Discussion

Physico-chemical and proximate quality of spent hen meat (SHM) emulsion

Table 2 revealed that the pH, moisture, protein, fat, ash, WHC and emulsion stability

of SHM emulsion differ significantly ($P < 0.05$) with incorporation of hydrated wheat bran.

The pH of all SHME added with hydrated wheat bran was significantly ($p < 0.05$) higher than control. The pH value of emulsion ranged from 5.64 to 6.18. The highest pH values (6.18) were obtained from the SHME-12 indicating that the pH of emulsion increased with the increase in level of hydrated wheat bran in the formulation. Similar variations in pH was also observed by Yılmaz (2005) for meat ball as well as Talukder and Sharma (2010) for chicken meat patties. The moisture contents of emulsion decreased significantly ($P < 0.05$) with the addition of wheat bran. The emulsion incorporated with highest level of hydrated wheat bran (12 %) recorded lowest moisture content. It might be due to replacement of high moisture lean meat (70-75 %) with low moisture wheat bran (12-15 %). Declining trend in moisture content of low fat meat balls with the addition of cereal bran was reported by Yasarlar *et al.*, (2007) and Haung *et al.*, (2011) for Turkish meat balls and Chinese-style sausages, respectively.

The protein and fat content were observed to be significantly ($P < 0.05$) lower in wheat bran added chicken meat emulsion as compared to control. Addition of 12 % hydrated wheat bran resulted in to lowest protein (15.20 %) and fat (8.04 %) as compared to other treatment. The lowering of moisture, fat and protein content with relative percentage in wheat bran incorporated SHM emulsion is attributed to the fact that it was added as a replacement of lean meat in the formulation and composition of wheat bran (protein 11-13 %, fat 2-3 % and moisture 12-15 %). Ash content of emulsion increased significantly ($P < 0.05$) with addition of wheat bran. Emulsion with 12 % hydrated wheat bran showed highest (2.98 %) ash content and lowest (1.94 %) for control meat emulsion. Our observations are in

consonance with the findings of Talukder and Sharma (2010). Water holding capacity (WHC) followed an increasing trend with the increase in level of incorporation of wheat bran. WHC was significantly ($P < 0.05$) higher in all treated emulsion than control. Increase in WHC with the incorporation of hydrated wheat bran might be due to ability of wheat bran to hold the moisture in the gel matrix (Tekin *et al.*, 2010) and presence of soluble dietary fiber (Dawkins *et al.*, 1999).

The emulsion stability was significantly ($P < 0.05$) increased in treated SHM emulsion than control. Among the treatments, SHME-12 exhibited highest emulsion stability and lowest in SHME-4. The increase in emulsion stability with the increase in levels of wheat bran might be due to entrapping and holding of moisture during application of heat (80°C). Similar increase in emulsion stability with addition of fiber was observed by Huffman (1992) for lean pork sausage and Hughes *et al.*, (1997) for frankfurters.

Proximate composition of spent hen meat nuggets

Results of proximate composition (moisture, protein, fat ash carbohydrate fiber, energy and moisture to protein ratio) of SHM nuggets influenced by hydrated wheat bran are presented in Table 3.

Decreasing trend was recorded for moisture content due to addition of hydrated wheat bran. The control had highest moisture content (63.32 %) whereas FEN-12 HWB had lowest (60.20 %) moisture content. Decrease in moisture content might be due to the addition of dietary fiber; wheat bran with the replacement of lean meat. The average moisture content of lean meat is significantly ($P < 0.05$) higher (70-75 %) than wheat bran (12-15 %). Yasarlar *et al.*, (2007) and Saricoban *et al.*, (2009) also documented

similar observation in Turkish meat balls and beef patties, respectively. The protein and fat contents of treated SHM followed a decreasing trend with the increase in additive amount of wheat bran. It is attributed to variation in formulation and composition of added wheat bran.

Further, the carbohydrate content increased significantly ($P < 0.05$) in all the treated nuggets than control and it also followed an increasing trend with the additive level of wheat bran. Yilmaz (2005) also found decrease in protein and fat contents of low fat meat balls added with wheat bran.

The moisture-protein ratio was recorded significantly ($P < 0.05$) higher in nuggets incorporated with 12 % hydrated wheat bran (3.88) as compare to control and increased gradually with increase fiber content of products. Similar increased in MPR was observed by Verma *et al.*, (2016) for low fat pork loaves added with inulin powder.

Results of statistical analyses indicated that ash, carbohydrate and fiber contents of SHM nuggets incorporated with hydrated wheat bran was significantly ($P < 0.05$) higher than control. Among the treatments, highest content of ash (3.63 %), carbohydrate (5.16 %) and fiber (6.98 %) were recorded for FEN-12. It might be due to more ash, carbohydrate and fiber content of wheat bran as compared to meat. Present findings are in agreement with that of Verma *et al.*, (2016) who observed increase in ash, carbohydrate and fiber contents of functional pork loaves incorporated with fiber. The critical evaluation of Table 3 revealed that the total fat percentage in all the fiber enriched SHM nuggets is lower than 10 %, threshold limit for low-fat meat products (Keeton, 1994). Therefore, the developed products can be categorized under low-fat and high-fiber meat products.

The energy (Kcal) content was significantly ($P < 0.05$) higher in control as compared to all treatments. It might be due to high protein and fat content of control as compared to treated products.

Among the treatments, FEN-12 showed lower energy value which might be due to lower protein and fat content. The energy content in developed products was lower by 11.33 - 14.80 %. Similar findings were observed by Verma *et al.*, (2016) for low fat pork loaves.

Physico-chemical quality of fiber enriched spent hen meat nuggets

The results on physico-chemical properties of spent hen meat nuggets incorporated with different levels of hydrated wheat bran are presented in Table 4.

The pH of SHM nuggets increased with the addition of wheat bran and it followed an increasing trend with the level of incorporation of wheat bran.

It is attributable to higher innate pH (8.5) of wheat bran than lean meat (5.86 ± 0.13).

Further on close perusal of Table 2 and 4, it was revealed that pH of SHM nuggets was higher than their respective SHM emulsion.

It might be due to concentration of components with the moisture loss during cooking and deamination of proteins due to heating. Babu *et al.*, (1994) also reported increase in pH on cooking due to increased salt concentration, loss of moisture and change in the net charge of proteins results from denaturation.

Lowest (0.878) water activity was recorded for FEN-12 HW and highest (0.901) in FEN-4 HW, however water activity was significantly ($P < 0.05$) higher in control than all

treatments. This might be due to firm binding of water with wheat bran. Decrease in moisture content with the incorporation of wheat bran correlate with decrease in water activity (a_w).

Incorporation of hydrated wheat bran significantly ($P < 0.05$) increased the cooking yield, which might be due to ability of wheat bran to hold the moisture and fat in the matrix. Cofrades *et al.*, (2000) also stated that increase in cooking yield with the incorporation of dietary fibers might be due to their water and fat binding properties.

It could be hypothesized that the mechanism responsible for moisture and fat retention might be related with the swelling of fibre in the wheat bran. Due to absorption of fat and interaction with the meat protein to form a matrix, which prevents the coalescence and migration of fat out of the product (Anderson and Berry, 2001).

The moisture retention percentage of wheat bran added nuggets increased significantly ($P < 0.05$) with the increase in level of hydrated wheat bran. The higher percentage of moisture retention might be due to effective moisture binding properties of wheat bran which, prevented oozing out of moisture during cooking.

Increase in WHC with the addition of wheat bran in nuggets also responsible for increased moisture retention, which might be due to the ability of wheat bran to hold the moisture in the matrix (Tekin *et al.*, 2010).

Similar increasing trend in fat retention percentage was observed in FEN-HWB. Dietary fiber present in wheat bran rich in hemicellulose and lignin, which helps to hold the fat due to longer length cellulose fiber that could retain more oil resulting in more fat retention after cooking (Ang, 1991).

Table.1 Formulation of fiber enriched spent hen meat nuggets using hydrated wheat bran

Ingredients (% w/w)	CON	Treatments		
		FEN-4	FEN-8	FEN-12
Deboned meat	70.00	66.00	62.00	58.00
Hydrated Wheat Bran (1:1)	0.00	4.00	8.00	12.00
Refined oil	7.50	7.50	7.50	7.50
Salt	1.50	1.50	1.50	1.50
Sodium tetra pyrophosphate	0.20	0.20	0.20	0.20
Chilled water	7.50	7.50	7.50	7.50
Refined wheat flour (Maida)	3.00	3.00	3.00	3.00
Spice mix	2.50	2.50	2.50	2.50
Condiments	3.00	3.00	3.00	3.00
Sugar	0.30	0.30	0.30	0.30
Egg albumen	4.50	4.50	4.50	4.50
Sodium nitrite	120 ppm	120 ppm	120 ppm	120 ppm

CON = Spent hen meat nuggets without hydrated wheat bran (HWB)

FEN-4 = Spent hen meat nuggets with 4.0 % HWB, FEN-8 = Spent hen meat nuggets with 8.0 % HWB

FEN-12 = Spent hen meat nuggets with 12.0 % HWB

Table.2 Physico-chemical and proximate qualities of SHM emulsion incorporated with various levels of hydrated wheat Bran (HWB)

Parameter	CON	SHME-4	SHME-8	SHME-12
pH	5.64 ± 0.01 ^a	5.95 ± 0.01 ^b	6.03 ± 0.02 ^c	6.18 ± 0.01 ^d
Moisture (%)	67.15 ± 0.02 ^d	64.28 ± 0.02 ^c	62.82 ± 0.02 ^b	61.01 ± 0.03 ^a
Protein (%)	16.50 ± 0.03 ^d	16.10 ± 0.01 ^c	15.60 ± 0.03 ^b	15.20 ± 0.02 ^a
Fat (%)	9.21 ± 0.03 ^d	8.92 ± 0.01 ^c	8.61 ± 0.02 ^b	8.04 ± 0.02 ^a
Ash (%)	1.94 ± 0.01 ^a	2.54 ± 0.01 ^b	2.77 ± 0.02 ^c	2.98 ± 0.01 ^d
WHC (%)	41.20 ± 0.03 ^a	49.40 ± 0.01 ^b	50.80 ± 0.02 ^c	51.70 ± 0.01 ^d
ES (%)	87.50 ± 0.29 ^a	92.50 ± 0.29 ^b	94.50 ± 0.29 ^c	95.50 ± 0.29 ^d

Means with different superscripts in row differ significantly (P<0.05) (n=6)

CON = Spent hen meat emulsion without hydrated wheat bran (HWB),

SHME-4 = Spent hen meat emulsion with 4.0 % HWB,

SHME-8 = Spent hen meat emulsion with 8.0 % HWB

SHME-12 = Spent hen meat emulsion with 12.0 % HWB

Table.3 Proximate composition of spent hen meat nuggets incorporated with various levels of hydrated wheat bran (HWB)

Parameter	CON	FEN-4	FEN-8	FEN-12
Moisture	63.32 ± 0.06 ^d	62.82 ± 0.05 ^c	61.50 ± 0.06 ^b	60.20 ± 0.03 ^a
Protein (%)	18.31 ± 0.05 ^d	17.90 ± 0.03 ^c	16.20 ± 0.07 ^b	15.50 ± 0.03 ^a
Fat (%)	11.44 ± 0.06 ^d	9.40 ± 0.02 ^c	8.99 ± 0.01 ^b	8.53 ± 0.02 ^a
Ash (%)	2.33 ± 0.01 ^a	3.45 ± 0.01 ^b	3.49 ± 0.01 ^c	3.63 ± 0.01 ^d
Carbohydrate (%)	1.54 ± 0.01 ^a	1.88 ± 0.01 ^b	4.07 ± 0.01 ^c	5.16 ± 0.01 ^d
Fiber (%)	3.06 ± 0.01 ^a	4.55 ± 0.02 ^b	5.75 ± 0.03 ^c	6.98 ± 0.03 ^d
Energy (Kcal)	182.73 ± 0.02 ^c	164.08 ± 0.02 ^a	162.31 ± 0.01 ^{ab}	159.72 ± 0.02 ^b
Moisture/Protein Ratio	3.46 ± 0.01 ^a	3.50 ± 0.01 ^b	3.80 ± 0.02 ^c	3.88 ± 0.01 ^d

Means with different superscripts in row differ significantly (P<0.05) (n=6)

CON = Spent hen meat nuggets without hydrated wheat bran (HWB),

FEN-4 = nuggets with 4.0 % HWB, FEN-8 = nuggets with 8.0 % HWB, FEN-12 = nuggets with 12.0 % HWB

Table.4 Physico-chemical parameters of spent hen meat nuggets incorporated with various levels of hydrated wheat bran (HWB)

Parameter	CON	FEN-4	FEN-8	FEN-12
pH	6.30 ± 0.01 ^a	6.38 ± 0.01 ^b	6.43 ± 0.01 ^c	6.45 ± 0.01 ^d
Water activity (a _w)	0.921 ± 0.003 ^d	0.901 ± 0.002 ^c	0.889 ± 0.001 ^b	0.878 ± 0.001 ^a
Cooking Yield (%)	88.54 ± 0.02 ^a	92.13 ± 0.04 ^b	93.88 ± 0.06 ^c	94.34 ± 0.03 ^d
Moisture Retention (%)	35.25 ± 0.01 ^a	39.56 ± 0.03 ^b	45.52 ± 0.02 ^c	50.40 ± 0.01 ^d
Fat Retention (%)	90.23 ± 0.07 ^a	93.35 ± 0.02 ^b	95.95 ± 0.01 ^c	98.65 ± 0.05 ^d
Shear (N)	0.98 ± 0.01 ^a	1.12 ± 0.01 ^b	1.19 ± 0.01 ^c	1.28 ± 0.01 ^d

Means with different superscripts in row differ significantly (P<0.05) (n=6)

CON = Spent hen meat nuggets without hydrated wheat bran (HWB),

FEN-4 = nuggets with 4.0 % HWB, FEN-8 = nuggets with 8.0 % HWB, FEN-12 = nuggets with 12.0 % HWB

Table.5 Instrumental color analysis of spent hen meat nuggets incorporated with various levels of hydrated wheat bran (HWB)

Parameter	CON	FEN-4	FEN-8	FEN-12
Lightness (L*)	47.87 ± 0.01 ^a	48.81 ± 0.02 ^b	52.59 ± 0.02 ^c	54.01 ± 0.03 ^d
Redness (a*)	9.89 ± 0.02 ^d	8.22 ± 0.02 ^c	7.72 ± 0.03 ^b	7.24 ± 0.02 ^a
Yellowness (b*)	19.28 ± 0.01 ^a	20.46 ± 0.03 ^b	21.31 ± 0.01 ^c	23.38 ± 0.01 ^d

Means with different superscripts in row differ significantly (P<0.05) (n=9)

CON = Spent hen meat nuggets without hydrated wheat bran (HWB),

FEN-4 = nuggets with 4.0 % HWB, FEN-8 = nuggets with 8.0 % HWB, FEN-12 = nuggets with 12.0 % HWB

Table.6 Instrumental Texture profile of spent hen meat nuggets incorporated with various levels of hydrated wheat bran (HWB)

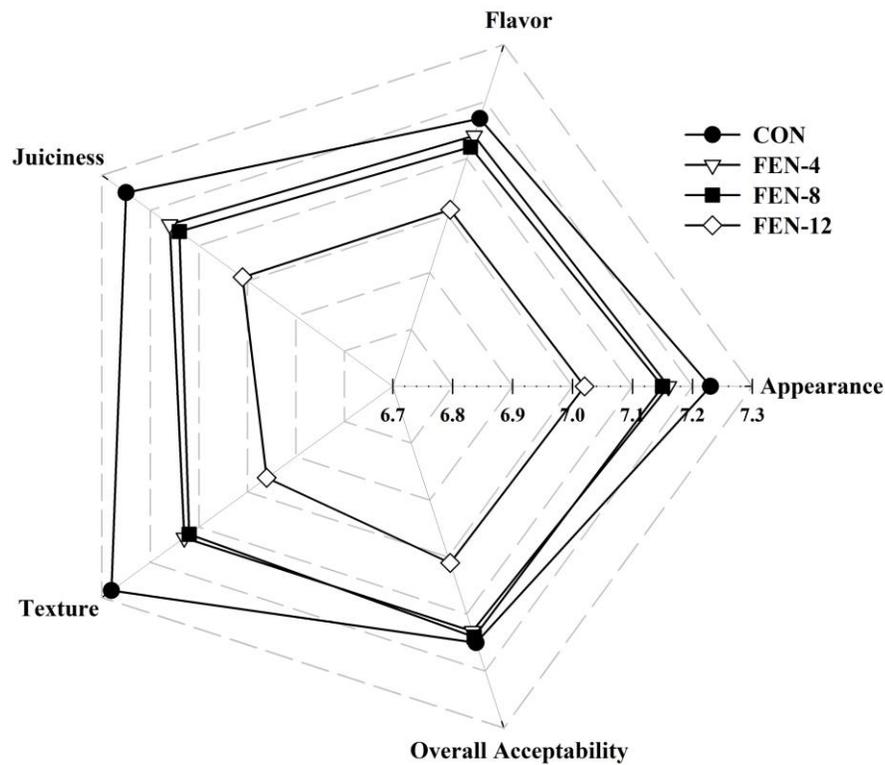
Parameter	CON	FEN-4	FEN-8	FEN-12
Hardness (N)	13.64 ± 0.03 ^a	14.10 ± 0.03 ^b	14.75 ± 0.03 ^c	16.01 ± 0.02 ^d
Springiness (mm)	11.94 ± 0.06 ^d	10.57 ± 0.03 ^c	10.24 ± 0.01 ^b	9.52 ± 0.02 ^a
Stringiness (mm)	18.32 ± 0.02 ^d	16.74 ± 0.03 ^c	16.04 ± 0.04 ^b	15.20 ± 0.01 ^a
Cohesiveness	0.65 ± 0.01 ^d	0.53 ± 0.01 ^c	0.49 ± 0.01 ^b	0.45 ± 0.01 ^a
Chewiness (J)	58.20 ± 0.01 ^a	61.30 ± 0.01 ^b	63.01 ± 0.02 ^c	65.97 ± 0.02 ^d
Gumminess (N)	6.91 ± 0.01 ^a	7.24 ± 0.01 ^b	7.28 ± 0.02 ^b	7.55 ± 0.03 ^c
Resilience	0.87 ± 0.01 ^c	0.85 ± 0.01 ^{bc}	0.84 ± 0.01 ^{ab}	0.83 ± 0.01 ^a

Means with different superscripts in row differ significantly (P<0.05) (n=9)

CON = Spent hen meat nuggets without hydrated wheat bran (HWB),

FEN-4 = nuggets with 4.0 % HWB, FEN-8 = nuggets with 8.0 % HWB, FEN-12 = nuggets with 12.0 % HWB

Fig.1 Sensory properties of spent hen meat nuggets incorporated with various levels of hydrated wheat bran (HWB)



CON = Spent hen meat nuggets without hydrated wheat bran (HWB),

FEN-4 = nuggets with 4.0 % HWB, FEN-8 = nuggets with 8.0 % HWB, FEN-12 = nuggets with 12.0 % HWB

It is observed that the shear press value increased significantly ($P < 0.05$) with incorporation of wheat bran. Lowest (0.98 N) shear press value has been reported for control while highest for FEN-12 (1.28 N). It might be due to increase in firmness of texture, swelling of fibers with moisture and higher interaction of protein-fiber in the meat matrix. Chang and Carpenter (1997) also reported higher shear press value for frankfurters added with oat bran.

Instrumental color analysis

The first stimulus for the consumer acceptability of meat and meat products is color. Therefore, it is important to assess color attributes at the time of incorporation of various non-meat ingredients in meat products. Hunter L^* , a^* and b^* values of the SHM incorporated with different levels of hydrated wheat bran (0, 4, 8 and 12 %) are presented in Table 5.

Hunter L^* , a^* and b^* values (Table 5) differed significantly ($P < 0.05$) due to incorporation of different levels of hydrated wheat bran. Lightness values of spent hen meat nuggets increased significantly ($P < 0.05$) with increase in level of hydrated wheat bran. Lowest L^* values (lightness) were observed in control while highest values for FEN-12 HW which shows that incorporation of hydrated wheat bran resulted in lighter colored meat products. Decrease in color and appearance of hydrated wheat bran added nuggets were in consonance with increased in lightness (L^*). Present findings are in agreement with Yilmaz (2005) for low fat meat balls and Yasarlar *et al.*, (2007) for Turkish meat balls added with cereal bran.

Redness (a^*) values were decreased significantly ($P < 0.05$) with addition of hydrated wheat bran, higher the wheat bran lower the redness. It might be due to dilution

of redness of lean meat with addition of white colored wheat bran. Similar declining trend was observed by Lin and Huang (2003) for low fat frankfurters incorporated with konjac/gellan gum mixed gels. The yellowness (b^*) increased significantly ($P < 0.05$) with the incorporation of hydrated wheat bran. It might be due to the presence of carotenoid pigments of wheat bran (Yilmaz, 2005). Hughes *et al.*, (1997) also who reported increase in yellowness (b^*) in frankfurters with the addition of oat bran.

Texture profile analysis

Comparative objective evaluation of different textural parameters in fiber enriched nuggets and control products (Table 6) clearly revealed that hardness of the product increased linearly with the increase in fiber content in the SHM nuggets. The hardness was measured highest in FEN-12 and lowest in control. Similar increase in hardness with addition of wheat bran was reported by Saricoban *et al.*, (2009) in beef patties and Yilmaz (2005) in meat balls. The springiness and stringiness significantly ($P < 0.05$) varied with the addition of hydrated wheat bran in SHM nuggets. The springiness and stringiness followed a decreasing trend with the increase in wheat bran content in the product. Springiness indicates the ability of the product regains its shape after deformation during the compression cycle (Texture Technologies, 2003). Springiness values were related to the elastic properties of nuggets, so decrease in the springiness indicated that the elasticity of nuggets is decreased with the increase in level of incorporation of hydrated wheat bran. It might be due to the formation of gel with the incorporation of hydrated wheat bran on cooking which lead to decrease in elasticity properties. Present findings are in agreement with the results reported by Saricoban *et al.*, (2009) for beef patties incorporated with wheat bran.

Cohesiveness is ability of food product to retain its structure after compression (Texture Technologies, 2003). Incorporation of hydrated wheat bran lead to decrease in cohesiveness significantly ($P<0.05$) and it followed a decreasing trend with the increase in the level of wheat bran in the formulation. Huang *et al.*, (2005) has not observed any effect with addition of rice bran in pork meat balls. Increase in hardness and decrease in cohesiveness values with the incorporation of bran were observed by Yadav *et al.*, (2016) for chicken sausage. Chewiness is resistance to compression. Chewiness and Gumminess values are directed by hardness, cohesiveness and springiness values of the product. Incorporation of hydrated wheat bran showed significant ($P<0.05$) increase in chewiness and gumminess values. Significantly ($P<0.05$) higher chewiness and gumminess values in FEN-12 HW might be due to their higher hardness values. Huang *et al.*, (2005) reported increase in chewiness and gumminess values with the incorporation of rice bran on kung-wan, a ground and emulsified pork meatballs.

Resilience is how well a product fights to regain its original position (Texture Technologies, 2003). It is observed that the resilience of SHM nuggets decreased significantly ($P<0.05$) due to incorporation of different levels of hydrated wheat bran. Decrease in resilience may be attributed to increase in hardness along with decrease in springiness and stringiness values with the incorporation of wheat bran. Saricoban *et al.*, (2009) reported similar significant decrease in resilience with the addition of wheat bran in beef patties.

Sensory quality

Marketing of meat products at consumer level depends upon sensory quality. Sensory scores (Fig. 1) for all the quality attributes of SHM nuggets varied significantly ($P<0.05$) with the

incorporation of different levels of hydrated wheat bran.

Appearance and color scores decreased with the increase in hydrated wheat bran content in the product. However, the sensory panelists rated FEN-4 and FEN-8 comparable. FEN-12 scored lowest and control scored highest appearance and color scores. These results are in conformity with our observations recorded by chromo color meter. However sensory panelists awarded significant ($P<0.05$) higher textual scores to control than all the treatments. These results can be correlated with the results of instrumental textural parameters

Flavour and juiciness scores varied in similar pattern, these were comparable for FEN-4 and FEN-8 and lowest for FEN-12 and highest for control amongst all the products. The diminution of meat flavor was noticed by the sensory panelist with the incorporation of higher amount of HWB on replacing the lean meat. The juiciness scores can be correlated with the decrease in moisture content in developed products.

The overall acceptability scores were highest for FEN-8 amongst treatments however it was statistically comparable with FEN-4 and control. The sensory panelists rated FEN-8 'Very Good to Excellent'. Similar significant ($P<0.05$) decrease in all the sensory attributes on addition of wheat and oat bran were observed by Talukder and Sharma (2010) for chicken meat patties and Yasarlar *et al.*, (2007) for Turkish meat balls.

Results concluded that the fiber enriched spent hen meat nuggets can be successfully developed with the addition of pre-hydrated 8 % wheat bran in the formulation. The developed product has 200 % higher fiber content, low-fat (< 10 % total fat), 15 % lower calories and comparable sensory attributes to

high fat (control) spent hen meat nuggets. Therefore, the authors recommend the results to meat industry for the commercial utilization of the developed technology.

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