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Quality characteristics of low fat chicken sausages fortified with pearl millet#

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Abstract

The present study was conducted to optimise the level of dietary fibre source viz. pearl millet flour at 5.0, 10.0 and 15.0% levels (BT1, BT2 and BT3) in formulation of chicken sausage. The emulsion pH, emulsion stability, product pH, cooking yield, moisture, ash content, fat retention and moisture retention values increased significantly (P<0.05), whereas, protein, emulsion fat and product fat content decreased significantly (P<0.05) with increase in level of pearl millet flour. There was no significant difference in water activity values between the control and treatments. Among the textural and colour parameters, hardness, springiness, cohesiveness, gumminess, chewiness, resilience and redness values increased significantly, whereas, lightness and yellowness values decreased significantly (P<0.05) in treatments. The scores of all sensory attributes decreased significantly (P<0.05) with pearl millet flour incorporation in chicken sausage. Among the treatments, the scores of BT3 were significantly lower than BT1; however, BT2 had comparable overall acceptability sensory scores with BT1 and BT3. Therefore, BT2- chicken sausage incorporated with 10.0% pearl millet was selected as the best treatment.

Keywords: *Chicken sausage*, *Pearl millet, Quality parameters*

The use of processed meat products is thought to affect the health of regular consumers and is also considered to be one of the causative factors for many diseases due to the low dietary fibre level. Dietary fibre contributes to the regulation of the gastrointestinal tract, cholesterol excretion, lowering blood sugar levels etc. A deficiency of Dietary fiber in the diet leads to various metabolic disorders of the population, which in turn lead to an increase in the incidence of colon cancer, cholelithiasis and atherosclerosis. Fibre from different sources show different degrees of water holding capacity and water binding (Anatasia and Eimear, 2012). Fibre (Food fibre)

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contributes to accelerated excretion of harmful substances from the body, which is especially important to prevent various life style diseases like constipation and GIT disorders. Meat lacks in this potential ingredient and incorporation of appropriate fibre rich ingredients can improve the health image of meat products (Verma and Banerjee, 2010). Meat products can be enriched by incorporation of dietary fibre from different sources to enhance the nutritional composition and desirability (Verma *et al.,* 2010). The functional and technological properties of dietary fibre does not alter the product but increases the cooking yield due to the water and fat binding properties (Talukder and Sharma, 2010). Because of proven health benefits, pearl millet (*Pennisetum glaucum*) is becoming one of the choices of possible components of functional foods in Western India. Pearl millet has an excellent amino acid profile, except for a deficiency of lysine (Burton *et al.* 1972). It is an important food item in the desert areas of India and Africa. It costs much less than other conventional cereals and has a high nutritional value. It has high dietary fibre (2.6–4.0%) and protein content (8.5–15.1%) and contains several essential minerals like calcium, magnesium, phosphorus, sodium, potassium, zinc, copper and iron (Abdalla *et al.*1998). Therefore, the present study was conducted to develop fibre fortified chicken sausages with the incorporation of pearl millet for healthy life style of consumer

Materials and methods

Live birds were procured from local market of Mathura and were slaughtered at the Meat Processing Laboratory of Department of Livestock Products Technology, DUVASU, Mathura.The carcasses were washed, deboned and trimmed in the laboratory. The deboned lean meat was stored at -18^0 C till further use. Cellulose casings (C19×84ft.) were procured from Food Aiders$^{(R)}$, New Delhi. Different spices, condiments *i.e.* onion, ginger and garlic (3:1:1), salt of food grade (TATA salt ®),food grade refined oil (Fortune®), excellent quality pearl millet were procured from local market, Mathura. Spices were cleaned thoroughly without any extraneous materials and kept for drying at 50ºC in a hot air oven for about 2-3 hrs to remove the moisture content followed by grinding into fine powder. Spice mix was formulated and stored for subsequent use. Condiments *i.e.* onion, ginger and garlic in the ratio 3:1:1 were peeled and chopped manually by a vegetable chopper. Pearl millet seeds were dried at 65ºC for 2-3 hours in a hot air oven. After drying, pearl millet seeds were ground into flour using a mixer grinder and packaged in pre sterilized LDPE pouches. Low density Polyethylene (LDPE) bags were sourced from local market and sterilized by exposing to UV light for 30 minutes before use. All the chemicals used in the study were of analytical grade and procured from Hi Media Laboratories (P) Ltd, Mumbai.

Methodology of preparation of chicken sausages

Frozen chicken meat was thawed at refrigeration temperature overnight. The thawed chicken meat was cut into small chunks and then minced in a mincer (Sirman, MOD-TC 32 R10U.P. INOX,Marsango, Italy) through 6mm plate first followed by mincing through 4mm plate. Other ingredients like common salt, vegetable oil, refined wheat flour, sodium tri polyphosphate, spice mixture and condiment mixture were weighed accurately according to formulation. Meat emulsion was prepared in a bowl chopper (Sirman,MOD C 15 2.8G 4.0 HP, Marsango, Italy). The minced meat was blended with salt, sodium tri polyphosphate for 1.5 minute. Water in the form of crushed ice was added and blending was continued for 1 min. This was followed by addition of spice mixture, condiments and other ingredients and mixing was again done for 1.5 to 2 minutes to get the desired emulsion. Adequate care was taken to keep the end point temperature below 18ºC by preparing the emulsion in the cool hours of morning, by addition of meat and other ingredients in a chilled/partially thawed form and by addition of crushed ice or ice water. The emulsion was filled in to artificial casings using a sausage filler (SF-260, ISO 9001:2000) and linked at about 12 cm intervals. Then these sausages were cooked in simmering water (>80ºC) for about 35 minutes. The formulation for chicken sausages is given in Table1.

Table 1. Formulation for the preparation of chicken sausage

Ingredients	Percent (%)
Chicken meat	71.2
Refined oil	10
Ice flakes	8
Refined wheat flour	4
Condiments	3
Spices	2
Salt	1.5
STPP	0.3
Total	**100**

Low fat chicken sausages were incorporated with pearl millet flour separately at 5, 10 and 15 % level to replace lean meat in formulation. The following abbreviations were used for present experiment: CT2- (control) chicken sausage incorporated without pearl millet flour.

BT1- chicken sausage incorporated with 5% pearl millet,

BT2- chicken sausage incorporated with 10% pearl millet,

BT3- chicken sausage incorporated with 15% pearl millet.

Physico- chemical properties

pH

The pH was determined by using a digital pH meter (WTW, Germany, model pH 330i) as per the procedure of Troutt *et al.* (1992).

Emulsion stability

The Emulsion stability was determined as per the procedure of Baliga and Madaiach, (1970).

Cooking yield

The weight of chicken sausages was recorded before and after cooking. The cooking yield was calculated as per the formula given below and expressed as percentage (Murphy *et al.,* 1975)

Weight of cooked chicken sausages × 100

Cooking yield % = Weight of raw stuffed sausage

Water activity

Water activity of each sample was measured three times in duplicate using a water activity meter (AquaLab 3 TE, Inc. Pullman, WA).

Moisture Retention

Moisture retention value represented the amount of moisture retained in the cooked product per 100 g of sample and was determined according to equation by El-Magoli *et al.* (1996) given below:

Moisture retention (%) = (% cooking yield x moisture in cooked sausage)/100

Fat retention

Fat retention was calculated according to method given by Murphy *et al.* (1975) with slight modifications.

Fat retention (%) = (A/B) x 100

A = Fat content in cooked sausage x weight of cooked sausage

B = Fat content in uncooked sausage x weight of uncooked sausage

Moisture content

Moisture was determined as per AOAC (1980) method. After cooling, the loss in weight was determined to calculate moisture content and expressed as %.

$$\text{Moisture \%} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

Protein content

The total protein content of chicken sausage was estimated as per method described in AOAC (1995) with suitable modifications using automatic digestion and distillation unit (KelPlus-KES 12L, Pelican

Industries, Chennai).

Fat

The Soxhlet method was used for estimation of fat (AOAC, 1995).

Ash

The total ash content of chicken sausage was estimated as per method described in AOAC (1995) in a muffle furnace at 500 ± 15ºC for 4hrs.

Texture profile analysis

The texture profile analysis of chicken sausages was done with the help of instrumental texture profile analyser (TA HD Plus Texture analyser). The procedure used for instrumental texture profile analysis was similar to that described by Bourne *et al.* (1978).The parameters determined were: Hardness(N/cm^2) = maximum force required to compress the sample(H); Springiness (cm/mm)=ability of sample to recover its original form after a deforming force was removed (S); Cohesiveness (Ratio) = Extent to which samples could be deformed prior to rupture(A2/A1, A1 being the total energy required for first compression and A2 total energy required for second compression); Gumminess (N/cm^2 or g/mm^2)=force necessary to disintegrate a semi solid sample for swallowing (H × Cohesiveness); and Chewiness (N/cm or g/mm) = work required to the sample for swallowing (S × Gumminess).

Instrumental colour analysis

The colour parameters of the chicken sausages were measured using Hunter colourimeter of ColourTech PCM+ (Colour Tec Associates Inc. Clinton NJ, USA) at department of Goat Products Technology, CIRG, Makdhum. The coin shaped lance of instrument attached to software was directly put on the surface of chicken sausage at randomly chosen six different points (Hunter and Harold, 1987). CIE *L**, *a** and *b** values were determined as indicators of lightness, redness and yellowness, respectively.

Sensory evaluation

The sensory quality of samples was adjudged using 8 point descriptive scale (Keeton*et al.*, 1984) where 8 denoted extremely desirable and 1 denoted extremely poor. A sensory panel (semi trained) of seven judges drawn from post-graduate students and faculty of Veterinary College, DUVASU, Mathura were requested to adjudge the products for their different quality attributes *viz.,* colour and appearance, flavor, texture, juiciness, saltiness, mouth coating, meat flavour intensity and overall acceptability.

Statistical analysis

Data were analysed statistically on 'SPSS-16.0' software package as per standard methods (Snedecor and Cochran 1994). Duplicate samples were drawn for each parameter and the experiment was replicated thrice (n=6). Sensory evaluation was performed by a panel of seven member judges three times, so total observations of each sensory attribute were 21 (n=21). Data were subjected to one way ANOVA, homogeneity test and Duncan's Multiple Range Test (DMRT) for comparing the means to find the effects between treatments at 5% level.

Results and discussion

Physico-chemical properties

The effects of pearl millet flour on physico-chemical properties of chicken sausage are presented in Table 2. Emulsion pH, emulsion stability, product pH, cooking yield and ash content values increased significantly ($P<0.05$) whereas protein content decreased significantly ($P<0.05$) with increasing level of pearl millet flour (PMF) incorporation in chicken sausage. Higher emulsion pH and product pH might be due to neutral nature of pearl millet. The gradual increase in pH with increased level of pearl millet flour in chicken nuggets was in agreement with findings of Para and Ganguly (2015). They found that the addition of 20% pearl millet flour to chicken nuggets caused an increase in pH of the products. Increase in emulsion stability with increase in the level of pearl millet flour might be due to the gelatinization of the starch at high temperature, which stabilized the emulsion (Comer, 1979). Again, higher yield observed in the present study might be due to the good

Table 2. Effect of pearl millet flour on physico-chemical parameters (Mean±SE) of chicken sausage

Parameters	CT2	BT1	BT2	BT3	Treatment Mean
Emulsion pH	6.01^{d}±0.02	6.08^{c}±0.02	6.16^{b}±0.02	6.24^{a}±0.01	6.12±0.03
Emulsion stability (%)	92.32^{d}±0.02	94.02^{c}±0.03	94.86^{b}±0.04	95.53^{a}±0.02	94.18±0.05
Emulsion fat (%)	6.82^{a}±0.01	6.63^{b}±0.02	6.58^{b}±0.05	6.47^{c}±0.04	6.62±0.03
Product pH	6.05^{d}±0.01	6.12^{c}±0.01	6.21^{b}±0.01	6.27^{a}±0.02	6.16±0.03
Cooking yield (%)	91.03^{d}±0.04	92.35^{c}±0.06	93.78^{b}±0.05	94.93^{a}±0.07	93.02±0.04
Moisture (%)	66.89^{b}±0.14	67.71^{ab}±0.15	68.11^{ab}±0.09	68.91^{a}±0.06	67.90±0.11
Protein (%)	17.88^{a}±0.07	16.73^{b}±0.04	16.26^{c}±0.03	15.77^{d}±0.03	16.66±0.06
Product fat (%)	6.44^{a}±0.01	6.32^{b}±0.01	6.28^{b}±0.01	6.17^{c}±0.03	6.30±0.03
Ash (%)	2.59^{d}±0.02	2.78^{c}±0.01	2.95^{b}±0.02	3.12^{a}±0.01	2.86±0.04
Fat retention (%)	85.96^{b}±0.06	88.04^{ab}±0.02	89.50^{ab}±0.06	90.52^{a}±0.05	88.50±0.06
Water activity (a_w)	0.984±0.01	0.982±0.03	0.982±0.02	0.983±0.01	0.982±0.01
Moisture retention (%)	60.89^{b}±0.03	62.53^{ab}±0.05	63.88^{ab}±0.04	65.42^{a}±0.04	63.18±0.05

Note: Means bearing different superscripts in a row differ significantly (P<0.05)

gelation capacity of pearl millet (Oshodi *et al.,* 1999). Moisture and fat retention values of BT3 were significantly (P<0.05) higher than CT2, however these values for BT1 and BT2 were comparable to CT2 and BT3. Higher moisture content with increased level of pearl millet flour might be due to water absorption capacity of natural fibres. Fat globules might be embedded in gel structure of protein lattice and hence leaching out of fat during cooking of the product was minimised resulting in higher fat retention values. Product fat and emulsion fat levels decreased significantly (P<0.05) in treatments when compared to control. Any processed meat product containing <10% fat is categorized as low fat product. As per Jones *et al.* (1970), pearl millet flour contained 67.5% carbohydrate, 11.6% protein, 5.0% fat, 1.2% crude fibre and 2.35% ash content.

Textural parameters

The effects of pearl millet flour on textural parameters of chicken sausage are presented in Table 3. The values of all textural parameters increased significantly (P<0.05) with increased level of pearl millet flour in low fat chicken sausages, however there was no significant difference between CT2 and BT1 for cohesiveness, gumminess and chewiness values. Higher textural parameter values in treatments might be due to interaction of fibre and pectin with water resulting in higher viscosity and gumminess in product. Santhi and Kalaikannan (2014) reported that increased oat flour levels (10% and 20%) significantly (P<0.05) increased the hardness of cooked chicken nuggets as compared to control. The findings of the present study about TPA is in harmony with the findings of Devatkal *et al.*(2011)who showed that the incorporation of 10% sorghum flour significantly (P<0.05) increased hardness, gumminess, and chewiness values of chicken nuggets. Yoo *et al.*(2007)also observed higher values of hardness, springiness, gumminess and chewiness in low fat sausages than those of the regular fat sausages.

Colour parameters

The effects of pearl millet flour on colour parameters of chicken sausage are presented in Table 4. The lightness and yellowness values decreased significantly (P<0.05) whereas redness values increased significantly (P<0.05) with increased level of pearl millet flour in chicken sausages. There was no significant difference between BT2 and BT3 for redness as well as between CT2 and BT1 for yellowness values. Lower lightness and higher redness values in treatments might be due to greyish brown colour of pearl millet flour which imparted brownish colour to the product on cooking. Rosli *et al.* (2011) also reported significantly (P<0.05) lower lightness and yellowness values in chicken patties with addition of oyster mushroom as a dietary fibre source.

Table 3. Effect of pearl millet flour on textural parameters (Mean±SE) of chicken sausage

Parameters	CT2	BT1	BT2	BT3	Treatment mean
Hardness (N/cm^2)	13.30^d±0.02	16.02^c±0.05	18.79^b±0.06	21.01^a±0.06	17.28±0.07
Springiness (mm)	24.02^d±0.07	25.39^c±0.05	26.11^b±0.07	26.51^a±0.04	25.76±0.06
Cohesiveness (Ratio)	0.69^c±0.03	0.72^c±0.04	0.79^b±0.04	0.82^a±0.02	0.75±0.02
Gumminess (N/cm^2)	6.55^c±0.04	6.82^c±0.06	7.12^b±0.05	7.62^a±0.05	7.02±0.04
Chewiness (N/cm)	133.91^c±0.07	134.71^c±0.06	135.12^b±0.08	139.35^a±0.05	135.77±0.06
Resilience (Ratio)	0.59^d±0.03	0.63^c±0.03	0.68^b±0.04	0.73^a±0.04	0.65±0.02

Note: Means bearing different superscripts in a row differ significantly (P<0.05)

Table 4. Effect of pearl millet flour on colour parameters (Mean±SE) of chicken sausage

Parameters	CT2	BT1	BT2	BT3	Treatment mean
Lightness (*L**)	41.25^a±0.05	39.08^b±0.03	38.61^c±0.03	36.58^d±0.04	38.88±0.04
Redness (*a**)	8.22^c±0.05	9.63^b±0.03	10.17^a±0.03	10.38^a±0.05	9.60±0.03
Yellowness (*b**)	9.28^a±0.03	8.89^a±0.04	8.17^b±0.05	7.87^c±0.04	8.55±0.03

Note: Means bearing different superscripts in a row differ significantly (P<0.05)

Table 5. Effect of pearl millet flour on sensory scores (Mean±SE) of chicken sausage

Attributes	CT2	BT1	BT2	BT3	Treatment mean
Colour and appearance	7.32^a±0.04	7.15^b±0.05	7.09^b±0.03	6.95^c±0.03	7.12±0.03
Flavour	7.25^a±0.03	7.15^b±0.03	7.07^b±0.04	6.86^c±0.03	7.08±0.04
Texture	7.34^a±0.04	7.28^b±0.03	7.11^{bc}±0.04	7.02^c±0.03	7.18±0.04
Juiciness	7.25^a±0.03	7.16^b±0.04	7.04^{bc}±0.03	6.95^c±0.05	7.10±0.03
Saltiness	7.36^a±0.03	7.29^{ab}±0.03	7.21^b±0.04	7.13^c±0.05	7.24±0.04
Mouth coating	7.38^a±0.03	7.28^{ab}±0.05	7.14^b±0.04	6.87^c±0.03	7.16±0.05
Meat flavour intensity	7.32^a±0.05	7.12^b±0.04	7.03^{bc}±0.05	6.84^c±0.04	7.07±0.05
Overall acceptability	7.37^a±0.04	7.14^b±0.03	7.06^{bc}±0.04	6.92^c±0.05	7.12±0.04

Note: Means bearing different superscripts in a row differ significantly (P<0.05)

Sensory evaluation

The effects of pearl millet flour on sensory scores of chicken sausages are presented in Table 5.Colour and flavour scores decreased significantly (P<0.05) with increased level of pearl millet flour incorporation on low fat chicken sausage, however no significant difference was observed between BT1 and BT2. The findings of lower colour and appearance scores might be related to lower lightness and higher redness values of chicken sausage with pearl millet flour incorporation, as also observed in instrumental colour analysis in present study. Padda *et al*. (1989) also observed significant (P<0.05) decrease in sensory scores of goat meat balls with increased level of roasted *besan*. Kumar and Sharma (2006) and Bhat and Pathak (2009) also observed similar findings in the flavour of extended meat products. Saltiness and mouth coating scores of CT2 were significantly (P<0.05) higher than BT2 and BT3, however scores of BT1 were comparable to CT2 and BT2. Lower saltiness scores at higher level of pearl millet flour incorporation in treatments might be due to more moisture retention capacity of flour resulting in less salty taste in treatments than control. Texture, juiciness, meat flavour intensity and overall acceptability scores decreased significantly (P<0.05) in treatments. Verma *et al.* (1984) reported that a decrease in sensory scores at higher extender levels may be due to the exchange of structural meat protein by extender. Yang *et al.* (2007) showed that low-fat pork sausages of good acceptance could be made by adding hydrated oatmeal, up to 25 percent. In present study, the scores of BT2 for various sensory attributes including overall acceptability were comparable to BT1 and BT3. The sensory scores decreased significantly (P<0.05) in BT3, whereas BT2 was

much acceptable by sensory panelists in terms of flavour, texture and overall acceptability. Therefore, BT2- chicken sausage incorporated with 10.0% pearl millet was selected as the best treatment

Conclusion

From this study, it can be concluded that pearl millet flour at 10% can be successfully utilised in the formulation of low-fat chicken sausages without affecting the physicochemical, textural and sensory attributes. Low-fat chicken sausages with pearl millet flour is healthier and with enhanced functionality for consumers. Incorporation of pearl millet flour also increased the emulsion stability and cooking yield which indicated its commercial importance as it will ultimately reduce the cost of production. Low-fat chicken sausages with good to excellent quality, nutritional value and acceptance can be prepared by adding 10% pearl millet flour.

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Conflict of interest

The authors declare that they have no conflict of interest.

References

Abdalla, A.A., El Tinay, A.H., Mohamed, B.E. and Abdalla, A.H. 1998. Effect of traditional processes on phytate and mineral content of pearl millet. *Food Chem.* **63**: 79-84.

Anastasia, K. and Eimear, G. 2012. Recent advances in the development of high-fibre baked products. *Trends in Food Sci. Technol.* **28**: 4-14.

AOAC. 1980. Official methods of analysis (13th Ed.). Washington, DC: Association of Official Analytical Chemists.

AOAC. 1995. Official Method of Analysis. (16th Ed.) Association of Official Analytical Chemists, Washington, DC.

Baliga, B.R. and Madaiah, N. 1970. Quality of sausages emulsion prepared from mutton. *J.Food Sci.* **35**: 383-385.

Bhat, Z.F.and Pathak, V. 2009. Effect of mung bean (*Vigna radiata*) on quality characteristics of oven roasted chicken seekh kababs. *Fleischwirtschaft Int.***6**: 58-60.

Bourne, M.C., Kenny, J.F. and Barnard, J. 1978. Computer assisted readout of data from texture profile analysis curves 1. *J. Texture Stud.***9**: 481-494.

Burton, G.W., Wallace, A.T. and Rachie, K.O. 1972. Chemical composition and nutritive value of pearl millet (*Pennisetum typhoides* (Burm.) grain 1. *CropSci.***12**: 187-188.

Comer, F.W. 1979. Functionality of fillers in comminuted meat products. *Can. Inst. Food Technol. J*. **12**: 157-165.

Devatkal, S.K., Kadam, D.M., Naik, P.K. and Sahoo, J. 2011. Quality characteristics of gluten free chicken nuggets extended with sorghum flour. *J. Food Qual.* **34**: 88-92.

El-Magoli, S.B., Laroia, S. and Hansen, P.M.T. 1996. Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. *Meat Sci.* **42**: 179-193.

Hunter, R.S. and Harold, R.W. 1987. The measurement of appearance. John Wiley and Sons.

Jones, R.W., Beckwith, A.C., Khoo, U. and Inglett, G.E. 1970. Protein composition of proso millet. *J. Agric. Food Chemi.***18**: 37-39.

Keeton, J.T., Foegeding, E.A. and Patana Anake, C. 1984. A comparison of nonmeat proteins, sodium tripolyphosphate

and processing temperature effects on physical and sensory properties of frankfurters. *J. Food Sci.* **49**: 1462-1465.

Kumar, R.R. and Sharma, B.D. 2006. Efficacy of barley flour as extender in chicken patties from spent hen meat. *J. Appl. Anim. Res.***30**: 53-55.

Murphy, E.W., Criner, P.E. and Gray, B.C. 1975. Comparisons of methods for calculating retentions of nutrients in cooked foods. *J. Agric. Food Chem.,***23**: 1153-1157.

Oshodi, H.N., Ogungbenle, M.O. and Oladimeji, A.A. 1999. Chemical composition, nutritionally valuable minerals and functional properties of benniseed (*Sesamum radiatum*), pearl millet (*Pennisetum typhoides*) and quinoa (*Chenopodium quinoa*) flours. *Int. J. Food Sci. Nutr*. **50**: 325-331.

Padda, G.S., Sharma, N. and Bisht, G.S. 1989. Effect of some vegetative extenders on organoleptic and physico-chemical properties of goat meat balls. *Indian J. Meat Sci. Technol.***2**: 116-122.

Para, P.A. and Ganguly, S. 2015. Effect of bajra flour (Pearl millet) on some quality and sensory attributes of chicken nuggets. *Asian J. Anim. Sci.* **10**: 107-114.

Rosli, W.I., Solihah, M.A., Aishah, M., Nik Fakurudin, N.A. and Mohsin, S.S.J. 2011. Colour, textural properties, cooking characteristics and fibre content of chicken patty added with oyster mushroom (*Pleurotus sajor-caju*). *Int. Food Res. J.***18**: 612-618.

Santhi, D. and Kalaikannan, A. 2014. The effect of the addition of oat flour in low-fat chicken nuggets. *J. Nutr. Food Sci.* 4: 1.

Snedecor, G.W. and Cochran, W.G. 1994. Statistical methods, 6th Ed, Allied Pacific Pvt. Ltd., Bombay, 557.

Talukder, S. and Sharma, D.P. 2010. Development of dietary fiber rich chicken meat patties using wheat and oat bran. *J. Food Sci. Technol.***47**: 224-229.

Troutt, E.S., Hunt, M.C., Johnson, D.E., Claus, J.R., Kastner, C.L. and Kropf, D.H. 1992. Characteristics of low fat ground beef containing texture modifying ingredients. *J. Food Sci.* **57**: 19-24.

Verma, A.K. and Banerjee, R. 2010. Dietary fibre as functional ingredient in meat products: a novel approach for healthy living—a review. *J. Food Sci. Technol*. **47**: 247-257.

Verma, A.K., Sharma, B.D. and Banerjee, R. 2010. Effect of sodium chloride replacement and apple pulp inclusion on the physicochemical, textural and sensory properties of low fat chicken nuggets. LWT-*Food Sci. Technol*. **43**: 715-719.

Verma, M.M., Ledward, D.A. and Lawrie, R.A. 1984. Lipid oxidation and metmyoglobin formation in sausages containing chickpea flour. *Meat Sci.* **11**: 171-189.

Yang, H.S., Choi, S.G., Jeon, J.T., Park, G.B. and Joo, S.T. 2007. Textural and sensory properties of low fat pork sausages with added hydrated oatmeal and tofu as texture-modifying agents. *Meat Sci.* **75**: 283-289.

Yoo, S.S., Kook, S.H., Park, S.Y., Shim, J.H. and Chin, K.B. 2007. Physicochemical characteristics, textural properties and volatile compounds in comminuted sausages as affected by various fat levels and fat replacers. *Int. J. Food Sci. Technol.* **42**: 1114-1122. ■