Original Research Article

Effect of different cooking methods on Proximate Composition, Vitamins and Sensory Properties of Spent Hen Muscle

1. Introduction

Meat has been reported to be flesh of animal suitable for human consumption by Lawrie and Ledward (2006) and Sharma and Sharma, (2011) and it is supplied by different food animals such as cattle, goats, sheep, dog, pork, chicken, ducks, geese, pigeons, quails, Ostrich, broiler and spent hen as reported by Oluyemi and Roberts (2007). Some of these animals produce meats with religious restriction, but chicken meat has no restriction and its consumption can improve the nutritional status of individuals.

Spent hen is an old bird special breed for consistently and persistently egg production for a period of 12 – 18 months and thereafter used for meat and meat products production at the end of its reproductive cycle. It starts its egg production usually as a pullet from 16 – 20 weeks (Encyclopedia Americana, 2001; Banerjee, 2005), rises sharply and reaching peak at about 32 - 35 weeks of age and continue until sudden change in feed causes an early molting which delays egg laying process. In bird's egg production has no end, but the rate and size may decline with age due to unhealthy conditions, physical defects and when this occurs it become uneconomic to maintain as reported by Abalti *et al.* (2005) and it is disposed as spent hen during festivities.in Nigeria.

However, Wise farmers occasional examine their stock during production periods to avoid wastage of their resources. Moreover, meat is a complex food, enwrapped with different levels of connective tissues, but highly nutritious. However, meat subjected to heat treatment to make it edible, digestible, improve flavor and desirable colour, as well as increase shelf- life (Tornberg, 2005). Steam treatment permits attainment of moist-free texture, retention of meat's natural flavour and juices as well as offers less effect on meat fat compared to other wet heat methods. Moreover, steamed meat is highly cherished and desired by adolescent, convalescent and people

with weak digestive intestine. However, it results in meat structural, tissue modification and nutritional deteriorative changes.

2. **Materials and Method**

2.1. Sample procurement

Five live spent hens used in the study were purchased from the commercial farm of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology, Agbani, Nigeria. The birds were slaughtered individually by cutting the major veins and arteries of the neck, bled thoroughly and scaled at 85 ℃ for 30 seconds as reported by Alugwu *et al*. (2014), defeathered and eviscerated. The breast muscles of the birds were separated from the birds and utilized in the study.

2.2. Steam Generation Process and Utilization

A metal pot was half filled with clean water and placed on top a hot plate. A support to hold the sample in a perforated iron basket was added in the metal pot, whereas samples trimmed of skin, connective tissues, fat and bone, refrigerated to harden the muscles for easy slicing into $2cm^3$ thickness. These sliced samples were divided into three portions. Two portion was for each cooking method (roasting and steaming). Each cooking portion was subdivided into two cooking internal temperatures of 60 ^{0}C and 70 ^{0}C.Whereas the three portion served as the control. Thereafter, thawing samples for steaming were added to the iron basket and a thermometer attached to a sample. The hot plate was switched on for steam generation. This process continued until the internal temperature of the meat reached 60 ^{0}C and it was cooked for 10 min. This process was repeated for another until the internal temperature of the meat reached 70 ^{0}C and it was cooked for 10 min. The roasted samples was done in a fabricated baking equipment and the samples were inserted in the baker with a hole to pass and attached thermometer to a sample to check its cooking internal temperatures for 60 ^{0}C and it was cooked for 10 min and 70 ^{0}C and it was cooked for 10 min as roasted samples. Thereafter, these samples were allowed to cool in ambient temperature, surface moisture mopped with blotting paper and packaged in Ziploc bag and stored in refrigerator for further analysis.

2.3. Proximate Composition

2.3.1. Moisture Content Determination of the samples.

Moisture content of the samples was determined by the air oven method using standard methods of AOAC (2010). Moisture dish was cleaned and weighed (W_1). Five-gram of the samples was weighed into tarred moisture dishes (W_2). These samples were dried in a vacuum hot air oven at 105 ^{0}C for 2 h. The moisture dish was removed from the oven and cooled in desiccators to a constant weight (W_3). The dishes were weighed again, and percentage moisture content calculated as shown in eqn.1

$$\text{Moisture Content (\%)} = \frac{W2-W3}{W2-W1} \text{ X } 100 \qquad \text{Eqn.1}$$

Where: w_1 =weight of empty moisture dish

w_2 = weight of moisture dish with sample prior heat treatment

w_3 = weight of moisture dish with sample after heat treatment

2.3.2. Fat Content Determination of the Sample

The fat content of the sample was determined as described by (AOAC.2010). Three ground meat sample was weighed (W_1) into previously weighed thimbles and its mouth plugged with defatted cotton wool to prevent sample from flowing out. Therefore, the thimble with the sample was placed into the Soxhlet extractor and mounted on a 250mL Soxhlet flask previously weighed (W_2) and its capacity filled three quarter with Hexane. The Soxhlet apparatus was then mounted on top of a heating mantle and fat extracted from the samples for 2 hours or four refluxes. Consequently, the thimble was removed from the extractor, and the hexane was evaporated from the flask. Later, the flask and oil was subjected to oven to free traces of hexane from the oil and cooled in desiccators. Thereafter, the weight of flask with oil was determined after cooling the flask in the desiccators (W_3). The percentage fat content was calculated as shown in eqn.2.

$$\text{Fat Content (\%)} = \frac{W3-W2}{W1} \text{ X } 100 \qquad \text{Eqn.2}$$

Where: w_1 =weight of sample

w_2 = weight of empty flask

w_3 = weight of flask with fat

2.3.3. Ash Content Determination of the Sample

The ash content of the samples was determined by Muffle furnace using standard methods of AOAC (2010). The ground sample (2g) was weighed (W_1) into a crucible of known weight (W_2). The crucible containing the sample was placed in the Muffle furnace heated earlier previously at 500 ^{0}C and left for 6 h until the final product was clearly whitish ash. Thereafter, the crucible was removed from the Muffle furnace, placed in a desiccator and allowed to cool. Consequently, reweighed (W_3) and the ash content was calculated as shown in Eqn.3

$$\text{Ash Content (\%)} = \frac{W3-W2}{W1} \text{ X } 100 \qquad \text{Eqn.3}$$

Where: w_1 =weight of sample

w_2 = weight of crucible

w_3 = weight of crucible with ash

2.3.4. Protein Content Determination of the Sample

2.3.4.1. Determination of protein content

The protein content of the samples was determined according to the standard methods of AOAC (2010), using Kjeldahl method.

Digestion of the sample: Two grams of the samples were weighed into Kjeldahl flask and 5g of anhydrous sodium sulphate added. Twenty-five mL of con H_2SO_4 was added with few chips heated in the fume chamber until clear solution was obtained. The solution was cooled and transferred into 250 mL volumetric flask and made up to mark with distilled water.

Distillation: The distillation unit was carried out using a well cleaned Markham apparatus 10 mL conical flask (received flask) containing 5 mL of 2% Boric and 2 drops of methyl red indicator was placed under the condenser. The 5 mL of the sample digest were pipette into the apparatus through the small funnel on the distillation unit. The digest was washed down with distilled water followed by addition of 10 mL of 60% sodium hydroxides.

Titration: The solution in the flask was then titrated with 0.I N HCL until the first permanent pink colour appeared. The blank was titrated in the same way.

$$\% \text{ Nitrogen} = \frac{(Vs - Vb) \times N \text{ acid} \times 100}{W}$$

Where, Vs = volume (ml) of acid required to titrate sample

Vb = volume (ml) of acid required to titrate the blank

N acid = Normality of acid (0.1N)

W = weight of sample in gram

Therefore, protein % = N x 6.25 (conversion factor for protein)

2.4. Vitamin Determination of the samples.

The vitamins B_1, B_2 and B_9 contents of the samples were determined as described by AOAC, (2010). A 0.2 g gram of the pulverized sample was weighed into different test tube and homogenized with 5 mL ethanoic sodium hydroxide. Thereafter, the mixture was filtered and 2 mL potassium dichromate (k_2Cro_7) added to the filtrate and the mixture allowed to stand for 10 min for colour development and the absorbance read at 560 nm against blank and standard vitamin B_1.

The vitamin B_2 was determined by weighing 0.2 g pulverized sample into different test tubes and mixed with 2 mL 4 % sodium sulphate and 10 mL added to the mixture, homogenized and incubated at 30 °C for 2 h. Thereafter, the absorbance was read in Spectrophotometer at 510 nm against blank and standard vitamin $B_{2.}$

The vitamin B_9 of the samples was determined by weighing 0.2 g pulverized samples into series of 250 mL breakers and 10 mL distilled water added to the samples in the different breakers. The mixture was shaken and allowed to settle, centrifuged at 3000 rpm for 10 min. The upper layer was decanted and absorbance was measured at 379 nm with Ultraviolet spectrophotometer

2.5. Statistical Analysis

The data generated were subjected to one way analysis of variance (ANOVA) using Statistical Package of Social Sciences (SPSS version 23.0) software. Means were separated using Duncan New Multiple Range Test (DNMRT) at ($p < 0.05$).

3. **Results and discussion**

3.1. Effect of Heat Processing on Proximate Composition of the Samples

The effect of different heat treatment on the proximate composition on the samples is shown in Table1. Table 1 showed that raw samples had higher moisture content of 74.92 % compared to samples cooked by RO and ST at 60 ^{0}C and 70 ^{0}C. Samples cooked by ST at 60 ^{0}C had significantly higher moisture content of 70.44 % compared to samples cooked by RO that had 65.68 %. Samples by cooked by ST at 70 ^{0}C had higher moisture content of 69.86 % compared to RO cooked samples that had 64.49 %. It was observed in Table 1 that increasing cooking temperature to 70 ^{0}C resulted to higher reduction moisture content of the cooked samples. The lower moisture content of samples cooked at 70 ^{0}C could be attributed to cooking losses of moisture and leaching of melted fatty substances from the coked samples. Heat from the cooking methods induced structural and compositional denaturation of proteins and causes, release of water held by capillary forces and bound to proteins as reported by Aaslyng *et al.* (2003). The findings of this research are in agreement with findings of Sigh and Verma (2000). The ST mean moisture content of 70.15 % was significantly ($p < 0.05$) higher than RO mean moisture content

of 65.09 %. The higher moisture content of ST cooked samples could be attributed to water absorption during the moist heat cooking of samples compared to dry cooking method.

The protein content of uncooked chicken samples was 20.78 %. This value was significantly ($p < 0.05$) higher than mean protein contents of RO (17.87 %) and ST (18.11%) cooked samples. The protein content of ST cooked samples was higher than RO cooked samples. However, this difference was statistically not significant ($p > 0.05$). Increase cooking temperature decreased protein contents of cooked chicken samples in both cooking methods. The reduction in protein content with increase in cooking temperature could be attributed to destruction of some amino acids and browning of products. This result agrees with reported findings of Sharma and Sharma (2011) and Alugwu (2018).

The fat content of cooked samples was higher than uncooked fat content of 6.29 %. The differences were significantly ($p < 0.05$) different. The increases of fat content of cooked samples could be attributed to water dehydration effects and concentration of dry matters by heat in the cooked samples. Samples cooked by ST methods had higher fat content of 10.13 % than RO cooked method of 8.16 %. The reduction in fat content of RO cooked samples could be attributed to melting and dripping effects of fat upon application of heat. The results of this research agree with reported findings of Achir *et al.* (2009) and Hussain *et al*. (2013).

The ash content of cooked chicken samples had significantly ($p < 0.05$) higher ash content than uncooked samples. Samples cooked at 70 ^{0}C had higher values of inorganic matters than samples cooked at 60 ^{0}C. Samples cooked by RO method had higher mean values of 1.67 % compared to ST mean value of 1.65 %. However, there was no significant different ($p > 0.05$) in ash content of samples cooked by RO and ST methods. This result is in agreement with earlier reported studies by Alugwu *et al*. (2014).

Table 1: Proximate composition (%) of chicken processed by different cooking methods and temperatures

Cooking method	Cooking internal temperature	Moisture	Protein	Fat	Ash

	(°C)				
Raw	0	74.92^{a} ±0.27	20.78^{a} ±0.49	6.29^{c} ± 0.06	1.45^{b} ± 0.04
RO	60	65.68±0.44	18.23 ± 0.06	9.76 ± 0.25	1.63 ± 0.04
	70	64.49 ± 0.49	17.50 ± 0.04	10.51± 0.04	1.70±0.01
Mean		65.09^{c} ± 0.79	17.87^{b} ± 0.42	10.14^{a} ± 0.54	1.67^{a} ±0.05
ST	60	70.44 ± 0.27	18.16 ± 0.21	7.99 ± 0.06	1.61 ± 0.03
	70	69.86 ± 0.06	18.05 ± 0.14	8.34 ± 0.16	1.69 ± 0.01
Mean		70.15^{b} ± 0.37	18.11^{b} ± 0.16	8.17^{b} ± 0.23	1.65^{a} ± 0.05

Data are mean of duplicate determinations ± standard deviations

Values with different superscripts in the same column differ significantly ($p < 0.05$)

RO roasting

ST steaming

3 .2. Effect of Heat Processing on vitamin composition of the Samples

The results of vitamin content of the samples are shown in Table 2. Table 2 showed that vitamin B_1 of the samples decreased significantly ($p < 0.05$) with cooking. The uncooked samples had significantly ($p < 0.05$) higher vitamin B_1 content of 167.52 mg/100g than mean values of 117.72 mg/100g and 110.08 mg/100g in samples cooked by RO and ST. The lower vitamin B_1 content of ST cooked samples could be attributed to leaching actions of moist heat on the samples. It was observed that samples cooked at lower temperatures had higher vitamin B_1 content than samples cooked at higher temperatures. The reduction of vitamin B1 with increasing cooking temperature could be attributed to thermal denaturation. These results are in line with

reported findings by Lynch and Young (2000) who reported thermal reduction and vitaminB_1 losses by cooking. The percentage vitamin B_1 losses in the cooking methods of RO and ST were 29.73 % and 34.29 %, respectively. The findings are not in agreement with findings by Al-Khalifa and Dawood (1993) and Pathare and Roskilly (2016) who reported that vitamin B_1 was sensitive to heat and 30 – 60 % losses of vitamin B_1 occurred during roasting of chicken breast meat.

The uncooked samples vitamin B_2 content of 21.34 mg/100 g was significantly ($p < 0.05$) higher than cooked samples of RO and ST vitamin B_2 contents of 8.51 mg/100 g and 6.94 mg/100 g. The vitamin B_2 content of moist heat cooking (ST) of 6.94 mg/100 g was lower than dry heat cooking (RO). Vitamin B_2 is stable to heat and oxidation, but reduced by light as reported by Leskova *et al.* (2006) and Gerber *et al.* (2009). The lower value of ST could be attributed to thermal degradation and stripping action of vitamin B_2 from substrates by moist heat.

The results in Table 2 showed that folic acid -vitamin B_9 reduced significantly ($p < 0.05$) with heat application. The reduction of folic acid with cooking could be attributed to thermal degradation of proteins and leaching out of the vitamin. Table 2 showed that uncooked samples had significantly ($p < 0.05$) higher folic acid content of 95.43 mg/100 g than RO and ST cooked samples, which had folic contents of 47.03 mg/100 g and 38.75 mg/100g, respectively. The folic acid content of the samples decreased with increasing cooking temperatures. This decrease of folic acid with increase cooking temperature could be attributed to thermal degradation of high molecular weight proteins as reported by Lynch and Young (2000) and Murphy and Marks (2000). Samples cooked by RO method had significantly ($p < 0.05$) higher folic acid content than ST cooked samples. This higher folic acid content of RO in the cooking temperatures, suggesting that there was less stripping of folic acid content and drip loss at each temperature compared to ST cooking method.

Table 2: Vitamin composition (mg/100 g) of chicken processed by different methods and temperatures

Cooking method	Cooking internal temperature (°C)	Vit.B_1	Vit.B_2	Vit.B_9
Raw	0	121.84^{a}± 0.58	21.34^{a} ± 0.65	95.43^{a}±0.14
RO	60	117.74± 0.48	8.63 ±0.04	47.17 ± 0.06
	70	113.59 ± 0.62	8.39 ±0.29	46.90 ± 0.11
Mean		115.67^{b} ± 2.45	8.51^{b}± 0.22	47.03^{b} ± 017
ST	60	120.34 ± 0.30	7.56± 0.01	39.13 ± 0.20
	70	102.41± 0.61	6.31 ± 0.20	38.37± 0.06
Mean		101.38^{c} ± 5.77	6.94^{a} ± 0.73	38.75^{c} ± 0.45

Data are mean of duplicate determinations ± standard deviations

Values with different superscripts in the same column differ significantly ($p < 0.05$)

RO roasting

ST steaming

3 .3. Effect of Heat Processing on sensory properties of the Samples

The results of sensory properties of the samples are shown in Fig.1. Fig.1 showed that cooking affected the sensory properties of texture, flavour, juiciness and overall acceptability scores of cooked spent hen meat.

The texture scores of samples showed that RO and ST samples cooked at 60 ^{0}C were each rated moderately crispy, whereas RO and ST cooked at 70 ^{0}C were each rated very much crispy. There were no significant different ($p > 0.05$) in texture scores. Samples cooked by RO at 70 ^{0}C had the highest textural scores of the panelists. There were no significant different ($p > 0.05$) in texture scores of samples cooked at 70 ^{0}C. The increase in texture scores of samples cooked at 70 ^{0}C could be attributed to an increase in the denaturation of myosin and collagen as reported by Garcia – Segovia *et al*. (2007) and Khan *et al.* (2014). The results of this research showed that cooking increased texture scores of cooked spent breast meat as a result of higher collagen solubilisation effects by cooking temperature.

The flavour scores of samples showed that that RO and ST samples cooked at 60 ^{0}C were rated by panelists as moderately desirable and slightly desirable, whereas RO and ST cooked at 70 ^{0}C were rated very much desirable and slightly desirable. The results of Fig.1 showed that RO cooked samples at 70 ^{0}C had significantly ($p < 0.05$) higher scores compared to ST cooked samples. The results showed that higher cooking temperature develops specific meat aroma and taste which influences the judgement of consumers even before consumption. There was significant difference ($p < 0.05$) in flavour rating of cooking methods by the panelist.

The juiciness scores of samples showed that RO and ST samples cooked at 60 ^{0}C had higher juiciness scores samples and rated by panelists as very much juicy and moderately juicy. Samples cooked by RO and ST at 70 ^{0}C were rated by panelists as moderately juicy and slightly juicy, respectively. Samples cooked by RO method 60 ^{0}C had higher juiciness and rated by panelists as moderately juicy compared to ST cooked samples, which was rated slightly juicy. The mean juiciness of the cooked methods RO and ST was each rated by panelists as very much juicy and moderately juicy. There was no significant difference ($p > 0.05$) in juiciness of the cooking methods. This finding is in agreement with reported findings by Turp (2016) on meatballs.

The overall acceptability scores of samples cooked at 60 ^{0}C showed that sample cooked by ST had higher overall acceptability scores and rated by panelists as neither liked nor disliked, compared to samples cooked at 70 ^{0}C by RO, which had the least overall acceptability scores and rated by panelists as moderately disliked. Samples cooked at 60 ^{0}C had higher mean overall acceptability scores and rated by panelists as neither liked and disliked compared to samples cooked at 70 ^{0}C, which was rated by panelists as moderately disliked. There was significant difference ($p <0.05$) among the cooking temperature in overall acceptability scores. Conversely, there was no significant difference ($p > 0.05$) among the cooking methods in overall acceptability scores. This result is in line with reported findings by Turp (2016).

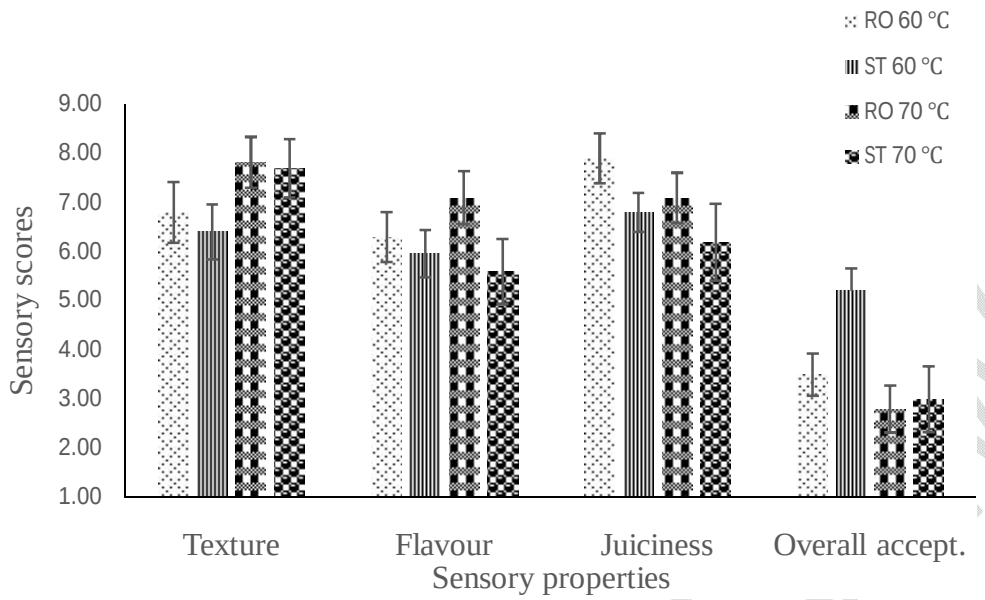

Fig.1 Sensory properties of chicken muscle cooked at different methods and temperatures

4. **Conclusion**

The results of study showed that cooking methods reduced significantly ($p < 0.05$) moisture and protein but increased significantly ($p < 0.05$) fat and ash contents of cooked spent breast muscles. Samples cooked at 70 ^{0}C had higher reduction in moisture and protein contents compared to cooking at 60 ^{0}C. Whereas increasing cooking temperatures increase the fat and ash contents of cooked samples.

Cooking methods decreased significantly ($p < 0.05$) the vitamins B_1, B_2 and B_3 contents of cooked spent hen breast muscles. The RO cooked samples had significantly ($p < 0.05$) higher vitamins B_1, B_2 and B_3 contents than ST The reduction in the vitamin content increases with increasing cooking temperatures.

The sensory properties scores by panelists revealed no significant differences ($p < 0.05$) by different cooking methods on sensory texture. Samples cooked at 70 ^{0}C by RO had significant ($p < 0.05$) higher flavour rating of cooking methods by the panelist. The mean juiciness of the cooked methods RO and ST was each rated by panelists as very much juicy and moderately juicy. There was no significant difference ($p > 0.05$) in juiciness of the cooking methods. There were significant differences ($p <0.05$) among the cooking temperatures in overall acceptability scores. Conversely, there were no significant differences ($p > 0.05$) among the cooking methods in overall acceptability scores.

References

Aaslyng, M.D. Bejerholm, C., Erthjerg, P., Benjamin, H. C and Anderson, H J. (2003). Cooking loss and juiciness of pork in relation to raw meat quality and cooking Procedure. Food Quality Preference 14: 277 -288

Abalti, A; Bekana, M; Woldemsekel, M and Lobago, F (2006) Female genital tract abnormalities `of zebu cattle slaughtered at Bahir-Dar Town, North-West Ethiopia. Tropical Animal Health Production 38:505 – 510

Achir N, Vitrac O, Trystram G (2009). Heat and mass transfer during frying. In Advances In Deep Fat Frying of Foods, (Sahin S, Sumnu SG, eds.), CRC Press, New York, pp. 115- 142

Al-Khalifa, A.S. and Dawood, A. A. (1993). Effect of cooking methods on thiamin and Riboflavin contents of chicken meat. Food Chemistry 48 (1):69 – 74

Alugwu, S.U., Okonkwo, T. M. and Okoye, J. I. (2014). Effect of heat processing methods on mineral contents of chicken broiler meat. Proceedings of the 38th Annual Conference/ AGM of Nigerian Institute of Food Science and Technology 38: 33 – 34.

Alugwu, S.U. (2018). Effect of different temperature and time on protein content of chicken breast meat. Canadian Society of Bioresource Engineering (CSBE) /SCGAB Annual General Meeting and Technical Conference in Guelph, 22 - 25th July, 2018.

AOAC (2010). Official methods of Analysis (18th edition) Association of Official Analytical Chemists, Washington D.C.

Banerjee, G. C. (2005). Animal Husbandry 8th edition, Oxford and BH Published Co. Ltd.

García-Segovia, P., Andrés-Bello, A., Martnez-Monzo, J. (2007). Effect of cooking method on Mechanical properties, colour and structure of beef muscle (Pectorals), Journal of Food Engineering 80 (3):813-821.

Gerber, N., Scheeder, M. R. L. and Wenk, C. (2009). The influence of cooking and fat trimming on the actual nutrient intake from meat. Meat Science 81, 148 – 154.

Hussain, A. I., Chatha, S. I. S., Arshad, T. M., Adzahoor, A. and Afzal, S. (2013). Comparative study of different cooking methods on nutritional and fatty acid profile of chicken meat. Journal of Chemical Society of Pakistan Vol. 25 (3):678 – 684.

Khan, M. A., Ali, S., Abid, M., Alimad, H., Zhang, L., Tume, R. K., Zhou, G. (2014). Enhanced texture, yield and safety of a ready to eat salted duck meat product using a high pressure-heat process. Food Science Engineering Technology21: 50 – 57.

Lawrie, R. and Ledward, D. A. (2006). Meat Science 7th edition. Cambridge – Wood Head Publishing Limited. www.collinsdictionary.com. Retrieved 16th June2017

Lesokovia, E., Kubikova, J., Kovacikova, E., Kosicka, M., Portubska, J and Holcikova, K. (2006).
Vitamin losses: Retention during heat treatment and continual changes expressed by Mathematical models. Review. Journal of Food Composition and Analysis19:252 – 276.

Lynch, P. L. M. and Young, I. S. (2000). Determination of thiamine by high performance liquid chromatography. Journal of chromatography A, 881: 267 – 284.

Murphy, R. Y and Marks, B .P (2000). Effects of meat temperature on proteins, Texture and cook Loss for ground chicken Breast Patties. *Poultry Science* 79:99-104.

New Encyclopedia Americana (2001) .Chicken and domestication and Egg production 6: 438-442

Oluyemi, J .A and Roberts, F .A. (2007). Poultry production in Warm Climates, Macmillan Press Ltd., London and Basingstoke

Pathare, P. B. and Roskilly, A.P. (2016). Quality and energy evaluation in meat cooking. Food Engineering Review 8: 435 – 447.

Sharma, B. D. and Sharma, K. (2011). Outlines of Meat Science and Technology. Jaypee Brothers Medical PublishersLtd, India.

SPSS (2015). Statistical Package for Social Sciences Research (SPSS version 23.0) Inc., Chicago.

Tornberg, E (2005). Effect of heat on proteins- implications on structure and quality of meat products. Meat science 70(3): 493-508

Turp, G.Y. (2016). Influence of cooking methods on characteristics of meatball. Meat Science121:40 – 46.