

Original Research Article

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

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### **ABSTRACT**

The main aim of the study was to evaluate the impact of different cooking methods and internal cooking temperatures (60 and 70 °C) on the quality characteristics of spent hen muscle. Five spent hens were slaughtered, bled thoroughly and scaled at 85 °C for 30 sec and defeathered, eviscerated and breast muscles separated and frozen to harden for easy slicing into dimensions. These slices were divided into three, one for raw, another roasting (RO) and last steaming (ST). Each slice for cooking was divided into two cooking internal temperatures of 60 °C and 70 °C. Fifty gram weighed, inserted and cooked differently at 60 °C and 70 °C for 0 and 10 min after thawing. Proximate composition, vitamin content and sensory properties of the cooked samples were studied. The results showed that samples cooked by ST had significantly ( $p < 0.05$ ) higher mean moisture content of 70.44 %, protein content of 18.11 %, and fat content of 10.13 %. Whereas samples cooked by RO method had higher mean ash content of 1.67 %. However, the differences in ash content of these cooking methods were statistically not significant ( $p > 0.05$ ). Increasing cooking temperature decreased moisture, protein, but increased fat and ash contents of cooked chicken spent hen. The RO cooked samples had significantly ( $p < 0.05$ ) higher vitamins B<sub>1</sub>, B<sub>2</sub> and folic contents of 117.72 mg/100 g, 8.51 mg/100 g and 47.03 mg/100 g, respectively. The RO cooked samples at 70 °C had higher textural scores and rated by panelist as very much crispy. Increasing cooking internal temperatures increased sensory textural scores of cooked spent hen meat. The flavour of RO cooked samples was higher than ST cooked samples and rated by panelist as moderately desirable.

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Keywords: Spent hen, chicken breast, cooking methods, cooking internal temperature, time

### 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). It is the most delicious and cherished food in the World (Alugwu et al. 2022a) and 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. Bird 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 and Alugwu *et al.* 2022b). 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 °C 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<sup>3</sup> thickness were employed. These sliced samples were divided into three portions. Two portions was used for the cooking methods (roasting and steaming). Each cooking portion was subdivided into two cooking internal temperatures of 60 °C and 70 °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 °C and it was cooked for 10 min. This process was repeated for another until the internal temperature of the meat reached 70 °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 °C and it was cooked for 10 min and 70 °C 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 °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

$$\text{Moisture Content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad \text{Eqn.1}$$

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 by Soxhlet method using standard methods of 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.

$$\text{Fat Content (\%)} = \frac{W_3 - W_2}{W_1} \times 100 \quad \text{Eqn.2}$$

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 previously heated at 500 °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

$$\text{Ash Content (\%)} = \frac{W_3 - W_2}{W_1} \times 100 \quad \text{Eqn.3}$$

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 acid and 2 drops of methyl red indicator was placed under the condenser. The 5 mL of the sample digest were pipetted 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 hydroxide. **Titration:** The solution in the flask was then titrated with 0.1 N HCL until the first permanent pink colour appeared. The blank was titrated in the same way.

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

Where,  $V_s$  = volume (mL) of acid required to titrate sample

$V_b$  = 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<sub>1</sub>, B<sub>2</sub> and B<sub>9</sub> contents of the samples were determined using standard methods of 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<sub>2</sub>CrO<sub>7</sub>) 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<sub>1</sub>.

The vitamin B<sub>2</sub> was determined by weighing 0.2 g pulverized sample into different test tubes and mixed with 2 mL 4 % sodium sulphate and 10 mL of distilled water 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<sub>2</sub>.

The vitamin B<sub>9</sub> of the samples was determined by weighing 0.2 g pulverized samples into series of 250 mL breakers and 10 mL of 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 Table 1. Table 1 showed that raw samples had higher moisture content of 74.92 % compared to samples cooked by RO and ST at 60 °C and 70 °C. Samples cooked by ST at 60 °C had significantly higher moisture content of 70.44 % compared to samples cooked by RO that had 65.68 %. Samples cooked by ST at 70 °C had higher moisture content of 69.86 % compared to RO cooked samples that had 64.49 %. It was observed that increasing cooking temperature to 70 °C resulted to higher moisture content **reduction** of the cooked samples. The lower moisture content of samples cooked at 70 °C could be attributed to cooking losses of moisture and leaching of melted fatty substances from the cooked 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 Singh 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 °C had higher values of inorganic matters than samples cooked at 60 °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 Edris *et al.* (2012) which stated the ash content of uncooked chicken breast increased from (1.95 %) to (2.375 %) and Zuzanna *et al.* (2021)

Table 1. Proximate composition (%) of chicken processed by different methods and internal temperatures

| Cooking method | Cooking internal temperature (°C) | Moisture                  | Protein                   | Fat                       | Ash                      |
|----------------|-----------------------------------|---------------------------|---------------------------|---------------------------|--------------------------|
| Raw            | 0                                 | 74.92 <sup>a</sup> ±0.27  | 20.78 <sup>a</sup> ±0.49  | 6.29 <sup>c</sup> ± 0.06  | 1.45 <sup>b</sup> ± 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 <sup>c</sup> ± 0.79 | 17.87 <sup>b</sup> ± 0.42 | 10.14 <sup>a</sup> ± 0.54 | 1.67 <sup>a</sup> ±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 <sup>b</sup> ± 0.37 | 18.11 <sup>b</sup> ± 0.16 | 8.17 <sup>b</sup> ± 0.23  | 1.65 <sup>a</sup> ± 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<sub>1</sub> of the samples decreased significantly ( $p < 0.05$ ) with cooking. The uncooked samples had significantly ( $p < 0.05$ ) higher vitamin B<sub>1</sub> 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<sub>1</sub> 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<sub>1</sub> content than samples cooked at higher temperatures. The reduction of vitamin B<sub>1</sub> with increasing cooking temperature could be attributed to thermal denaturation. These results are in line with reported findings by Lynch and Young (2000) and Bakhru (2010) who reported thermal reduction and vitaminB<sub>1</sub> losses by cooking. The percentage vitamin B<sub>1</sub> losses in the cooking methods of RO and ST were 29.73 % and 34.29 %, respectively. The findings are in agreement with findings by Al-Khalifa and Dawood (1993) and Pathare and Roskilly (2016) who reported that vitamin B<sub>1</sub> was sensitive to heat and 30 – 60 % losses of vitamin B<sub>1</sub> occurred during roasting of chicken breast meat.

The uncooked samples vitamin B<sub>2</sub> content of 21.34 mg/100 g was significantly ( $p < 0.05$ ) higher than cooked samples of RO and ST vitamin B<sub>2</sub> contents of 8.51 mg/100 g and 6.94 mg/100 g. The vitamin B<sub>2</sub> content of moist heat cooking (ST) of 6.94 mg/100 g was lower than dry heat cooking (RO). Vitamin B<sub>2</sub> 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<sub>2</sub> from substrates by moist heat.

The results in Table 2 showed that folic acid -vitamin B<sub>9</sub> 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 internal temperatures

| Cooking method | Cooking internal temperature (°C) | Vit.B <sub>1</sub>         | Vit.B <sub>2</sub>        | Vit.B <sub>9</sub>        |
|----------------|-----------------------------------|----------------------------|---------------------------|---------------------------|
| Raw            | 0                                 | 121.84 <sup>a</sup> ± 0.58 | 21.34 <sup>a</sup> ± 0.65 | 95.43 <sup>a</sup> ± 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 <sup>b</sup> ± 2.45 | 8.51 <sup>b</sup> ± 0.22  | 47.03 <sup>b</sup> ± 0.17 |
| 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 <sup>c</sup> ± 5.77 | 6.94 <sup>a</sup> ± 0.73  | 38.75 <sup>c</sup> ± 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 cooking methods and internal temperatures 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 °C were each rated moderately crispy, whereas RO and ST cooked at 70 °C were each rated very much crispy. There were no significant difference ( $p > 0.05$ ) in texture scores. Samples cooked by RO at 70 °C had the highest textural scores of the panelists. There were no significant difference ( $p > 0.05$ ) in texture scores of samples cooked at 70 °C. The increase in texture scores of samples cooked at 70 °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 RO and ST samples cooked at 60 °C were rated by panelists as moderately desirable and slightly desirable, whereas RO and ST cooked at 70 °C were rated very much desirable and slightly desirable. The results of Fig.1 showed that RO cooked samples at 70 °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 °C had higher juiciness scores and rated by panelists as very much juicy and moderately juicy. Samples cooked by RO and ST at 70 °C were rated by panelists as moderately juicy and slightly juicy, respectively. Samples cooked by RO method at 60 °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 cooking 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 °C showed that samples cooked by ST had higher overall acceptability scores and rated by panelists as neither liked nor disliked, compared to samples cooked at 70 °C by RO, which had the least overall acceptability scores and rated by panelists as moderately disliked. Samples cooked at 60 °C had higher mean overall acceptability scores and rated by panelists as neither liked and disliked compared to samples cooked at 70 °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).

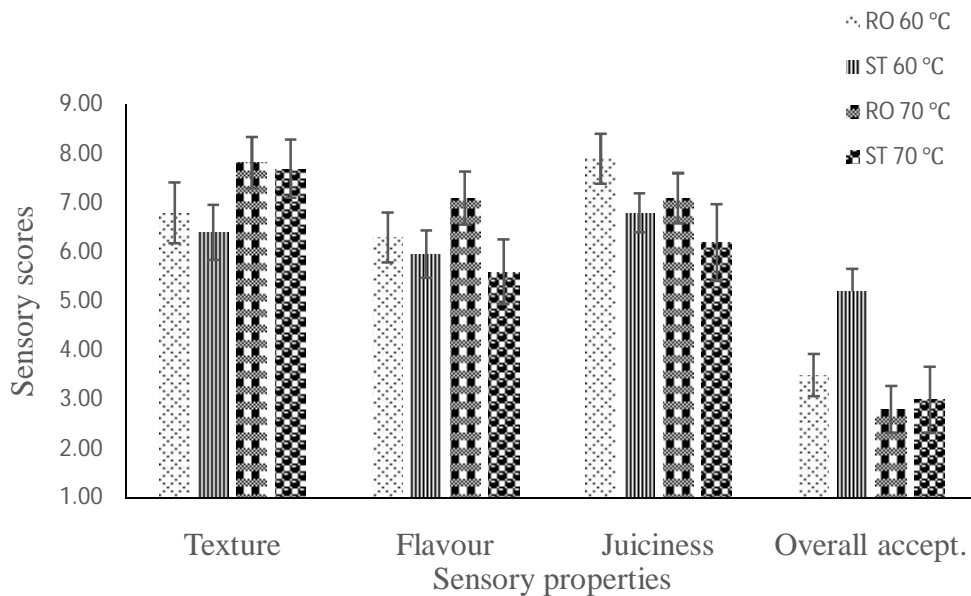


Fig.1 Sensory properties of chicken muscle cooked at different methods and internal temperatures

#### 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 °C had higher reduction in moisture and protein contents compared to cooking at 60 °C. Whereas increasing cooking **internal** temperatures increase the fat and ash contents of cooked samples.

Cooking methods decreased significantly ( $p < 0.05$ ) the vitamins B<sub>1</sub>, B<sub>2</sub> and **B<sub>9</sub>** contents of cooked spent hen breast muscles. The RO cooked samples had significantly ( $p < 0.05$ ) higher vitamins B<sub>1</sub>, B<sub>2</sub> and **B<sub>9</sub>** contents than ST **cooked samples**. The reduction in the vitamin content increases with increasing cooking **internal** 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 °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.

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