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DESCRIPTIVE SENSORY QUALITY OF KENYA'S INDIGENOUS CHICKEN MEAT FROM DIFFERENT ECOTYPE- CLUSTERS REARED UNDER AN INTENSIVE SYSTEM

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ABSTRACT

Indigenous chicken (IC) in Kenya performs a major food security and socio-economic function for most households, especially of the rural poor. The trend has been to move from rearing IC on free-range systems to more intensive and semi intensive systems. This study was conducted by use of Quantitative Descriptive Analysis (QDA) and the Just About Right (JAR) scale scores to quantify the appeal of the IC meat reared under intensive systems. The IC used in the study had been obtained from Taita, Kakamega and Narok ecotype clusters kept under the intensive system at Indigenous Chicken Improvement Programme (INCIP) unit at Egerton University. During the intensive rearing, the chickens were given the same treatment in terms of feed, disease control at all the stages and water was given *ad-libitum*. The chickens were slaughtered at the same age and only cocks were used as control for sensorial differences accruing due to sex. Five cocks from each ecotype cluster were slaughtered after a feed withdrawal period of 8-10 hours and their meat prepared by boiling for sensory evaluation after ageing on ice for 3-6 hours. A trained panel of tasters (13-15) was used to evaluate the descriptive and JAR sensorial quality of indigenous chickens' meat from the breast and thighs. One commercial broiler (Kenbro) was used as a control. Results showed that there was significant effect at $P<0.05$ of the ecotype of the IC on its meat aroma, flavour and brown colour intensity. The JAR scale showed that the consumers' scores for the colour, flavour, juiciness, tenderness of indigenous chicken was 'just about right' compared to broiler which was described by colour as too light, flavour too strong, too juicy in terms of expression of juiciness and too tender with regard to texture. The Principal Component Analysis results showed that there were two principal components (colour and texture) that accounted for 55.4 % and 11.6% and 53.9 and 19% for both descriptive scores and JAR scores for IC meat, respectively. This study indicates sensorial differences among the Kenyan Indigenous chicken ecotypes (of different genetic characteristics) under intensive systems and demonstrates significant difference among various attributes from the commercial broiler.

Key words: Descriptive, sensory evaluation, Kenyan Indigenous chicken, ecotype cluster, intensive system

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INTRODUCTION

According to the Food and Agriculture Organization of the United Nations (FAO), the most important challenge facing the world today is food insecurity [1]. As a result, sub-Saharan African countries made a commitment to invest in poultry breeding as an area of focus in provision of dietary protein. This has elicited renewed interest in indigenous chicken (*Gallus domestica*) in the past few years with evidence suggesting that rearing of IC can improve the livelihood of most households in Kenya [2]. Women and children manage poultry keeping in most rural households. The poultry products are also expected to contribute to the world's increasing demand for animal products cheaply, quickly, and safely [1].

The demand for IC in Kenya has been on the rise [3]. Studies showed that Kenyan indigenous chickens (IC) are generally perceived to be more preferred by the consumers due to several desirable characteristics [3,4,5]. The quality attributes of the IC meat are concordant with consumer demands for its unique taste, texture, and nutritious leaner meat [4]. The demand for indigenous poultry is high as some consumers prefer IC meat to meat from broilers and layers [6]. They argue that it tastes better and it is more nutritious. There is a trend in Kenya and in most developing parts of the world to move away from the traditional rearing methods to semi-intensive and intensive systems of chicken rearing. In Kenya, the most comprehensive genetic evaluation of genetic material of indigenous chicken was first conducted through the INCIP programme at Egerton University. It used microsatellite allele markers to analyze genetic variability among the Kenyan indigenous chicken from all over the country. The result was that the Kenyan IC could be classified into Taita, Kakamega and Narok ecotypes clusters [7]. Livestock producers are in consensus that to be able to improve on productivity and quantity of IC, it will be paramount to introduce them to a mix of intensive and semi-intensive systems.

In spite of these marked advantages of IC in Kenya, there is not yet a documented systematic study that has attempted to validate this perception and enumerate reasons responsible for the desirable qualities of IC over the exotic broilers. Though there is a great genetic variation among IC in Kenya, limited studies have been done to determine whether this genetic variation affects the sensory qualities of IC particularly those growing under controlled environment (intensive systems). The increasing consumer demands and increasing intensification of the IC rearing, calls for a sensory evaluation for consumer acceptability on sensorial qualities that consumers feel are most important.

Descriptive sensory evaluations are vital in sensorial studies as they often bring almost quantitative results comparable to objective methods. This is because it makes use of well-trained panelists, who also go through the brainstorming session on relevant terms and then validation of the terms to retain only those that are sufficiently agreed to describe any given parameters of the product to be tested. The Just about right (JAR) are useful in predicting and explaining consumer acceptance and is useful information in supplementing for product optimization [8]. Using both in a sensory study usually gives a more complete assessment and better explanation to the responses obtained from the panelists. Therefore, the aim of this study was to determine the sensory appeal of the IC from different cluster ecotypes in Kenya reared under the intensive system. The results will inform on the effect of genetic variability brought about by cluster ecotypes on the sensory appeal of the IC meat to the consumers.

MATERIALS AND METHODS

Sample preparation and Determination of Sensory quality of IC meat

Indigenous chicken from the 3 cluster ecotypes (Kakamega, Taita and Narok) were reared under intensive units at INCIP Egerton University, Kenya. These three clusters represented the three ecotype classes (clusters) of IC in Kenya. These are the Western, the Rift valley, and the Coastal region. Five healthy cocks from each ecotype cluster were selected randomly for conducting of sensory evaluation. The IC were slaughtered at 8-10 weeks of age. The birds were slaughtered after a withdrawal period of 8-10 hours, thoroughly bled; then scalded at 60^{o}C for two minutes. The carcasses were then chilled at 12^{o}C for 30 minutes and then aged on ice for 2.5 hours before deboning. The chilling aspect was to aided skin removal and the deboning process. The cooked samples of the left drum sticks from the indigenous and exotic chickens were presented to screened and trained panel of tasters for descriptive sensory evaluation. Left drum sticks were chosen for uniformity and based on finding that the left tends to be more tender, and juicier because of less activity from the chicken. Descriptive sensory analysis was conducted on the breasts (which had sufficient quantity of meat than the wings) and thigh meats at the Dairy and Food Science Department sensory evaluation room of Egerton University.

Sample preparation

Boiled chicken meat was prepared by first deboning the meat and cutting into small pieces approximately of 2 x 2 cm. Meat from each carcass was cooked separately. The IC meat pieces were put into the cooking pot and water added to cover the meat and cooked for 45 min-60 minutes. A sample of the broiler meat prepared in the same way as IC was presented as a control. After tempering at room temperature for about 10 minutes, samples were presented for descriptive sensory analysis. Samples were randomized by product type (ecotype cluster) and then by meat type (breast meat or thigh). Each panelist was presented with 6 pieces on a white sensory evaluation plates labeled with 3-digit blinding codes.

Screening of panelists and training:

A trained descriptive panel of chicken meat tasters (13-15) members as recommended by sensory spectrum Inc, Chatham, NJ conducted quantitative descriptive analysis (DQA). The QDA method [9], was used as a descriptive test. The panel was trained according to the ISO procedures [10]. In the prescreening testing, the assessors were trained in developing sensory descriptors and the definition of the sensory attributes. They developed and agreed on vocabulary, words and intensities. The panel was screened through affective tests and acuity test on relevant sensory attributes. An orientation was done to familiarize the tasters with the colour, flavour, and texture definitions of the IC meat sample. The panel reduced the initial list from about 20 attributes, to 9 used in this case as shown in Table 1.

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The trained panel used descriptive textural attributes to evaluate tenderness characteristics of breast and thigh meat. Initial hardness, cohesiveness, and moisture release was evaluated in the first bite stage, whereas hardness of mass, cohesiveness of mass, fibrousness, and number of chews to swallow were evaluated in the chew down stage.

Just-About-Right (JAR) scales were used to assess the appropriateness of colour (1 = much too light, 2 = too light, 3 = just about right, 4 = too dark, 5 = much too dark), the appropriateness of tenderness (1 = much too tough, 5 = much too tender), the appropriateness of juiciness (1 = much too dry, 5 = much too juicy), and the appropriateness of flavor (1 = much too weak, 5 = much too strong). The JAR scales were used because they were useful for diagnostics, while hedonic scales do not allow determination of the appropriateness of intensity of the attribute [11].

Statistical analysis:
Data from the hedonic scales and JAR scales was analyzed using SAS version 9.1 for the descriptive statistics, analysis of variance, correlation, and principal component analysis (PCA) and means separated using Duncan's Multiple Range Test (DMRT) in a nested experimental design procedure at $P<0.05$. The PCA data was analyzed using the PRINCOMP procedures of the SAS standardized data to zero and unit variance [12].

RESULTS AND DICSUSSION

Descriptive Quality Analysis

Sensory quality is very vital to the realization of a consumer's food preference. It consists of qualitative, quantitative, or hedonic quality measurement. Ideal poultry meat is considered to have high nutritive value and great functional roles such as flavour, tenderness, juiciness of the cooked product among others [13]. For chicken meat, the main sensory features are: colour, tenderness, juiciness and flavour [14]. The current study gives a descriptive hedonic quality measurement as well as JAR and PCA for the main attribute of Kenyan IC meat as described by a trained panel and compared to broiler (Figures 1,2,3 and4). The descriptive test is often very reliable and correlated to instrumental analysis [15,16,17]. However, this method is extensive and time consuming and hence more time was taken by the panelists in this study to agree on the descriptive terms. The Principle Component analysis of the QDA and JAR analysis are presented in Figure 5 and 6.

The panel score rating of the descriptive sensory attributes for the IC breasts and thigh meat is shown in Figure 2, while the legend for the quantitative analysis is presented in Table I.

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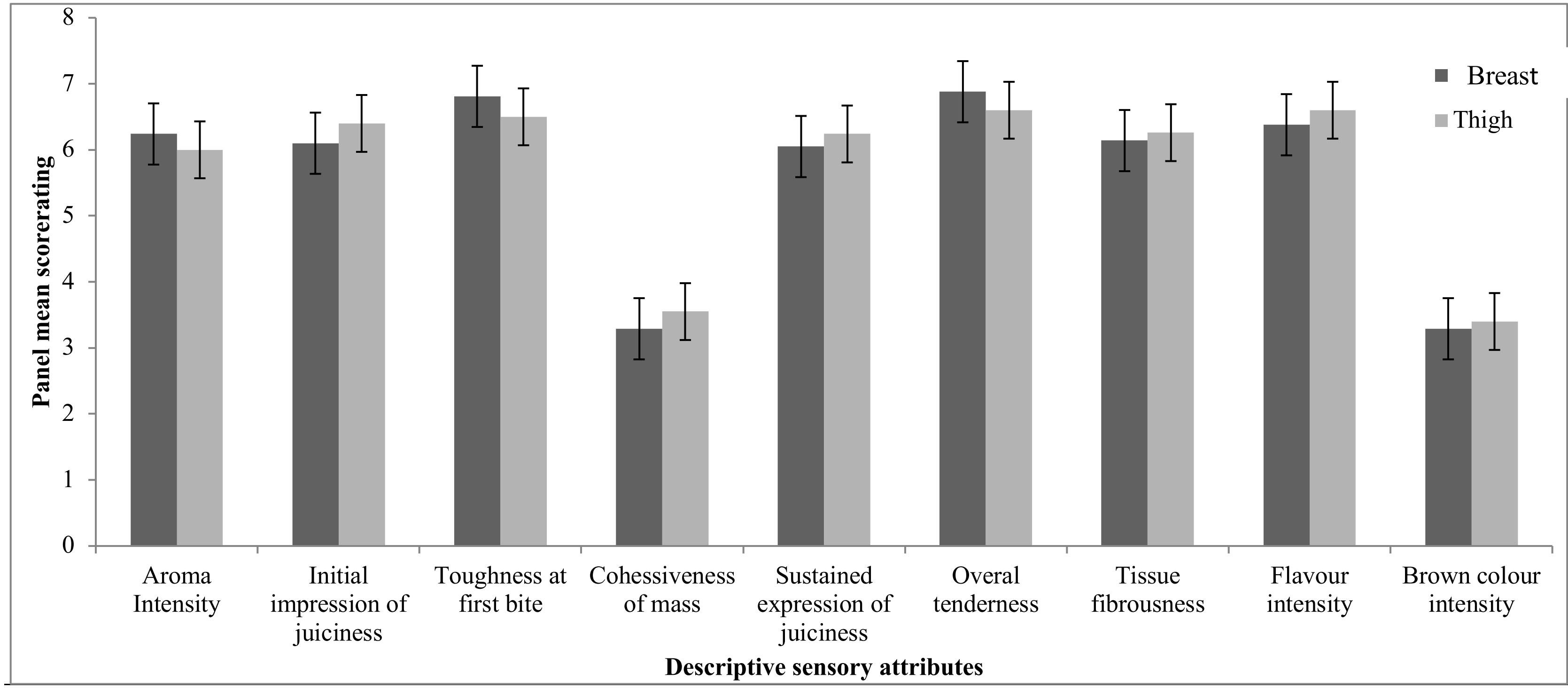

Figure 1: The mean descriptive analysis results of the different attributes from breast and drum sticks (thigh) from the broiler

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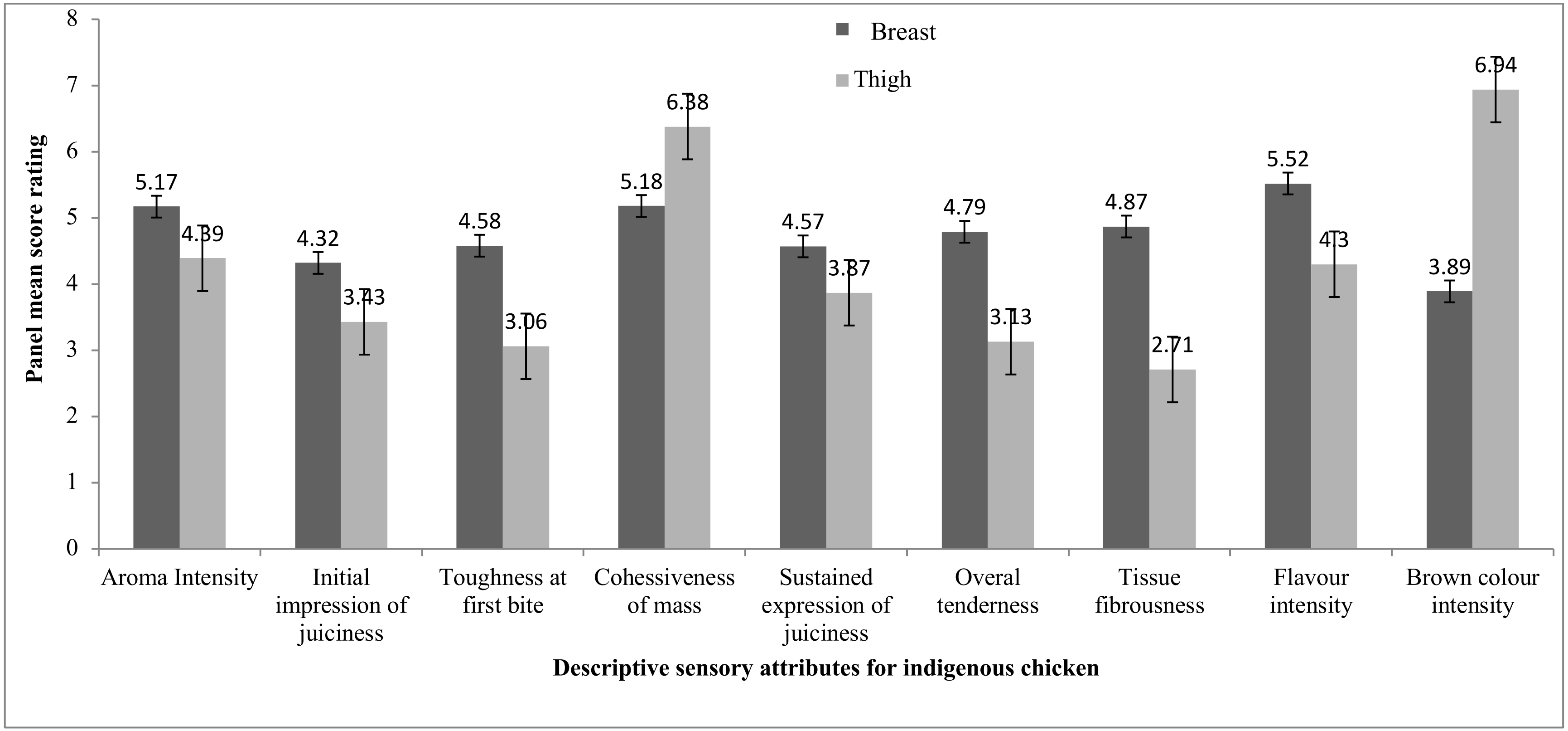

Figure 2: The mean descriptive analysis results of the different attributes from breast and drum sticks (thigh) of IC meat

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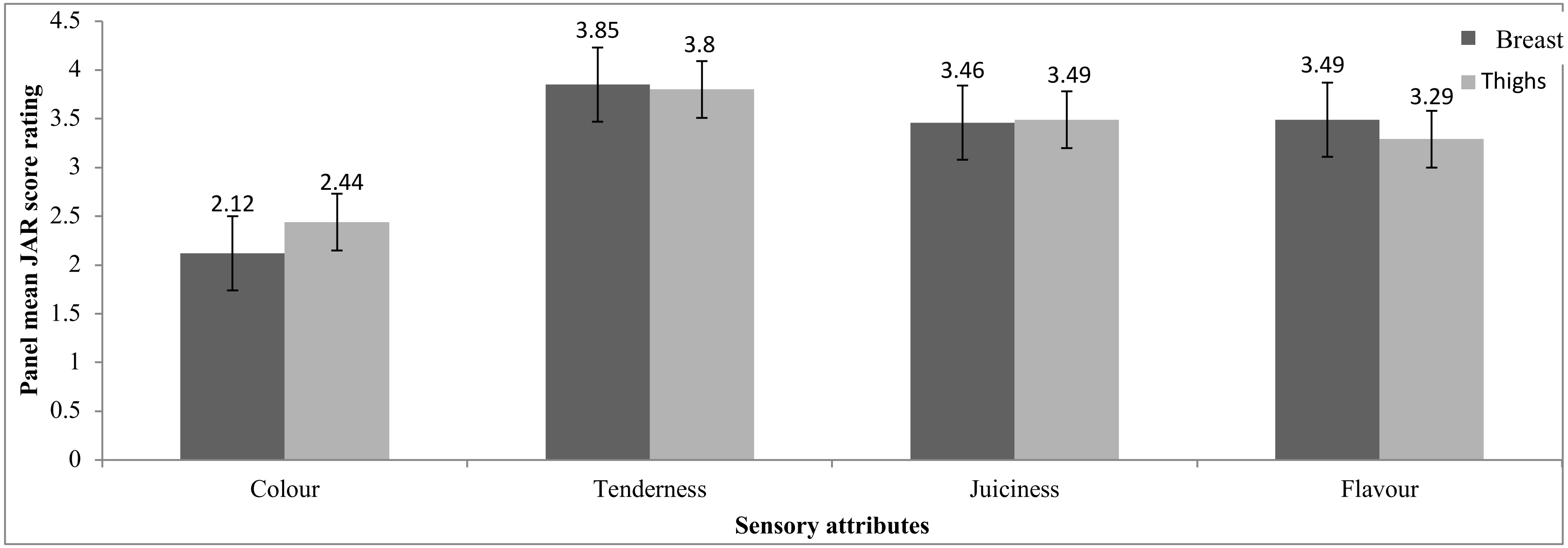

Figure 3: The JAR scores for colour, tenderness, juiciness, and flavour attributes for broiler chicken breasts and thigh

Legend

Appropriateness of colour (1 = much too light, 2 = too light, 3 = just about right, 4 = too dark, 5 = much too dark**), Appropriateness of tenderness** (1 = much too tough, 2=too tough, 3 = just about right, 4=too tough, 5 = much too tender), **Appropriateness of juiciness** (1 = much too dry, 2=too dry, 3 = just about right, 4=too juicy, 5 = much too juicy)
Appropriateness of flavour (1 = much too weak, 2=too weak, 3 = just about right, 4=too strong, 5 = much too strong)

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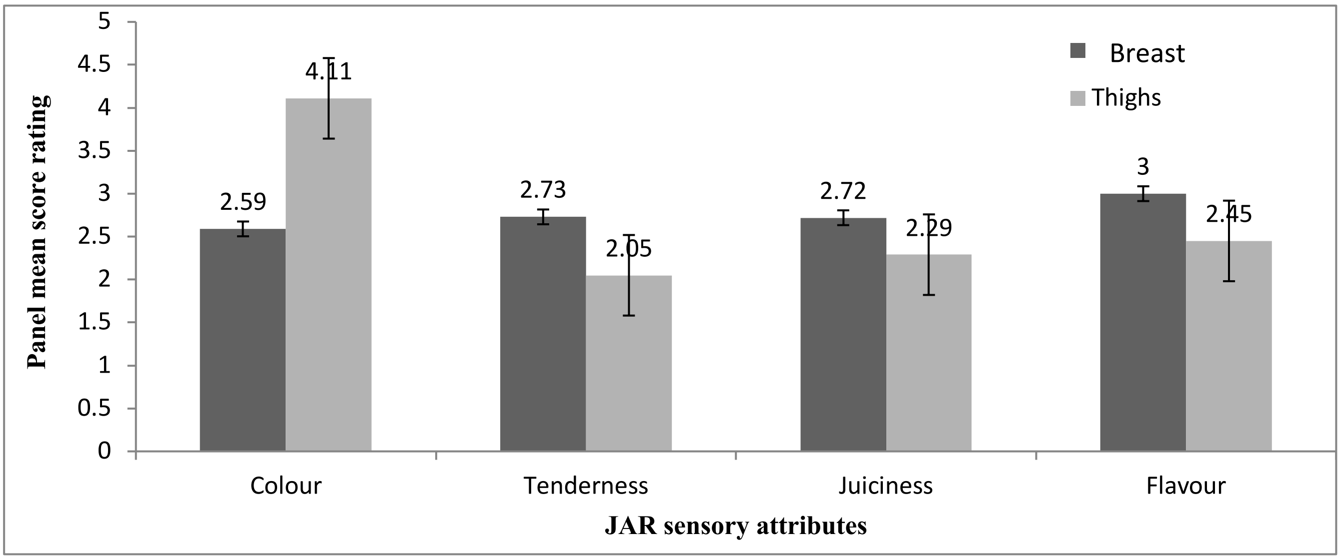

Figure 4: The JAR scores for colour, tenderness, juiciness and flavour attributes for IC chicken breasts and thighs

Appropriateness of tenderness (1 = much too tough, 2=too tough, 3 = just about right, 4=too tough, 5 = much too tender), **Appropriateness of juiciness** (1 = much too dry, 2=too dry, 3 = just about right, 4=too juicy, 5 = much too juicy) and **Appropriateness of flavor** (1 = much too weak, 2=too weak, 3 = just about right, 4=too strong, 5 = much too strong)

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Principal Component Analysis (PCA)

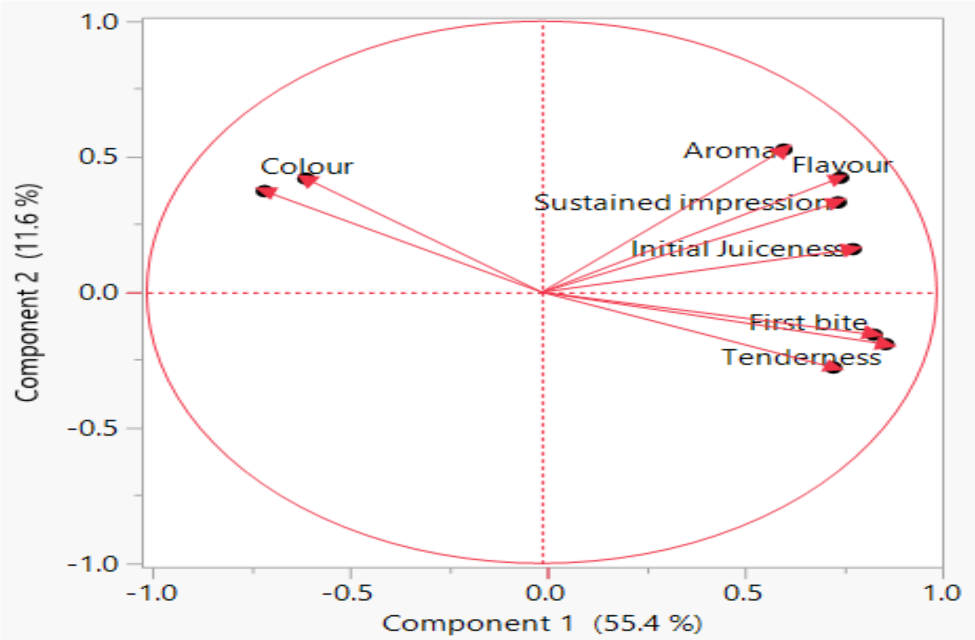

Figure 5: Plot of the principal component analysis showing the relationship among sensory attributes of chicken meat on hedonic rating

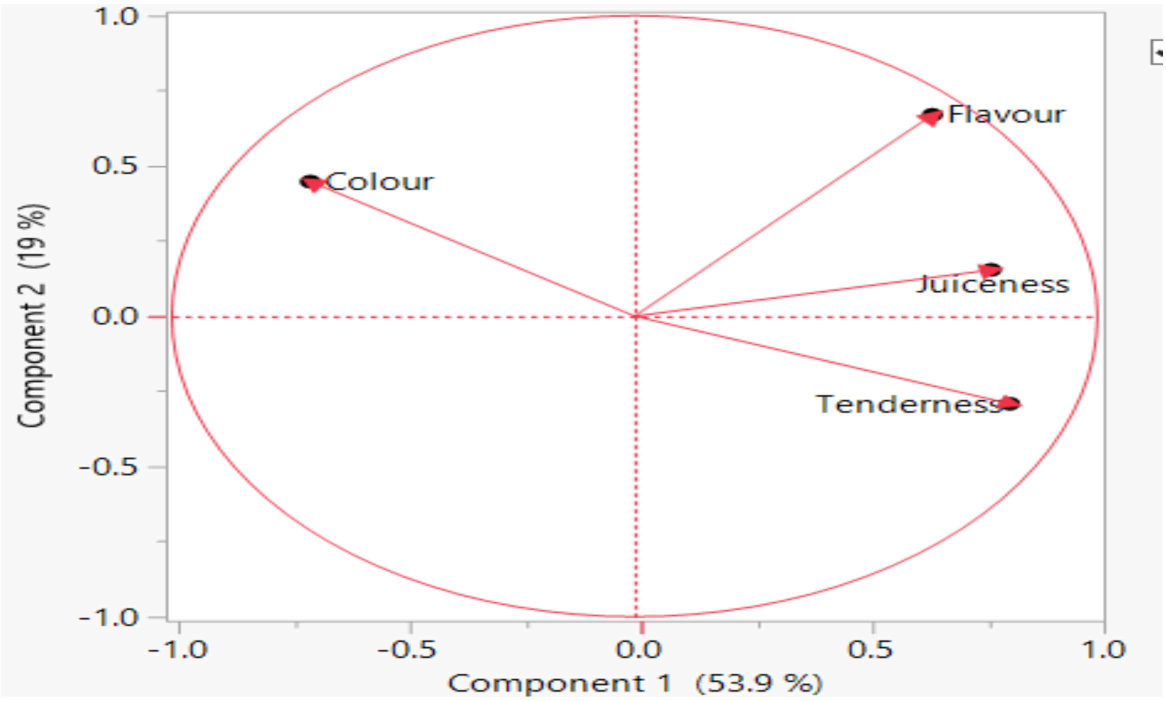

Figure 6: The relationship among sensory attributes of chicken meat on JAR rating

The correlation coefficients between the sensory attributes in the JAR scale in chicken meat are presented in Table 5 and 6. The loading matrix for the QDA and JAR analysis of chicken meat are presented in Tables 4 and 7. The most important correlations were noted between colour and meat tenderness (-0.4741), tenderness and juiciness (0.5345) and flavour and juiciness (0.3795). The negative correlation here means that the colour intensity is indirectly proportional to meat tenderness.

Flavour/Aroma

Both flavour and aroma are complex attributes of meat and are affected by; species, age, fatness, type of tissue, locality, gender, diet and method of cooking [18]. Many studies have demonstrated the close relationship between the flavour preference of chicken and overall acceptance [19, 20]. This study confirms the finding of [21, 22] that flavour of chicken depends on breed, and cut of meat. Even though Tshabalala *et al*. [23] found no significant difference between broiler and IC for the specific sensory attributes of interest, it must be borne in mind that their study was based on same age for both broiler and Ethiopian IC. They also did not find any significant difference in flavour among the consumers for the different parts of chicken. With increasing age however, significant differences were found between broiler and IC as well as for breast and thigh meats of the broiler and IC. In the current study, the ages of the IC and the broilers were different. This may also explain the significant difference reported between the IC and broiler meats as well as from breast and thighs from the IC meat and broiler. The panelists also noted clearly that the part of the meat whether thigh or breast, has a distinct influence on flavour and aroma (Table 2 and 3). Flavour is one of the primary attributes of consumer choice for chicken; Flavour attributes are often expressed as flavour and overall flavour intensity [24]. Among the different ecotype clusters of indigenous chicken, the significant differences especially between Taita and the other two (Kakamega and Narok) ecotypes can be traced to the fact that, the Taita ecotype happens to be generally a smaller and learner IC based on carcass and dressed weights on (data not shown) compared to the two other ecotypes. This study, therefore, posits that the Taita ecotype may be targeted to the consumers that prefer leaner chicken meat even though that may mean compromising on the overall chicken flavour intensity. On the other hand, the Kakamega ecotype should be a delicacy for consumers who prefer a much juicier and high flavour intensity IC meat. The majority of IC chickens are enjoyed by cooking, boiling and later frying and addition of a preferred set of spices. The current study prepared chicken by boiling and adding same amount of salt just to taste. This cancelled any flavour differences that may accrue from different methods of preparation and by use of different spices.

Texture Attributes

Texture is also one of the most important determinants of consumer preference for poultry meat. Many terms are used by descriptive sensory panelists to describe textural attributes of poultry meat. These terms could include; fibrousness, first bite hardness, cohesiveness of mass and overall tenderness [25]. In the current study, overall tenderness, toughness of meat at first bite, tissue fibrousness, and cohesiveness of mass were terms used to describe texture attributes of the chicken meat samples (Table 1). Of these terms, tenderness is most important sensory characteristic of meat and has drawn lots of interest from researchers [26]. The tenderness of meat is the sum total of the mechanical strength of skeletal muscle tissue and it's weakening during the post-mortem aging of meat. The former depends on species, breed, age, sex and individual skeletal muscle tissue of animals and fowls [27]. Meat tenderness originates in structural and biochemical properties of skeletal muscle fibres, especially myofibrils and intermediate filaments, and of the intramuscular connective tissue, (the endomysium and perimysium), which are composed of collagen fibrils and fibers. Fletcher [28] observed that collagen cross linking increased with age of chicken and was generally associated with toughness. The presence of abundant collagen tissue means that the initial hardness (first bite) will be significantly higher. On the other hand, due to the presence of abundant collagen material, the meat sample will tend to be more cohesive through the chewing process hence the negative correlation noted between these two variables (initial hardness and cohesiveness of mass) (Table 5). At the same time, the cohesiveness of mass is also negatively correlated to the tenderness. Meat tenderness has been described as a function of age, breed, and feeding regime of poultry. In the present study all IC ecotypes were kept under the same feeding regime and were approximately same age. The difference in texture reported here may therefore be the result of the difference in their genetic makeup. The time of ageing from animal slaughter and meat consumption and other components also determine meat tenderness [29]. In the present study, all the chicken meats were treated and aged the same. Studies show that muscle size increases with the biological age and poultry meat may be tougher with age [30]. Other factors that may affect tenderness include: fat content, muscle fibre, composition, electrical stimulation, ageing regime, cooking [28]. Tender poultry meat rapidly releases juices and fewer residues remains in the mouth after chewing [28]. This is clearly supported from the results of this study in which the tenderness is negatively correlated to cohesiveness of mass (Table, 5).

Juiciness

Juiciness is another important factor for determining consumers' preferences for indigenous chicken [31]. Juiciness may be determined by tasting panels and described either as initial impression of juiciness, or sustained expression of juiciness. Two factors may be responsible for this. The first is the higher drip losses which may be due to the large surface area of breast meat compared to the muscle size. The other factor could be the lower content of intra-muscular fat due to the tendency of the lower growing IC chicken to have leaner meat. Although both Chartin and Fanatico and others [32, 33] found out that higher fat content was related to tenderness; they however did not find a correlation of the tenderness to juiciness. In the present study, there is a very clear positive correlation between tenderness and juiciness. All samples that scored highest in terms of tenderness also recorded higher scores for juiciness. Fanatico [34] recommended an evaluation of both initial and sustained impression of juiciness and the current study makes this investigation. The panelists' results showed a positive correlation between the initial and sustained impression of juiciness. However, with regard to JAR scale, the broiler meats were found to tend toward to juicy, while the Kakamega ecotype IC was closest to JAR score on juiciness. The Narok ecotype was too reported to be too dry. The JAR in this case helps put the descriptive scores into perspective by bringing out exactly how the panelists and consumers will respond to the given product.

Colour

Colour is one of the most used consumer attributes in making choice of purchase of poultry products. Overall the breast muscle discolours more than thigh meat because it not only contributes to the largest percentage of live weight, its light colour renders any slight discolourations more noticeable [34]. The panelists reported a pattern in colour difference between the breast meat and the thigh meat for both broiler and the IC. The breast had more intense brown colour for broiler chicken though this was not significantly different from the colour of IC breasts. But on the thigh scores, the colours of IC meat were significantly darker than the broiler. This may explain the reason for the lower score recorded for thigh meats for both the IC and the broiler compared to breasts. The JAR scores reported colour of broiler breast meat as too light compared to the IC meat samples which were closest to the JAR scale. The multivariate PCA is applicable to the analysis of descriptive sensory attributes [35]. The PCA indicated that colour has had a negative loading for the first principal component and a positive one for the second principal component. This study showed that presence of an intense brown colour is almost in all cases related to lower degree of meat tenderness, lower flavour intensity, and less juiciness. Since meat colour is an easier attribute to assess, this attribute may be very helpful to manufactures and consumers in making decisions about the suitability of a given poultry product for a given process or its acceptability. Principal component analysis offers an effective approach for determining the most important sensory factors hence helps producers in product development. This study shows that colour was an important attribute in distinguishing among the samples. In this respect, PCA reinforces the more subjective JAR scale measures [36, 37,38]. It provides an objective way of aggregating indicators so that the variation in data can be accounted for as concisely as possible. The PCA ignores any attributes that did not distinguish significantly among the samples.

CONCLUSION

The descriptive analysis results indicated significant difference in scores between breasts (highest score in aroma, initial impression of juiciness, toughness at first bite, sustained expression of juiciness, overall tenderness and flavor) and thighs (highest scores on cohesiveness of mass and brown colour intensity). There were also significant differences among the different ecotypes with regard to aroma, flavour, and brown colour intensity. The JAR scale showed that the consumers' scores for the colour, flavour, juiciness, tenderness of indigenous chicken as 'just about right' compared to broiler which was described as too light, flavour too strong, too juicy in terms of expression of juiciness and too tender with regard to texture. The PCA results showed that two Principal Components were responsible for 55.4 % and 11.6% and 53.9 and 19% for both descriptive and JAR scores for IC meat, respectively. It shows colour as the most important attribute for distinguishing among the different samples. This study shows a very interesting relationship between the JAR scores and the descriptive quantitative tests, with JAR scores giving best indication in developing a product that would be most liked by the consumers. This study for the very first time indicates sensorial differences among the Kenyan Indigenous chicken ecotypes (of different genetic characteristics) under intensive systems. It has also brought out significant difference among various attributes (particularly colour, tenderness and flavour) and the broiler. We recommend further studies to be conducted to evaluate the differences in sensory quality in these three ecotype clusters that are reared by free range and those reared under intensive systems.

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Table 1: Legend of 9-point hedonic scale used for quantitative descriptive sensory evaluation

	ATTRIBUTE	SUBJECTIVE RANKING
1	Aroma intensity	(1 =Extremely bland to 8 = Extremely intense)
2	Initial impression of juiciness (moisture release)	(1 = Extremely dry to 8 = Extremely juicy)
3	First bite (initial hardness)	(1 = Extremely tough to 8 = Extremely tender)
4	Cohesiveness of mass	(1=Extremely loose to 8=Extremely compact)
5	Sustained impression of juiciness	(1 = Extremely dry to 8 = Extremely juicy)
6	Muscle fibre and overall tenderness (chewiness)	(1 = Extremely tough, to 8 = Extremely tender
7	Amount of connective tissue (fibrousness)	(1= Extremely abundant to 8 = none
8	Overall chicken flavour intensity	(1= Extremely bland to 8 = extremely intense)
9	Brown colour intensity	(1= None to 8 = Extremely intense)

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Table 2: The mean±standard deviation of the sensory attributes rated using a 9-point hedonic scale for chickens from different ecotypes

Part	Variable	Ecotype			
		Broiler (n=42)	Narok (n=30)	Taita (n=28)	Kakamega (n=28)
Breast	Aroma	6.24±1.48[a]	4.70±1.78[b]	5.42±1.58[b]	5.43±1.62[b]
	Juiciness	6.10±1.51[a]	4.30±1.18[b]	4.19±1.41[b]	4.46±1.79[b]
	First bite	6.81±1.23[a]	4.23±1.61[b]	4.81±1.30[b]	4.75±1.82[b]
	Cohesiveness	3.29±1.83[b]	5.23±1.55[a]	5.04±1.43[a]	5.25±1.35[a]
	Impression	6.05±1.45[a]	4.50±1.50[b]	4.62±1.60[b]	4.61±1.31[b]
	Tenderness	6.88±1.17[a]	4.83±1.53[b]	4.65±1.35[b]	4.86±1.78[b]
	Fibrousness	6.14±2.03[a]	4.93±2.18[b]	5.27±1.82[b]	4.43±2.03[b]
	Flavor	6.38±1.48[a]	5.00±1.64[b]	5.77±1.37[ab]	5.86±1.53[ab]
	Color	3.29±2.10[a]	3.43±1.45[a]	4.12±1.24[a]	4.18±1.66[a]
Thigh	Aroma	6.00±1.67[a]	3.43±1.74[c]	5.00±1.62[b]	4.86±1.74[b]
	Juiciness	6.40±1.42[a]	2.93±1.48[c]	4.19±1.74[b]	3.25±1.73[b]
	First bite	6.50±1.57[a]	2.53±1.78[b]	3.35±1.65[b]	3.36±2.04[b]
	Cohesiveness	3.55±1.73[b]	6.77±1.25[a]	6.12±1.31[a]	6.21±1.23[a]
	Impression	6.24±1.54[a]	2.93±1.68[c]	4.85±1.74[b]	3.96±1.53[b]
	Tenderness	6.60±1.19[a]	2.90±1.92[b]	3.42±1.55[b]	3.11±1.62[b]
	Fibrousness	6.26±1.55[a]	2.37±1.79[b]	2.85±1.59[b]	2.96±1.86[b]
	Flavor	6.60±1.06[a]	3.50±1.80[b]	4.85±1.67[b]	4.64±1.70[b]
	Color	3.40±1.81[b]	7.03±0.72[a]	7.04±1.18[a]	6.75±1.38[a]

Means with same letter are not significantly different at $P<0.05$. Means separated by Duncans' Multiple Range test (DMRT)

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Table 3: The mean±standard deviation of the sensory attributes rated using Just-About-Right (JAR) scale for chickens from different ecotypes

Part	Variable	Ecotype			
		Broiler (n=42)	Narok (n=28)	Taita (n=28)	Kakamega (n=28)
Breast	Colour	2.12±0.87[a]	2.19±0.75[a]	2.88±0.43[a]	2.68±0.61[a]
	Tenderness	3.85±1.04[a]	2.85±0.54[b]	2.77±0.71[b]	2.57±1.23[b]
	Juiciness	3.46±1.00[a]	2.81±0.49[b]	2.38±0.57[b]	2.93±1.25[b]
	Flavour	3.49±0.95[a]	2.46±0.58[b]	3.15±0.61[ab]	3.36±1.03[ab]
Thigh	Colour	2.44±0.74[b]	3.96±0.88[a]	4.35±0.49[a]	4.04±0.74[a]
	Tenderness	3.80±1.05[a]	2.11±1.10[b]	1.96±0.66[b]	2.07±1.05[b]
	Juiciness	3.49±0.98[a]	2.04±0.96[b]	2.50±0.51[b]	2.36±1.09[b]
	Flavour	3.29±1.03[a]	1.96±0.92[b]	2.65±0.63[ab]	2.75±1.35[ab]

Means with same letter are not significantly different at P<0.05. Means separated by Duncans' Multiple Range Test (DMRT)

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Table 4: Loading matrix of the sensory analysis of the chicken meat on hedonic scale rating

	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6	Prin7	Prin8	Prin9
Aroma	0.61252	0.52604	-0.47103	0.18273	-0.06659	-0.16529	0.18672	-0.14934	0.06255
Initial juiciness	0.78739	0.15894	0.33553	-0.16382	-0.15534	-0.30995	0.13616	0.26902	0.06502
First bite	0.84087	-0.15656	0.13537	0.09826	-0.02693	0.37199	0.18742	-0.01456	0.25692
Mass cohesiveness	-0.70187	0.37297	0.08258	-0.33011	0.44083	0.05684	0.23040	0.00134	0.04289
Sustained impression	0.74995	0.33134	0.35990	-0.23021	-0.04124	0.01307	-0.20950	-0.31492	-0.01811
Tenderness	0.87034	-0.19137	0.07159	0.03683	0.08413	0.08067	0.27140	-0.04351	-0.33207
Fibrousness	0.73797	-0.27797	0.03724	0.24554	0.48989	-0.22853	-0.12999	-0.02509	0.08191
Flavor	0.75577	0.42256	-0.19416	-0.01810	0.12710	0.24538	-0.24349	0.26462	-0.08095
Color	-0.59679	0.41907	0.40970	0.54321	0.00793	0.04093	0.02782	0.02446	-0.04673

Key: Prin=Principal component

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Table 5: The correlation coefficients of the sensory attributes on the hedonic scale rating

	Aroma	Initial juiciness	First bite	Mass cohesiveness	Sustained impression	Tendern ess	Fibrousn ess	Flavor	Color
Aroma	1.0000	0.4288	0.3804	-0.3262	0.4294	0.4229	0.3229	0.6343	-0.2475
Initial juiciness		1.0000	0.5937	-0.4631	0.6896	0.6384	0.4848	0.5370	-0.3614
First bite			1.0000	-0.6064	0.5715	0.7690	0.5921	0.5589	-0.4507
mass Cohesiveness				1.0000	-0.3640	-0.5986	-0.5231	-0.3722	0.4399
Sustained impression					1.0000	0.5670	0.4287	0.6082	-0.2988
Tenderness						1.0000	0.6686	0.5421	-0.5243
Fibrousness							1.0000	0.4532	-0.4218
Flavor								1.0000	-0.3488
Colour									1.0000

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Table 6: The correlation coefficients of the sensory attributes on the JAR scale

	Color	Tenderness	Juiciness	Flavour
Colour	1.0000	-0.4741	-0.3033	-0.2980
Tenderness		1.0000	0.5345	0.2990
Juiciness			1.0000	0.3795
Flavor				1.0000

Table 7: Loading matrix of the parameters of the JAR scale

	Prin1	Prin2	Prin3	Prin4
Colour	-0.70079	0.44781	0.50306	0.23511
Tenderness	0.81046	-0.29139	0.23543	0.45035
Juiciness	0.77026	0.15428	0.50191	-0.36192
Flavour	0.64352	0.66999	-0.34943	0.12206

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