Characterisation of physical egg qualities in indigenous chicken under free range system of production in Western Kenya

Article *in* Livestock Research for Rural Development · July 2018

CITATIONS
2

READS
2,760

3 authors:

Caroline Wambui
Maseno University
9 PUBLICATIONS **114** CITATIONS
SEE PROFILE

E.K. Njoroge
Maseno University
1 PUBLICATION **2** CITATIONS
SEE PROFILE

Chrilukovian Wasike
Maseno University
37 PUBLICATIONS **230** CITATIONS
SEE PROFILE

Characterisation of physical egg qualities in indigenous chicken under free range system of production in Western Kenya

C C Wambui, E K Njoroge and C B Wasike

Department of Animal Science, School of Agriculture and Food Security, Maseno University, P O BOX, 333 – 40105, Maseno, Kenya
wambuicc@gmail.com

Abstract

The study was conducted with the aim of characterizing the indigenous chicken (IC) egg production system to determine management practices and how they impact on external egg qualities. Opportunity was taken to identify market channels available for IC eggs to small holder farmers at village level. A hundred farmers and ten indigenous chicken egg retailers were interviewed using questionnaires in Luanda south ward of Luanda sub-county, Vihiga County, Kenya.

The survey indicated that most farmers engaging in IC production were women between 21 and 40 years old. Free range system of production was prevalent and characterized by low investment in housing where 65% of farmers did not house their birds and 99% left their birds to scavenge with minimal supplementation as the main mode of feeding. Additionally, 95% of the farmers did not separate different ages of their flock. Consequently, egg production and external egg quality was low as exhibited by the low number of eggs per clutch (10-15 eggs), weight 46.53g, length 5.47mm, width 4.05mm, shell weight 4.63g, % shell 10.09, and shell thickness 0.77mm. The % shape of 74.0 fell within 72 and 76 for normal oval shaped hen eggs. The IC egg market was easily accessible within the locality and fetched higher prices compared to commercial layer eggs. Indigenous chicken egg value chain has enormous market potential. Emphasis should be targeted towards improved housing and feeding management practices with the aim of up scaling production to exploit existing high demand.

Key words: *egg value chain, external egg characteristics, management practices*

Introduction

In Africa, majority of the population is poor and live in rural areas eking out a living from subsistence farming in order to meet household food requirements (Moreki et al 2010). Animal production in general and especially chicken production plays a vital socio-economic role in rural livelihoods in Kenya and sub-Saharan Africa where they are

kept and reared by over 90% of rural households in small flocks of about 20 birds (Stotz 1983; King'ori et al 2010).

Poultry (ducks, turkey, guinea fowl, geese and chicken) are widely acknowledged as the livestock of the poor and forms part of most smallholder farming systems (Gueye 1998). According to Ochieng et al (2013) indigenous chicken (IC) *Gallus domesticus* account for over 80% of the total poultry population in Kenya and between 40 and 60% of the domestic marketed poultry eggs and meat. This contributes to the protein requirements of households in the country. Sale of poultry products as well as live birds increase and diversify revenue for households, in addition to being used in traditional medicine and for various cultural rights (King'ori 2004).

Productivity of indigenous chicken is rated low with an annual egg production per hen being 36-97, and very small egg size of about 46g compared to commercial breeds with a potential of 140 eggs per annum and an egg size of 60g (Okitoi 1997). The major cause of differences in egg qualities is greatly attributed to the mode of management of the flock in terms of nutrition, housing, breeding and health management (Addisu et al 2013).

Continuous evaluation of IC production systems is imperative to shed light on key areas that constrain production to highlight potential mitigation strategies for improving productivity. The study was conducted to document the IC egg value chain from production to market, characterize the external egg qualities and highlight constraints to egg production and marketing.

Materials and methods

Study site

A survey was conducted in Luanda South Ward of Luanda Sub County in Vihiga County of western region of Kenya. This included Esabalu, Ekwanda, Ebwiranyi, Em'maloba and Maseno sub locations (Figure 1). The ward had an approximate population of 19,994 and covers an area of approximately 20.80 square kilometers (KNBS 2013). The study area lies between longitude 34 ^{o}, 30' east and 35^{o} 0' west and between 0^{o} and 15' north. The equator cuts across the southern tip. Luanda south experiences bimodal rainfall with the long rains in March to June and the short rains during September to November. The average rainfall per annum ranges from 1800mm - 2000mm, and the temperature ranges between 14-30^{o}C with a mean temperature of 23^{o}C. Major soils are acrisols, well drained and slightly acidic (NEAP 2009).

Figure 1. Map of Luanda Sub County showing the study sub locations in Vihiga County, Kenya

Sampling procedure and data collection

Purposive sampling technique was used for the study where only farmers with not less than 10 birds participated in the study. A total of 100 farmers were interviewed using a structured questionnaire with 20 farmers selected from each sub – locations of Esabalu, Ekwanda, Ebwiranyi, Em'maloba and Maseno. A pilot study was done two weeks prior to the actual study to pre-test the questionnaire and adjustments made before data collection.

The questionnaire gathered background information of the farmer which included demographic details such as gender, age and level of education. Data on management practices such as flock structure, feeding, housing, health and breeding management practices was collected. Egg production, handling, incubation and marketing channels were documented. Information on marketers and consumers perception on egg traits of interests was also considered as well as constraints and losses faced in the business.

External egg qualities

Indigenous chicken eggs were procured from farmers and traders and additionally, opportunity was taken to compare IC eggs with eggs from commercial hybrid chickens procured within the study area. A total of 68 IC eggs and 10 from commercial layers

were procured for analysis. Unwillingness of individual farmers to sell their eggs, prompted an adjustment to analyse eggs from local traders within the study vicinity.

External egg quality characteristics analysed according to Tabeekh (2011) included;

a. Egg weight (g), measured using an analytical balance with 0.01g readability

b. Egg Length and width (mm), measured using a Vanier caliper to 0.1mm

c. Shape index, estimated using the equation, Shape index % = (egg width/ egg length) x 100

d. Shell weight (g), measured using an analytical balance (0.01g)

e. Shell thickness (mm), measured at three different points of the broad end, narrow end and in the middle part of the egg using a micrometer screw gauge (0.01mm). The average shell thickness was then recorded in mm

f. Shell ratio estimated from the expression, Shell ratio (%) = (shell weight/ egg weight) x 100

Data analysis

Survey data was coded in Statistical Package for Social Sciences (SPSS, version 20). Descriptive statistics were used to evaluate collected data on the production, marketing practices and external egg qualities of indigenous chicken egg production system.

Results and discussion

Demographics of IC respondents

Table 1 shows the demographic characteristics of the respondents in terms of gender, age and education level. Women who kept IC chicken were (66%) while men (34 %) an indication that majority of men engaged in off farm activities (Murekefu 2013). The results are in agreement with most studies in Africa which indicate that IC are predominantly kept by women culturally and are crucial in supplementing household income and food security (Ochieng et al 2012; Murekefu 2013).

The study showed that the majority of farmers were aged between 21 to 40 years (57%) which compares favorably to a study by Morenda et al (2013) in Ethiopia who found the same age bracket farmers to be at (40.9%). However, Murekefu (2013) indicated that 48% of respondents who engaged in IC production in Vihiga County were aged above fifty years while those aged between 21-30 years were a minority (11.7%). This indicated that the older people engaged more in rearing indigenous poultry a trend that could be changing as indicated in the current study where only 19% of the respondents

were above 50 years and majority (57%) were between the youthful age bracket of 21 and 40 years.

Farmers who had attained basic primary education were (91%). Vihiga County is one of the counties with the highest literacy levels in Kenya at 84.2% compared to national figure of 79%. Though, high literacy has a positive marginal effect on the adoption of new technologies such as feed supplementation and vaccination (Ochieng et al 2012), this was not the case in Luanda South ward indicating that other underlying factors among the respondents could be attributed to the low productivity of IC for egg production.

Table 1. Characterization of household respondents keeping IC for egg production in Luanda South Ward

Variables	Maseno	Ekwanda	Em'maloba	Esabalu	Ebwiranyi	*Overall*
	% of total					
Gender						
Male	40.0	20.0	40.0	47.6	21.1	34.0
Female	60.0	80.0	60.0	52.4	78.9	66.0
Age (years)						
<20	0.00	0.00	0.00	4.80	10.5	3.00
21-30	30.0	25.0	35.0	28.6	21.1	28.0
31-40	35.0	20.0	15.0	42.9	31.6	29.0
41-50	30.0	20.0	30.0	14.3	10.5	21.0
>50	5.00	35.0	20.0	9.50	26.3	19.0
Education level						
Primary	35.0	40.0	40.0	47.6	42.1	41.0
Secondary	40.0	40.0	40.0	28.6	36.8	37.0
Tertiary	5.00	5.00	5.00	19.0	13.8	10.0
Adult education	20.0	0.00	5.00	0.00	0.00	5.00
None	0.00	15.0	10.0	4.80	5.30	7.00

Management practices

Housing and feeding

Indigenous chicken were mostly kept for household income (47%) and food (45%). Family poultry production has been widely perceived as a fast way to ensure food security, generate employment income, and promote women empowerment at a relatively low investment (FAO, 2014). Birds were managed as one flock (95%) with no separation of the different age and sex of chicken. Sixty five percent of farmers used the kitchen to house the birds. Only a few farmers had permanent structures (16%), prefabricated (14%), and mud housed (5%) table 2. Ochieng et al (2013) also reported similar scenario where despite farmers being aware of benefits of housing of chicken flock, adoption of housing remained very low with majority of them (73 %) having no housing for chicken and housing of chicken at night in their living houses or kitchens was common. The IC production system was typical of low cost - low output system where low or no investment was made on housing and equipment a characteristic predominant of extensive or free range system of production.

Most farmers (99%) left the birds to scavenge and supplemented them using locally available material such as fish meal, kitchen remains, maize, mill remains, and vegetables to improve health and increase egg production. A small number of farmers

(1%) used commercial feeds especially during the planting seasons when there was total confinement of birds. High cost and shortage of commercial feed were cited as prohibiting factors to their use (Ayieko et al 2014).

Reproductive performance

The reproductive performance of IC in the study sub locations is presented in table 2. Most IC hens started laying eggs at the age of 5 months (42%). This is in agreement with Yadessa et al (2017) age of hen at first laying of 5.8 months in south western Ethiopia. Age at which bird lay their first egg is between 4 and 6 months which is usually influenced by a number of factors such as breed, lighting regime, feeding and quality of feed among other environmental factors. In the case of scavenging chickens in the tropics, poor feeding strategies lead to delayed maturity hence delays point of lay and size of the egg. Most hens laid 10-15 eggs before going broody (48%) which was within 14.36±3.87 average number of eggs per clutch by Yadessa et al (2017).

Assuming an average of 12.5 eggs per clutch and four clutches per year, the hens in Luanda South ward locality would give an average of 50 eggs per year. Productivity of indigenous chicken is rated low with an annual egg production per hen being 36-97, and very small egg size of about 46g compared to commercial breeds with a potential of 140 eggs per annum and an egg size of 60g (Okitoi 1997). Storage of eggs collected was found to be wanting as most of the eggs (73%) were stored in containers a factor that may have resulted to a high percentage loss through breakage and spoilage.

Flock structure

Chicks and hens dominated the flock structure and an average of (2) cocks were kept by farmers. This is the trend in most African studies on indigenous chicken and indicates that it is purposively done to ensure production of adequate replacement stock in a sustainable manner, and adequate number of eggs for sale and household consumption (Morenda et al 2013; Ochieng et al 2013; Ndegwa et al 2015). The total average number of chicken each farmer kept was (19) which was close to Ochieng et al (2013) who reported an average of 23 birds per household in western Kenya. This number was slightly higher than those reported for north west (7.13), and south west (4.85 and 11.2) Ethiopia (Halima et al 2007; Morenda et al 2013; Yadessa et al 2017). Differences in total chicken per household may indicated cultural differences in value attached to IC and production systems.

Two cocks on average were maintained per flock through deliberate sale so as to keep a reasonable ratio of cocks and hen or home consumption. Traditionally, chicken is a highly valued delicacy in western Kenya and households are known to slaughter cocks mainly for valued visitors. Farmers also selectively left one cock at a time for breeding purposes to prevent fighting, common where many cocks are present in the flock (Ochieng et al 2013). When calculated, the cock to hen ratio was 1:4. This showed that almost all hens were mated and the eggs produced were fertile. This was corroborated by the high hatchability index where out of 11 eggs set for a broody hen to sit on, 9 eggs hatched implying a hatchability of 82.8%.

Table 2. Management practices and flock dynamics of indigenous chicken egg production systems in Luanda south ward

	Maseno	Ekwanda	Em'maloba	Esabalu	Ebwiranyi	*Overall*
	% of total					
Housing						
Kitchen	70.0	65.0	75.0	52.4	63.2	65.0
Permanent	15.0	20.0	5.00	23.8	15.8	16.0
Prefabricated	10.0	15.0	10.0	23.8	10.5	14.0
Mud	50.0	0.00	10.0	0.00	10.5	5.00
Mode of feeding						
Scavenging	65.0	65.0	55.0	33.3	21.1	48.0
Supplementation	0.00	0.00	0.00	0.00	5.30	1.00
Both scavenging and supplementation	35.0	35.0	45.0	66.7	73.7	51.0
Age at first lay (months)						
4	15.0	45.0	30.0	23.8	31.6	29.0
5	65.0	25.0	35.0	52.4	31.6	42.0
6	20.0	20.0	25.0	14.3	5.30	17.0
>7	0.00	10.0	10.0	9.50	31.6	12.0
Eggs per clutch						
<5	35.0	40.0	30.0	42.9	47.4	39.0
5-10	5.00	15.0	15.0	14.3	15.8	13.0
10-15	60.0	45.0	55.0	42.9	36.8	48.0
Flock structure						
Chicks	9.00	11.0	10.0	8.00	5.00	9.00
Cocks	2.00	1.00	2.00	2.00	2.00	2.00
Hens	7.00	8.00	7.00	7.00	9.00	8.00
Total IC	18.0	21.0	20.0	20.0	17.0	19.0

Over 90% of the farmers prepared brooders from locally available materials such as plastic basins with ash, soil, sawdust, rugs or grass. Selection of eggs for hatching was based on the time the egg was laid (36%) and size (29%). However, 35% of the farmers did not base their selection on anything (table 2). This was indicative of a high level of awareness of factors affecting hatchability where it is advocated that eggs selected for incubation should not be more than 14 days old while medium sized eggs are the best for high hatchability indices.

Marketing of IC eggs

Majority of the households did not sell their eggs because they considered the eggs as a source of flock size development not as an end product. This led to a shortage of the eggs for the retailers creating high demand of IC eggs in the market, making it easy to market the eggs (Mathuva 2005). Indigenous chicken eggs were easily sold to the neighbors or at the local market whenever the family needed emergency cash. Farmers also carried out barter trade using their eggs in exchange for products and services such as, maize milling, soap and salt. Losses which occurred in the farm were from breakage (27%), predation (18%), and spoilage (19%), this was caused by poor storage methods indicated by (73%) who stored their eggs in containers.

It was noted that 80% of the retailers purchased the eggs directly from the farmer at the farm, while the other 20% was equally sourced from their own farms and brokers. Similar situation was observed by Mailu et al (2012) in a study of 68 farmers conducted in Machakos, Kibwezi, Nzaui and Mwala District where 70% of all IC sales were conducted at the farm gate while only 19% of the sales were at the local market. Local

communities provide the market for IC products and most of the time demand is unmet due to low scales of production. There is thus untapped potential in niche markets within the IC value chain for provision of specific products and services if some level of investment is made and goal of production geared towards business.

The egg price offered to 56% of the farmers at the farm gate level was Kenya shilling (Ksh) 10 (Figure 2) and most farmers (74%) found it easy to market their IC eggs in addition to fetching a relatively higher price compared to eggs from commercial layers. Farmers who took their eggs to the market fetched higher prices than those who waited for the retailers to get the eggs from the farm. In the local market 50% of IC eggs sold by farmers was purchased at Ksh 12 this was different from the farm gate price of (Ksh 10). On average, 70% of all eggs sold by traders retailed at (Ksh 15). Egg traders with stalls in the market have storage space thus are under no pressure to dispose off their stock at end of day at a lower price unlike ordinary farmers who probably participate in the open air market during market days and have to return home with unsold products. This could explain the discrepancy as to why farmers fetch lower prices (Ksh 12) for their eggs compared to traders (Ksh 15) at the market place.

Farm gate prices for commercial eggs on the other hand was Ksh 8 and retailed at between 10 - 12.5 Ksh at the market place. Although expensive, IC eggs were more preferred to commercial eggs by 60% of the consumers. This was mainly because consumers associated the IC eggs with quality nutrients, better taste and the colour of the yolk. Most customers preferred big sized eggs (40%), compared to colour (10%) while 50% did not consider any egg quality. Breakages and spoilage were the main causes of losses (60%) at the trader's level. This was caused by poor handling and storage mechanisms.

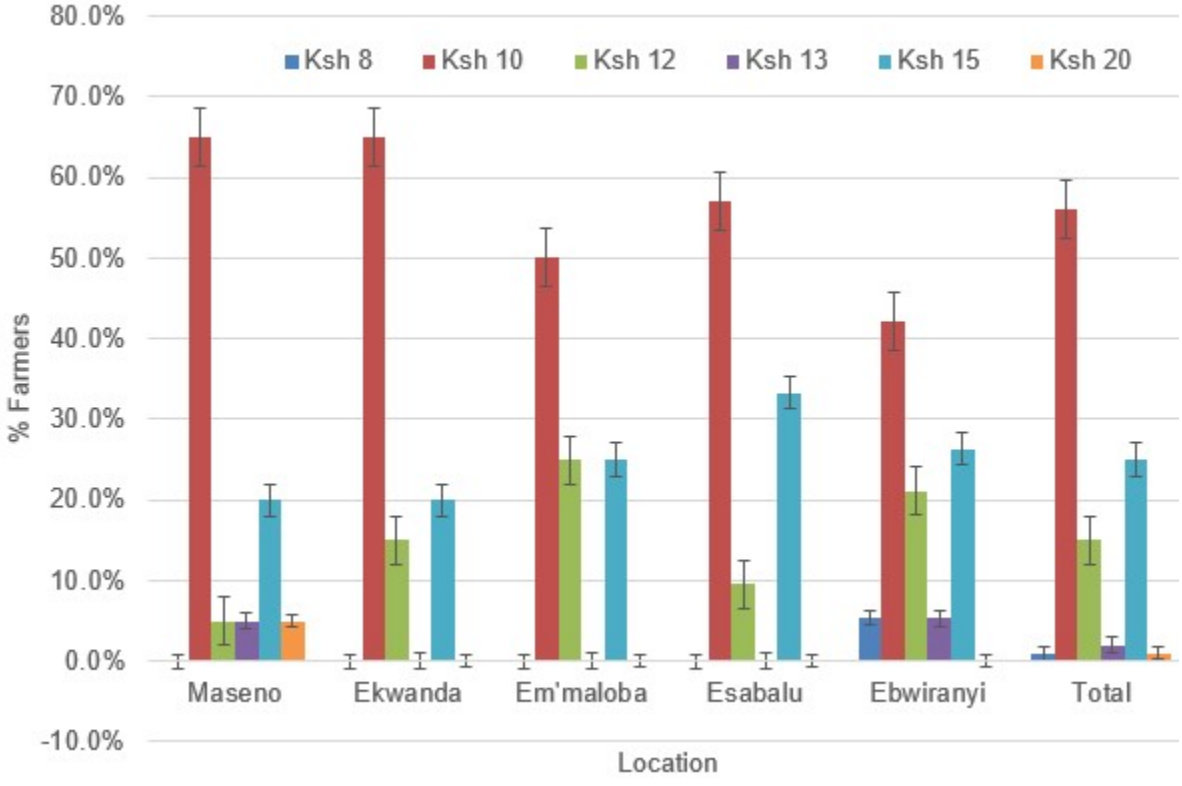

Figure 2. Farm gate prices of IC eggs at different locations of Luanda South ward

External egg characteristics

Table 3. A comparative analysis of the external egg qualities of IC and commercial layers in Luanda South ward (Means ± SEM)

Variable	Indigenous chicken eggs (n=68)	Commercial layers eggs (n=10)
Egg weight (g)	46.5± 0.68	63.5±0.48
Egg length (mm)	5.47±0.03	5.69±0.03
Egg width (mm)	4.05±0.03	4.44±0.02
Egg shape index (%)	74.1±0.45	77.8±0.53
Shell weight (g)	4.63±0.06	6.55±0.06
Shell %	10.1±0.20	10.3±0.08
Shell thickness (mm)	0.77±0.01	1.03±0.01

The average mean egg weight (46.53g) produced by indigenous chicken compares well to results found by Bobbo et al (2013) in Nigeria frizzle phenotype local chicken whose mean weight was 45.04g (table 3). However, this was much lower (36.6%) compared to commercial egg weight (63.5g). Commercial eggs had similar weights as (60.96 ± 0.56) indicated by (Hanusova et al 2015) for Oravka breed in Slovakia. In general, the characteristics of egg quality have genetic basis as observed between the indigenous chicken eggs and commercial chicken eggs. Observed differences are mostly linked to genetic factors, age of laying, season, climatic conditions and feed effects (King'ori 2012).

The mean egg length obtained from IC in the study was slightly higher (5.47mm) **c**ompared to that of frizzled chicken ecotype (5.05) reported in Nigeria (Bobbo et al, 2013). The value however was lower than that of commercial chicken eggs (5.69mm). The egg width value obtained was higher than that found by (Bobbo et al 2013) (3.95cm). The aim of study of Bobbo et al (2013) was to compare the egg quality traits of three phenotypes of village chicken where the quality traits of the frizzed chicken and naked neck compared well with our study though eggs in current study were nondescript. Differences observed in egg quality characteristics especially weight, percentage of eggshell, thickness and strength of eggshell and shape are important egg aspects that influence grading, packaging, price, acceptability by consumers and hatchability (King'ori 2012). Consumers in particular are more interested in the egg weight (size) among other factors such as cleanliness and freshness that enhance acceptability eggs (Hanusova et al 2015).

Egg shape index is an indicator of external egg quality. Values produced by indigenous chicken compared favorably with those of (Bobbo et al 2013) on naked neck ecotype in Nigeria, even though they were much lower compared to the commercial chicken (77.80). This difference was mainly due to breed effect whereby the commercial chicken are hybrids specifically selected for egg production.

Table 4. Correlations between external quality characteristics of indigenous chicken eggs

	Egg weight	Egg length	Egg width	Shell weight	Shape index %	Shell %	Shell thickness
Egg weight	1						
Egg length	0.56	1					
Egg width	0.91	0.48	1				

Shell weight	0.59	0.24	0.39	1			
Shape index%	0.55	-0.26	0.72	0.22	1		
Shell%	0.47	0.34	0.58	0.43	-0.38	1	
Shell thickness	0.46	0.048	0.31	0.57	0.29	0.12	1

Positive correlations were observed between egg weight and width and other egg parameters (Table 4) which was similarly observed by Bobbo et al (2013). Egg width is indicated to be a good estimator of shape index and thus can be used as a criterion for determining stiffness of eggs (Bobbo et al 2013). A negative correlation was observed between the egg length and shape index implying longer egg lengths contributed towards distortion of the normal oval shape of the egg -, while egg width enhanced the shape index. According to the study of Duman et al (2016) eggs were classified with respect to shape index (SI), namely as a sharp egg (SI < 72), a normal (standard) egg (SI = 72–76) or a round egg (SI > 76). The IC eggs in the study fell in the normal standard category (74.1) while the commercial eggs were round (77.8). Domestic hen eggs with unusual shapes such as those that are long and narrow, round, or flat-sided, are poorly graded since an egg is generally oval in shape (72–76). Round eggs and unusually long eggs have poor appearances and do not fit well in egg crates; therefore, they are much more likely to be broken during the transport than the eggs of normal shape (Duman et al 2016).

Conclusions

- Women dominated production of IC in Luanda South Ward for household food and income security and fell in the age group of 21 to 40 years of age.
- The youthful farmers between 21 to 40 years of age have potential to transform the enterprise from subsistence into income generating ventures if empowered with production and marketing skills.
- The low input free range system negatively impacted on egg productivity and external qualities such as egg weight, shell weight and thickness, parameters greatly influenced by interactions between genotype and feeding management where adequate provision of protein and mineral are key requirements.

Acknowledgements

The authors express gratitude to Department of Animal Science, Maseno University for facilitation to conduct the survey. Farmers and egg retailers who willfully participated and cooperated in the study. Special mention to Gilbert Muthoka, Paul Chege, Derrick Langat and Nicholas Kimutai who assisted in data collection.

References

Addisu H, Hailu M and Zewdu W 2013 Indigenous Chicken Production System and Breeding Practice in North Wollo, Amhara Region, Ethiopia. Poultry Fisheries Wildlife Science 1 (2): 1-9 Available at: https://www.omicsonline.org/open-access/indigenous-chicken-production-system-and-breeding-practice-in-north-wollo-amhara-region-ethiopia-pfw.1000108.php?aid=19316.

Ayieko M O D, Bett K E and Kabuge W L 2014 Profitability of indigenous chicken: The case of producers Makueni County, Kenya. Journal of Economics and Sustainable Development, 5 (11):15-23 Available at: http://iiste.org/Journals/index.php/JEDS/article/view/13834.

Bobbo A G, Baba S S and Yahaya M S 2013 Egg quality characteristics of three phenotypes of local chicken in Adamawa state. Journal of Agriculture and Veterinary Science, 4 (2):13-21 Available at: http://www.iosrjournals.org/iosr-javs/papers/vol4-issue2/C0421321.pdf.

Duman M, Şekeroğlu A, Yıldırım A, Eleroğlu H and Camcı Ö 2016 Relation between egg shape index and egg quality characteristics. European Poultry Science, 80: 1-9

FAO 2014 Family poultry development − Issues, opportunities and constraints. Animal Production and Health Working Paper. No. 12. Rome. Available at: http://www.fao.org/3/a-i3595e.pdf

Gueye E F 1998 Village eggs and fowl meat production in Africa. Worlds Poultry Science Journal 54:73-86

Halima H, Neser F W C, Vanmarkle-Koster E and Kock A D E 2007 Village based indigenous chicken production systems in north -west Ethiopia. Tropical Animal Health and Production, 39(3):189-197

Hanusova E, Hrnčár C, Hanus A and Oravcová M 2015 Effects of breed on some parameters of egg quality in laying hens. Acta Fytotechnica et Zootechnica , 18 (1): 20–24 Available at: http://www.acta.fapz.uniag.sk/journal/index.php/on_line/article/viewFile/129/pdf.

Kenya National Bureau of Statistics (KNBS) 2013 Statistical Abstract.

King'ori A M 2004 The protein and energy requirements of indigenous chicken (*Gallus domesticus*) of Kenya. PhD Thesis, Egerton University, Kenya, pp 93

King'ori A M 2012 Poultry egg external characteristics; egg weight, shape, and colour. Research Journal of Poultry Science, 5 (2): 11-17 Available at: http://medwelljournals.com/abstract/?doi=rjpscience.2012.14.17

Kingori A M, Wachira A M and Tuitoek J K 2010 Indigenous Chicken Production in Kenya: A Review. International Journal of Poultry Science 9 (4): 309-316 Available at: https://pdfs.semanticscholar.org/3a72/0154d43780f088d6b1707f16419611d3093c.pdf.

Mailu S K, Wachira M A, Munyasi J W, Nzioka M, Kabiru S K, Mwangi D M, Kaguthi P and Kithome J 2012 The influence of prices on market participation decisions of indigenous poultry farmers in four districts of Eastern province, Kenya. Journal of Agriculture and Social Research, 12(1): 1-10 Available at: https://www.ajol.info/index.php/jasr/article/download/81674/72340

Mathuva J M 2005 Value Chain Analysis of the Indigenous Poultry Sub-Sector, Kilifi and Kwale Districts – Kenya, Coastal Rural Support Programme

Moreki J C, Dikeme R and Poroga B 2010 The role of village poultry in food security and HIV/AIDS mitigation in Chobe District of Botswana. *Livestock Research for Rural Development. Volume 22, Article #55.* Retrieved April 20, 2018, from http://www.lrrd.org/lrrd22/3/more22055.htm

Morenda E, Harrepal S, Johanssen A, Sisaye T and Sahile Z 2013 Characteristics of Indigenous chicken production system in South west and South part of Ethiopia. British Journal of Poultry Science, 2 (3): 25-32 Available at: https://idosi.org/bjps/2(3)13/1.pdf

Murekefu F 2013 Selected factors affecting the development of indigenous poultry value chain in Vihiga county Kenya. MSc. Thesis, Egerton University, Kenya

National Environment Action Plan (NEAP) 2009 Republic of Kenya, Ministry of Environment and Mineral Resources. National Environment Management Authority, Vihiga District Environment Action Plan 2009-2013

Ndegwa J M, Mead R, Norrish P, Shepherd D D, Kimani C W, Wachira A M and Siamba D N 2015 Evaluating characteristics of indigenous chicken system with flock size trends in a participatory research on improved management practices in Kenya. Journal of Agricultural Studies, 3 (2): 97 -113 Available at: www.macrothink.org/journal/index.php/jas/article/download/6363/6309

Ochieng J, Owour G and Bebe B O 2013 Management practices and challenges in smallholder indigenous chicken production in Western Kenya. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 114 (1): 51–58 Available at: https://www.jarts.info/index.php/jarts/article/download/2013030542607/429

Ochieng J, Owuor G and Bebe B O 2012 Determinants of adoption of management interventions in indigenous chicken production in Kenya. African Journal of Agricultural and Resource Economics, 7 (1):39-50 Available at: https://ageconsearch.umn.edu/bitstream/156977/2/Ochieng_07_01.pdf

Okitoi l O 1997 Productivity of indigenous chicken in western Kenya, KARI. Nairobi, Kenya

Stotz D 1983 Production techniques and economics of smallholder livestock production systems in Kenya. In Farm Management Handbook. Vol 4.Jaetzold, R., and Schmidt, H., eds.Nairobi: Ministry of Agriculture, Kenya, in cooperation with the German AgriculturalTeam (GAT) of the GTZ, pp. 95–106

Tabeekh M A S A 2011 Evaluation of some external and internal egg quality traits of quails reared in Basrah city. Basrah Journal of Veterinary Research, 10(2):78-84

Yadessa E, Tulu D, Bogale A, Mengistu G, Aleme M, Shiferawu S, Esatu W and Amare A 2017 Characterization of smallholder poultry production systems in Mezhenger, Sheka and Benchi -Maji zones of south western Ethiopia. Academic Research Journal of Agricultural Science and Research, 5(1): 10-19

Received 8 May 2018; Accepted 24 May 2018; Published 3 July 2018

Go to top