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Full Length Research Paper

Rural farm families' probable acceptability of small ruminant's milk for consumption in Ogun State

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The nutritional intake of the rural households, which is largely characterised by carbohydrates at the expense of protein intake, has the potentials of being improved through the consumption of sheep and goats' milk. With the widespread of small ruminant keeping by rural households in most developing countries, the study embarked on investigation of possible acceptability of sheep and goats' milk for consumption by farm families in selected rural communities of Ogun State. With the use of interview guide to obtain information from the conveniently selected 150 rural farm families, the results showed that 72% of them reared goats, keeping between 6 and 10 of the animal; 84% consumed *wara* (local cheese) as milk product from cow's milk; and 20% occasionally consumed milk either in evaporated and/or powdered forms. Although, none of the rural farm families ever consumed sheep and goats' milk basically because it was hardly available in the Nigerian market in any form, 57.3% of them slightly accepted to consume the small ruminant's milk. Chi-square test of the relationship between farm families' socioeconomic characteristic; their milk consumption pattern and their probable acceptability of sheep and goats' milk for consumption showed no significant relationship. The study concluded that the rural farm families had a slight potential of accepting the small ruminants' milk for consumption and thus recommended that the farm families should be educated and trained on technical exploration of the small ruminants' milk for production and consumption.

Key words: Sheep and goats' milk, probable acceptability, consumption, rural farm families, Ogun State.

INTRODUCTION

Milk, which is one of the primary products of ruminant animals, constitutes essential diets of mankind, given its high nutritional value (Gulati et al., 2000; Bhat and Bhat, 2011). Consequently, milk consumption is rather considered a necessity or dietary essentials in the developed and affluent countries where the ruminant's product – milk, and milk products are readily consumed by citizens of such countries (Beldman and Daatselaar, 2013). In the developing or third world countries, of which Nigeria is one, milk consumption is considered a luxury and as such the ruminant's product is largely consumed by the affluent households in the country. In other words, milk is a rare commodity to low income earners and rural households in Nigeria and such their dietary intake is

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largely carbohydrate-based (Olarinde and Kuponiyi, 2005). The resultant effect of heavy dependence on carbohydrate-based food or poor protein intake of the households is a diseased condition often manifested as kwashiorkor, poor physical growth and mental development, high infant mortality and malnutrition in adult (Med-Health, 2015). In order to stem the tide of the poor living condition among the rural farm families in Nigeria, consumption of protein rich foods, one of which is milk, becomes essential and should be a regular feature of their menu.

The potential of adequately sourcing needed proteins by the rural families is the livestock kept by them, particularly the small ruminants. Sheep and goats are though generally reared for meat production in Nigeria (Zahradeen et al., 2009), the small ruminants have the added advantage of providing the rural farm families with milk for consumption (Malau-Aduli et al., 2004). Although, the reared small ruminants are dominantly local breeds, the breeds have been observed to have the capability of producing as much as 281.98 ml per day following parturition (Bemji et al., 2007), and this can be increased by 48 to 78% on administration of lactotropin (bovine samatotropin) after the peak lactation. Stimulation of the animals' milk increment, as expressed by James (2000, 2009), mostly takes place at the third week of lactation. This submission thus depicts that the Nigerian rural farm families could readily harness the milk production potentials of their small ruminants for milk production and consumption; and regular consumption of such milk would improve the nutritional status of their food intake.

But the questions at hand are: Do the rural farm families consume milk? What forms of milk do they consumed? How regular do the rural families consume milk? Are they willing to consume small ruminants' milk? What underlining factors could influence their probable consumption or rejection of sheep and goats' milk? To answer these questions, the study used the following objectives as guides for empirical assessment of the farm families' probable acceptability of sheep and goats' milk for consumption in selected rural communities in Ogun State.

(1) Describe the rural farm families' socioeconomic characteristics;
(2) Identify the forms of milk and milk products consumed by the rural families,
(3) Determine the farm families' pattern of milk and milk products consumption,
(4) Ascertain the rural farm families' probable acceptability of sheep and goats' milk for consumption.

Study hypothesis

$H0_1$: There is no significant association between the rural farm families' socioeconomic characteristics and their probable acceptability of sheep and goats' milk for consumption.

$H0_2$: Rural farm families' milk consumption pattern is not significantly associated with their probable acceptability of the small ruminants' milk for consumption.

METHODOLOGY

This study was conducted in selected rural communities in Ogun State. The State has Abeokuta as its capital, and a land area of about 16,409 sqkm. It is situated in the rainforest zone of Nigeria on latitudes 6° 30' and 8° 10' N and longitude 2° 15' and 4° 15' E. Ecologically, the State has a rainfall season of between 6 and 8 months, mostly between April and October, with temporary cessation in August ("August break"). For political administration, Ogun State is structured into 20 Local Government Areas (LGAs), and ethnically into four divisions, namely, Remo, Ijebu, Yewa and Egba. Out of the 20 LGAs in the State, six LGAs– Odeda, Obafemi-Owode, Abeokuta South, Abeokuta North, Itori and Ifo, which forms the study area, fall in the Egba division. The economies of the rural communities across the state were largely crop farming, followed by agro-processing and livestock rearing.

Study population

This consists of rural farm families rearing sheep and goats and resides in the selected rural communities for the study.

Sampling procedure

A total of ten rural communities, namely Alabata, Idera-Osiele, kila, Olugbo, Olokose, Olodo, Igbogila, Isaga-orile, Olorunda and kofesu were conveniently selected across the Egba division of the state. From each of the villages, fifteen farmers were randomly selected to give a total 150 respondents.

Data collection

A validated and reliable interview guide was used for data collection on the respondents' socio-economic characteristics, forms of milk and milk products consumed by the rural families, their consumption pattern of milk and milk products, and their acceptability of sheep and goats' milk for consumption. For measurement of the rural farm families' acceptance of small ruminants' milk for consumption, a self-developed 5-item rating scale was designed in form of a 5-point rating scale of Strongly Agree = 5, Agree = 4, Disagree = 3, Strongly Disagree = 2 and Undecided = 1. With this rating scale it suggests that the each of the respondents could only obtain a minimum mean score of 1 and maximum mean score of 5 on each of the statements; and for aggregation of the scores, each of the respondents could obtain a minimum score of 5 (if all responses were undecided that is, 1 x 5) and a maximum score of 25 (whereby all responses were strongly agree that is, 5 x 5).

Data analysis

Collected data were analysed and discussed with the use of descriptive statistical tools such as frequency counts and percentages for presentation of the results in tabular form; and chi-square test was used for the study hypotheses. This inferential

Table 1. Socioeconomic characteristics of respondents (n = 150).

Variables	Frequency	Percentage
Sex		
Male	78	52
Female	72	48
Age		
≤ 30	12	8
31 – 40	30	20
41 – 50	30	20
51 – 60	54	36
≥ 61	24	16
Marital status		
Single	51	34
Married	99	66
Family size		
> 5	57	38
6 – 8	84	56
9 – 11	9	6
Educational background		
No formal education	6	4
Vocational education	18	12
Primary school education	27	18
Secondary school education	84	56
Tertiary education	15	10
Occupation		
Farming	69	46
Artisan	42	28
Traders	39	26
Religion		
Christianity	75	50
Islam	54	36
Traditional religion	21	14

*Not all the respondents had sheep.

statistical tool was found appropriate for the study hypothesis basically because the study variables were measured at nominal level. Although, the use of the 5-item-statement-scale constitutes interval/ratio level of measurement, the obtained data were scaled down to ordinal level thereby making it fit for application of chi-square analytical tool.

For analyses of responses on each of the 5-item acceptability statements, a mean value for each of the statements were computed and as such rated in the order of 1.0 – 2.34; 2.35 – 3.69 and 3.70 – 5.0 to imply unacceptability, slight acceptability and high acceptability respectively. On another note, the 5-item statements were aggregated so as to reflect the overall score obtained by each of the respondents and this was rated at the interval of 5 – 11; 12 – 18 and 19 – 25 to indicate unacceptability, slight acceptability and high acceptability of small ruminants' milk.

RESULT AND DISCUSSION

Socioeconomic characteristics of respondents

Socioeconomic characteristics of the surveyed rural farm families, indicated in Table 1, shows that 52% of them were male, about 66% of them were married and 56% of them had between 6 and 8 family members. This

observation though suggests that sheep and goats are largely kept by households in rural areas, Sumberg and Cassaday (1985) submitted that small ruminants are largely owned by individual men and women rather than domestic unit or kin. The study though observed that a little more male (52%) than their female (48%) counterpart as owners of the small ruminants, Hulela (2010) stresses that roles played by women in the management of sheep and goats were not significantly different from that of men.

Age characteristics of the respondents show that 36% of them were within the age range of 51 and 60 years and 56% of them had secondary school education as the highest level of education. With farming as the main occupation of 46% of the farm families, it suggests that sheep and goats are largely reared alongside crop cultivation. This is in line with Pollot and Wilson (2009) and Ozung et al. (2011) submission that small ruminants are either reared together with crop production as integrated farming and/or as security against crop failure and for financial security. With 50% of the respondents practicing Christianity as mode of worship and others into one form of religion or the other, implies that rearing of sheep and goats has no religious hindrances among the rearers.

Small ruminant keeping characteristics

Small ruminant management characteristics of the rural farm families, as reflected in Table 2, shows that goats were largely reared by the respondents with 72% of them keeping between 6 and 10 of the farm animals. As much as 42% of them reared the same number of sheep, and 40% of the farm families had been rearing the small ruminants for upward of 11 to 15 years. This observation goes in line with Sumberg and Cassaday (1985) submission that sheep and goats are reared by as much as 75% the rural population in West Africa. In the same vein, Dossa et al. (2008) observed higher ownership of goats (91%) than sheep (35%) among the rural dwellers in southern region of Benin republic.

Interactive discussion with the respondents on why most of them had higher number goats than sheep revealed factors such as hardiness of goats to withstand harsh environmental condition than sheep, the twining (and sometimes triplets) birth-given quality of the animal against single parturition quality of sheep and the cheaper cost of acquiring goats against the cost of owning a sheep. The hardiness and adaptability of sheep and goats to a particular area depends on genetic make-up and human selection for adaptation to environmental condition of the area (Najari et al., 2005; Serradilla 2001). Based on the market survey of prices of sheep and goats, Lawal-Adebowale (2012) affirms the rural farm families' indication of cheaper cost of goats than that of sheep as underlining factor for having more number of goats than sheep.

Extensive system of management was found to be the dominant method of livestock keeping among 73.3% of the ruminant farmers in the study area. Adoption of this system of management cannot be unconnected with the system's cheaper cost of management (Lawal-Adeowale, 2012) as the farm animals were provided with little or no housing units, medication and animal feed but were allowed to roam the communities for grazing available grasses/forage and kitchen wastes.

Forms of milk and milk products consumption by the rural farm families

In Table 3 are the milk and milk products consumed by the farm families in the rural communities. Majority of them consumed milk products such as local cheese commonly referred to as *wara* in Nigeria (Akinyele et al., 1999), and this was largely consumed either fresh or fried as respectively observed among 84 and 70% of the respondents. Other local milk products consumed by 18% of the rural farm families was *nono* – a fermented local milk (Adesokan et al., 2011), and industrial processed yoghurt by 14% of the respondents. Consumption of *nono* and yoghurt by a less proportion of the farm families could be attributed to their non-consideration of milk and/or milk products as part of basic food for consumption but as refreshment by individuals who might felt the need for their consumption.

Interactive discussion with the respondents on sources of the milk products consumed by them however shows that *wara* and *nono*, and yoghurt were never made by the farm families but sourced or bought from milk products' vendors. This observation goes in line with Bankole (1990); Joseph et al. (1998); Yahuza (2001); Uzeh et al. (2006) and Omotosho et al. (2013) that *nono*, for instance, is locally produced in homes and villages, particularly by the Fulani women, and sold to interested individuals for consumption. Yoghurt on the other hand is sought from bicycle riders who hawked the product in the neighbourhood or on the road side. Purchase of the milk products by the farm families could be attributed to non-availability of cow or cow milk to them and their lack of the technical-know-how on how to produce the milk products.

Consumption of the local cheese – *wara,* by higher proportion (84%) of the farm families could be attributed to their developed tastes for the product and its affordability. For instance, the respondents found the product affordable at ₦20.00 (13cent)[1] for about 10g. Although the same price goes for about 50cl of the fermented local milk (*nono*), consumption of this product by a lesser proportion (18%) of the respondents was

[1] The exchange rate was based on ₦175 to one United States of America's dollar, as at November 2014

Table 2. Small ruminant keeping characteristics of respondents (n = 150).

Variables	Frequency	Percentage
Number of goats kept		
≤ 5	3	2
6 – 10	108	72
11 – 15	36	24
≥ 16	3	2
Number of sheep kept		
≤ 5	39	26*
6 – 10	63	42
11 – 15	6	4
≥ 16	0	0
Management system		
Intensive	9	6
Semi-intensive	31	20.7
Extensive	110	73.3
Years of sheep and goat keeping		
≤ 5	6	4
6 – 10	39	26
11 – 15	60	40
≥ 16	45	30

Table 3. Forms of milk and milk products consumed by the rural farm families (n = 150).

Variables	Frequency	Percentages	Sources of milk/milk products
Milk products			
Fresh cheese (*wara*)	126	84*	Cattle
Fermented milk (*nono*)	18	18	Cattle
Yoghurt	21	14	Cattle
Fried cheese	105	70	Cattle
Milk			
Powdered milk	33	22	Cattle
Evaporated milk	27	18	Cattle

* Multiple responses

found to have been brought about by less taste for the product by most of the farm families.

Yoghurt, which on the other hand has wider acceptability for consumption in Nigeria, especially in the urban areas, was however observed to be less consumed by a few (14%) of the surveyed rural farm families. Interactive discussion on this observation with the respondents revealed high cost of the milk product as a responsible factor for the observed low level of consumption. Market investigation in this regard showed that the milk product, which is largely produced commercially by medium and large scale industries in the country or imported from foreign industries, could be obtained for consumption at a least price of ₦80.00 for (46 cent) for 90 ml and ₦100.00 (57cents) for 200 ml of the yoghurt. And given the level of poverty ravaging the farm families, the marketing prices of the yoghurt thus become expensive for them to bear.

Further interaction with the farm families shows that they were of the conviction that the consumed local milk and milk products were mainly from cattle source. This observation goes in line with Omotosho et al. (2013) that *nono*, for instance, is locally produced from cattle's milk in homes and villages and sold to interested individuals for

Table 4. Pattern/regularity of milk and milk products consumption (n = 150).

Variables	Milk		Milk products	
	Frequency	Percentage	Frequency	Percentage
Pattern of consumption				
Daily	0	0	0	0
Weekly	0	0	0	0
Bi-weekly	0	0	24	16
Monthly	18	12	51	34
As the need arises	45	30	75	50

consumption. According to Aduku and Olukosi (1991), the patronage of *nono* and other locally produced milk for consumption by most people in Nigeria is believed to have been influenced by high market prices of imported or commercially processed milk and milk products.

Examination of the respondents' consumption of the commercially produced milk, that is, evaporated and powdered milk, shows that 40% of them consumed the milk (powdered milk by 22% and evaporated milk by 18% of them). The observed low level of consumption of the commercially processed milk by the respondents was attributed to non-afford the milk, especially for every member of the households whenever their need its consumption. Market survey of the commercially produced milk shows that a tin of 170 g evaporated milk cost as much as ₦100.00 (57 cent) and a tin of 450 g powdered milk cost upward of ₦600.00 (US$3.43). The observed consumption of evaporated and powdered milk by 18 and 22% of the farm families respectively, was as a result of market availability of small size packages of the milk in sachets of varying grams and sold at affordable prices. For instance, the least quantity of the sachet powdered milk, which was 7 g costs ₦10.00 (5.7 cent) followed by 20 g of the milk at ₦20.00 (11.4 cent) per sachet. The least quantity of evaporated milk put at 70 g costs ₦50.00 (28.6 cent) per sachet.

Pattern or regularity of milk and milk products consumption

Pattern of milk and milk products consumption, as indicated in Table 4, shows that half (50%) of the farm families took the local milk products as the need may arise and some (34%) of them consumed the product at least once a month. A few of the respondents consumed milk at least once a month (12%) and as the need may rise by 30% of them. This observed irregularity of milk and milk products consumption by majority of the farm families suggests that they could hardly afford the market price of processed milk or milk products and at the same time hardly explored their small ruminants for milk production and consumption.

On another note, non-affordability of milk for consumption by the farm families cannot be unconnected with their level of poverty, in which most of them depends on about US$2 dollars a day for meeting their daily food needs (Otte et al., 2012). In view of this, they hardly spend on milk for consumption but largely on plant-based foods that are less expensive in relation to milk. In essence, milk consumption is rather considered a luxury and as such is largely consumed occasionally or when it becomes necessary or a must take by the respondents.

The non-exploitation of the small ruminants for milk production and consumption by the respondents may be due to their lack of insight into extracting the sheep and goats' milk for consumption or lack of technical-know-how on how the small ruminants' milk could be milked and locally processed for consumption. In addition, the non-exploitation of the small ruminants for milk consumption could be attributed to the little or no precedent of such practice in the culture or environment of the surveyed farm families.

Rural farm families' probable acceptability of small ruminants' milk for consumption

Examination of rural farm families probable acceptability of small ruminants' milk for consumption, as indicated in Table 5, shows that they slightly accepted that *"Sheep and goats are cheap source of milk for household consumption"* ($\bar{X}$= 2.48); and slightly accepted that the animals *"…could be explored for the purpose of meeting protein requirement of the family*" ($\bar{X}$= 2.80). They also had slight acceptability that*"sheep and goats' milk is as attractive as that of cattle's* ($\bar{X}$= 2.82) and the understanding that *"Sheep and goats' milk… and/or milk products … could serve as substitute for that of cattle's* ($\bar{X}$= 2.88). This observation is congruent to Midau (2012) observation that ruminants' milk, particularly that of goats, is rich in nutritional content and as such could be used to supplement the nutritional status of the rural farm families.

The farm families' conception of sheep and goats' milk for consumption could though have been based on the

Table 5. Measures of rural farm families' acceptability of sheep and goats' milk for consumption (n = 150).

Acceptability measures	Mean	Standard deviation
A) Probable acceptability of small ruminants' milk		
1) Sheep and goats are cheap source of milk for household consumption	2.48	0.838
2) Sheep and goats' milk could be explored for the purpose of meeting protein requirement of the family	2.80	0.728
3) Sheep and goats' milk could serve as substitute for cattle's milk	2.88	0.798
4) Milk from sheep and goats is as attractive as that of cattle's	2.82	0.522
5) Cheese from sheep and goats can be substituted for cattle's	2.88	0.789

Category	Class interval of aggregated scores	Frequency	Percentage
Unacceptable	5 – 11	41	27.4
Slightly acceptable	12 – 18	86	57.3
Highly acceptable	19 – 25	23	15.3

Implications of the mean value for each of the statements: 1.0 – 2.34 = unacceptable; 2.35 – 3.69 = slightly acceptable and 3.70 – 5.0 = highly acceptability.

Table 6. Chi-square test of the relationship between the rural farm families' socioeconomic characteristics and their probable acceptability of sheep and goats' milk consumption.

Variables	χ^2	*df*	$P_{\alpha\ 0.05}$	Decision
Age	5.939	8	0.919	NS
Religion	4.627	4	0.592	NS
Family size	7.837	2	0.250	NS
Farming experience	9.654	4	0.379	NS
Marital status	13.028	3	0.161	NS
Education	2.279	8	0.892	NS
Chi-square test of the relationship between the rural farm families' pattern of milk consumption and their probable acceptability of sheep and goats' milk consumption				
Pattern of milk consumption	8.026	2	0.096	NS

assumption that the small ruminants could be exploited for milk production and consumption, the observed disposition of the respondents suggests the existence of possible acceptance of the small ruminant's milk for consumption in the study area. Realisation of this possibility however depends on education and training of the respondents on small ruminant's milk exploitation and processing for consumption.

Aggregation of the 5-item statements on the farm families' probable acceptability sheep and goats' milk for consumption, highlighted in Table 5, shows that more than half of the respondents (57.3%) slightly accepted sheep and goats' milk for consumption and a little more than quarter (27.4%) of them found consumption of the small ruminants' milk unacceptable for consumption. A few of the rural farm families (15.3%) however found the small ruminants' milk highly acceptable for consumption. This observation implies that, a few of the respondents' were though averse to consumption of sheep and goats' milk, a larger proportion of them had the potentials of accepting the small ruminants' milk for consumption.

Chi-square test of the relationship between the rural farm families' socioeconomic characteristics and their probable acceptability of sheep and goats' milk consumption

Result of the chi-square test of the relationship between the respondent's socio-economic characteristics and their level of probable acceptability of sheep and goats' milk consumption (Table 6) shows no significant relationship at $p<0.05$ level. This implies that none of the respondents' socioeconomic characteristics, specifically age, religion, marital status and level of education had anything to do with their disposition to sheep and goats' milk consumption in the study area. A non-significant relationship was similarly observed between the rural

farm families' level of probable acceptability of the small ruminant's milk for consumption and their pattern/regularity of milk consumption, given the implication that the rare occasion of milk consumption by the respondents had nothing to do with their possible acceptability of the small ruminant's milk for consumption in the surveyed rural communities.

The observed non-significant relationship between the tested variables and probable small ruminant's milk acceptability may have been informed by the rare cases of the small ruminant's milk production, marketing and consumption in the surveyed rural communities. This is based on fact that cow's milk constitutes the main milk readily available in the Nigerian markets, and even the source of locally produced milk or milk products. As pointed out by Olasupo et al. (1996), the local milk and milk products production in Nigeria, particularly by the Fulanis, were from cattle. In addition, sheep and goats rearing, as observed by Lawal-Adebowale (2012), are hardly raised for milk, but largely for meat consumption and income generation in southwest Nigeria, a region that is largely occupied by the Yoruba speaking tribes.

CONCLUSION AND RECOMMENDATION

Based on the outcome of analysis of the rural farm families' probable acceptability of sheep and goats' milk for consumption in the selected rural communities of Ogun State, and their pattern of milk and milk products consumption, it was concluded that small ruminants' milk were never consumed by the rural dwellers in the study area. This is not unconnected with the fact that milk or milk products from sheep and goats were hardly available in the Nigerian markets; and hardly were the small ruminants' milk production potentials explored for consumption, particularly in the context southern part of Nigeria. Notwithstanding this submission, the study observed that the rural farm families had slight acceptability of the small ruminants' milk for consumption suggesting that they could favourably accept the small ruminant's milk for consumption. This assertive position is premised on the fact that the rural farm families had little or no cultural biases against the small ruminant rearing and the animals' milk, they cherished its nutritive value and favoured substitution of the sheep and goats' milk for that of cattle's. In view of this, the following recommendations are thus proffered as way to stimulate the rural farm families' acceptability of sheep and goats' milk for consumption.

(1) The rural farm families should be educated and enlightened on nutritional values of sheep and goats' milk and its potential benefits to human's health.

(2) Milk production capacity of their local breeds of sheep and goats should be enhanced through the introduction of high-milk producing small ruminants for crosses with the rural farm families' local breeds.

(3) The rural farm families need to be provided technical training on efficient milking and processing of the small ruminants' milk for safe consumption.

Conflict of Interest

The authors have not declared any conflict of interest.

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Statistical determination of chick sex from pre-hatch egg measurements

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This study was aimed at using weight and morphometric measures of hatching eggs to predict the sex of chicks they would produce *a priori,* by building a statistical discriminant function. The data for the study came from three different strains (Anak, Marshall and Ross) of broiler hens that have adapted well to the hot humid environment of South Western Nigeria. A total of 1826 hatching eggs of the three strains were incubated, out of which only 1002 were successfully hatched. Eggs for the study were appropriately tagged and hatched in individual hatching compartments to prevent crossing of the chicks at break-out, and were immediately tagged and sexed by anatomical inspection of vent by a professional. A Principal Component Analysis (PCA) indicated that the first two components accounted for 98% of the total variation, with high loadings from egg weight, length, width and shape index. These variables were used to build a discriminant function in predicting chick sex across the three strains. There were significant (P<0.01) differences in fertility and hatchability across the strains with fertility been highest in Marshall (86.67%) but least in Ross (52.77%) strain, whereas hatchability was highest in the Ross (82.22%) but least in Marshall (72.67%) strain. It was observed that the accuracy of the prediction method was consistently higher in male than female chicks across the three strains studied albeit with different precision across the three strains.

Key words: Morphometric measures, discriminant function, fertility.

INTRODUCTION

The broiler birds evolved after several years of genetic improvement, and their relevance and success as a relatively cheaper and steady source of animal protein hinges on their shorter life span and higher meat yield. Much progress in the productivity indices of Broilers are now achieved through improvement of several environmental factors regarding their growth, health and maintenance.

Sex of the birds had been reported to be a significant factor (Rondelli et al., 2003) in the actualization of these improvements at various stages of the animal's life. It has been well established that productivity performances of broiler birds is highly impacted by the way they are reared, that is, either as straight-run (mixed sex) or separate-sex (Ayhan et al., 2004; Atasoy and Aksoy, 2005; Abanikannda et al., 2009). Although birds raised as separate sex averagely performed better than birds raised together without sexual delineation, due to the fact that there are minimal wastages resulting from consequences of peck order and sex difference.

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However the additional cost of sexing chicks at hatch discourages most commercial operators from separating the birds according to sex. Sexing is done by colour, feather or anatomical inspection, with ease of determination decreasing in that order (Abanikannda et al., 2009).

In Nigeria where electricity is largely epileptic (USAID, 2006), the additional cost of incubating eggs incurred from diesel for generators to run incubators calls for a means by which cost of hatching eggs could be reduced.

Since male chicks attract less income when compared to female chicks at hatch, this study, therefore aims at seeking alternative non-invasive and less expensive means of predicting the sex of a chick using measurements and indices obtained from its egg.

MATERIALS AND METHODS

An initial total of 1826 viable hatching eggs were sourced from three strains of broiler parent stock comprising, Anak (606), Marshall (570) and Ross (650), from three different reputable farms in the humid tropical South West Nigeria. After an initial incubation period of 14 days, the eggs were candled and 1322 eggs cumulatively accounting for 72.4% of total eggs set, comprising Anak (485), Marshall (494) and Ross (343) were fertile. The Marshall strain was raised on litter and naturally pen-mated, the Anak strain was kept in cages but also mated naturally, whereas the Ross strain was kept in cages and artificially inseminated.

The procedures for egg identification, tagging, measurements and incubation are described in Abanikannda et al. (2009). The fertile eggs after candling at the 14th day of incubation were placed in demarcated hatching chambers and covered with wire gauze to prevent the crossing of the chicks to other compartments at hatching. The sex of the chicks was determined by a trained professional, through anatomical inspection of the chick's vent on the day of hatch. Each chick sex was recorded against the egg's code that hatched in that compartment. In all, a total of 1002 chicks hatched and were weighed and sexed.

Measurements in this study were taken with digital weighing scale and vernier callipers and flex measuring tape. The indices were computed as prescribed by various authorities (Panda, 1996; Narushin, 2005). The six measurements taken include; egg weight, egg length, egg width, vertical circumference, horizontal circumference and egg weight at 18th day of incubation, while the four indices computed include; shape index, egg surface area, egg volume and egg density. Due to the large number of measurements and indices (10), a principal component analysis was conducted and it was observed that the first two components accounted for about 98% of the total variation recorded in the study, with only egg weight, egg length, egg width and shape index having high loadings on the two components.

All statistical analyses were done using JMP$^{(R)}$ 2007 statistical software. Basic descriptive statistics of these three measures and index were computed for all eggs studied and the mean values for each strain were computed.

Discriminant Analysis seeks to find a way to predict a classification (X) variable (nominal or ordinal) based on known continuous responses (Y). It is used to classify observations into two or more groups if you have a sample with known groups and can also used to investigate how variables contribute to group separation (JMP, 2007). Discriminant analysis is a method of predicting some level of a one-way classification based on known values of the responses. The technique is based on how close a set of measurement variables are to the multivariate means of the levels being predicted. Measurement variables are specified as Y effects and the classification variable as a single X effect (JMP, 2007).

A discriminant function was computed to classify the eggs into respective sex (male or female) based on the measurements and index. Two thirds of the data were randomly selected across the three strains and used as training data for the discrimination, while the remaining one-third was used as test data for the discriminant analysis.

The discrimination Ratio, D, is computed:

$$D = \sqrt{2\left(\frac{M}{E}\right) - 1} \quad = \quad \sqrt{2\left(\frac{P}{E}\right) + 1} \quad = \quad \sqrt{2\left(\frac{P}{T - P}\right) + 1}$$

Where, M = estimated measurement variance; P = estimated part variance; E = estimated variance of measurement error, and T = estimated total variance.

RESULTS AND DISCUSSION

Fertility

The mean fertility for all eggs (N=1826) determined at the 14th day incubation was 72.40% (Table 1), with the highest (86.67%) recorded by Marshall, while Ross had the least of 52.77%. This obvious difference across the strains may be attributed to different breeding practices employed by the farms. The very low fertility of Ross may be due to the fact that eggs were collected only three days after the birds were artificially inseminated, which is rather earlier than prescribed waiting period. The Ross hens had been withdrawn from breeding programmes for some time and were only introduced to breeding for the purpose of this study. Fertility was greatly influenced ($P<0.001$) by the strain of bird, with each of the three strains being statistically ($P<0.01$) different from the other two strains.

Hatchability

Mean hatchability was 75.79% (Table 1), relative to the total fertile eggs (N=1322). Strain of hen was a significant ($P<0.01$) source of variation in hatchability, with the three strains exhibiting statistical ($P<0.01$) difference in hatchability. The Ross strain had the highest hatchability (82.22%), which implies that if adequate time lapse was allowed between insemination and egg collection, this strain seems to be the most promising of the three studied.

Sex ratio

The average sex proportion in the entire study was 53.7 and 46.3% respectively (Table 2) for male and female chicks. This proportion was fairly consistent across the three strains, and the sex ratio was independent ($P>0.05$)

Table 1. Fertility and Hatchability of eggs by strain of hen.

Breeds	Eggs set	Fertile eggs	Hatched eggs	Fertility (%)	Hatchability (%)
Anak	606	485	361	80.03[b]	74.43[b]
Marshall	570	494	359	86.67[a]	72.67[c]
Ross	650	343	282	52.77[c]	82.22[a]
Total	1826	1322	1002	72.40	75.79

Means with different superscripts within the same column are significantly (P<0.05) different.

Table 2. Mean ± standard errors of egg measurements by breed and sex.

Breeds	Hatched eggs	Egg weight (g)	Egg length (mm)	Egg width (mm)	Vertical circumference (mm)	Horizontal circumference (mm)
Anak	361	58.66±0.28	57.38±0.14	42.93±0.08	16.38±0.04	14.07±0.04
Male	196	58.93±0.40	57.32±0.18	43.08±0.12	16.38±0.05	14.09±0.05
Female	165	58.33±0.41	57.45±0.21	42.75±0.12	16.37±0.05	14.05±0.05
Marshall	359	60.33±0.35	57.39±0.17	43.62±0.09	16.28±0.04	14.08±0.03
Male	192	60.37±0.47	57.37±0.24	43.66±0.12	16.28±0.06	14.10±0.05
Female	167	60.29±0.51	57.43±0.25	43.57±0.13	16.28±0.06	14.06±0.05
Ross	282	66.01±0.30	59.65±0.15	45.41±0.10	16.72±0.03	14.40±0.03
Male	150	66.37±0.42	59.76±0.21	45.40±0.14	16.74±0.04	14.38±0.04
Female	132	65.61±0.44	59.53±0.22	45.42±0.15	16.70±0.04	14.43±0.04
Combined	1002	61.33±0.21	58.02±0.09	43.87±0.06	16.44±0.02	14.17±0.02
Male	538	61.52±0.28	58.01±0.13	43.93±0.08	16.43±0.03	14.16±0.03
Female	464	61.11±0.30	58.03±0.14	43.80±0.09	16.44±0.03	14.18±0.03

of strain. The male accounted for 54.3, 53.5 and 53.2% in Anak, Marshall and Ross respectively, while female accounted for 45.7, 46.5 and 46.8%, respectively.

Descriptive statistics of all the ten measurements and indices are presented in Tables 2 and 3. It was observed that Ross had the highest values for all the four variables presented, while Anak consistently had the least. However, it is worthy of note that largest differences due to sex for all variables was recorded in Anak but it was not large enough to be statistically significant (P>0.05).

Pre-hatch sex determination of broiler chicks

The classification and its associated error rates are presented in Table 4. The accuracy of classification by sex in the entire study was 66.87%, while the accuracy for Anak, Marshall and Ross was 66.76, 63.23 and 69.15%, respectively. Amongst the three strains, the Marshall had the best accuracy for classifying male chicks (93.75%) and the worst accuracy (28.14%) for classifying female chicks.

Accuracy of prediction was higher for males compared to females within each of the strains and the combined data. This implies that male chicks are better predicted from egg measurements than female chicks. The consistently higher proportion for males in the original data may contribute to this enhanced accuracy for male.

Conclusions

The following conclusions and recommendations could be drawn from this study; Weight and morphometric measurements of hatching eggs promise to be good discriminating factors in predicting sex of chick prior to hatching and it provides a cheaper alternative to sexing chicks following hatch and can easily be determined by automating the procedure for measuring the eggs and computing indices. Reliability and accuracy of the method is dependent on breed and differences in the measured variables due to sex of the chicks. Sexing chicks at the hatchery would reduce wastages in feed consumption and feed conversion efficiency of broiler chicks during brooding and rearing. The method can be applied to other groups of birds where it is more profitable to have a particular sex over the other. This discriminating method should be further investigated to include more measures,

Table 3. Mean ± standard errors of computed indices by breed and sex.

Breeds	Hatched eggs	18th day egg weight (g)	Shape index (%)	Egg density (g/mm^3)	Egg surface area (mm^2)	Egg volume (mm^3)
Anak	361	50.60±0.27	74.92±0.18	1.06±0.00003	70.67±0.24	55.99±0.28
Male	196	50.82±0.38	75.25±0.25	1.06±0.00004	70.90±0.33	56.29±0.39
Female	165	50.34±0.38	74.53±0.26	1.06±0.00004	70.39±0.35	55.64±0.44
Marshall	359	52.56±0.31	76.15±0.20	1.06±0.00004	72.02±0.28	57.74±0.34
Male	192	52.58±0.42	76.27±0.28	1.06±0.00005	72.07±0.38	57.80±0.46
Female	167	52.54±0.45	76.00±0.27	1.06±0.00005	71.97±0.42	57.66±0.51
Ross	282	58.28±0.30	76.24±0.23	1.06±0.00003	77.63±0.27	64.55±0.34
Male	150	58.30±0.39	76.09±0.31	1.06±0.00004	77.71±0.37	64.63±0.47
Female	132	58.25±0.45	76.41±0.35	1.06±0.00004	77.55±0.39	64.45±0.50
Combined	1002	53.46±0.20	75.73±0.12	1.06±0.00002	73.11±0.18	59.03±0.22
Male	538	53.38±0.29	75.85±0.16	1.06±0.00003	73.22±0.24	59.16±0.29
Female	464	53.53±0.27	75.59±0.17	1.06±0.00003	72.99±0.26	58.87±0.29

Table 4. Reclassification error rate of discriminate functions by breed.

Breeds	Actual no eggs	Classified as male	Classified as female	Classification error rate
Anak	361			0.3324
Male	196	156	40	0.2041
Female	165	80	85	0.4848
Marshall	359			0.3677
Male	192	180	12	0.0625
Female	167	120	47	0.7186
Ross	282			0.3085
Male	150	119	31	0.2067
Female	132	56	76	0.4242
Combined	1002			0.3313
Male	538	494	44	0.0818
Female	464	288	176	0.6207

indices and larger sample size to further examine the potentials of this method.

Conflict of Interest

The authors have not declared any conflict of interest.

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