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RESEARCH ARTICLE

External and internal characteristics of ostrich eggs from Dibete Ostrich farm.

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Abstract

A total of 39 ostrich eggs from three different flocks (A, B and C) were obtained from Dibete Ostrich Multiplication Unit (DOMU) and used to assess the internal and external egg quality characteristics. The experiment was conducted at Botswana University of Agriculture and Natural Resources (BUAN). Eggs were individually weighed prior to opening in the Meat Science Laboratory at BUAN using a saw in order to remove the internal contents. Parameters studied include egg weight, shell thickness, shell weight, shell percentage, egg contents weight, egg shape index, egg surface area, SWUSA, albumen ratio, shell ratio, yolk ratio, yolk index, shell volume, shell density, egg volume, egg specific gravity. Results showed that only the Haugh unit was significantly (p<.0001) different among the flocks while other parameters were not significantly (p>0.05) different from each other. Egg weight was highly and positively correlated with egg contents weight, egg surface area, albumen ratio and egg volume (r=0.97884, 0.99958, 0.60295 and 0.98344, respectively; p<.0001, <.0001, <.0001 and<.0001, respectively) but highly and negatively correlated with yolk ratio (r=-0.60498; p=0.0001) and weakly and positively correlated with shell weight, Haugh unit and shell volume (r= 0.4648; p=0.0029, 0.36348; p=0.0229, and 0.45506; p=0.0036, respectively). Shell thickness was positively and significantly correlated with shell weight, shell percentage, SWUSA, shell ratio and shell density (r=0.48506, 0.51737, 0.53380, 0.51737, 0.50416, respectively; P=0.0017, 0.0007, 0.0005, 0.0007, 0.0011, respectively). Egg specific gravity was positively and significantly (r=0.43329; p=0.0059) correlated with shell volume. Ostriches of different ages should be reared separately though there is very little variation in quality traits.

Introduction:-

Ostrich eggs are the largest eggs produced by a living bird measuring 15.24 cm in length and 12.7 cm in diameter (Cooper, 2001). The weight of an ostrich eggranges from 1.0 to 2.0 kg (Pleti et al., 2009).According to Cooper et al.(2009), ostrich egg shell thickness ranges from 1.6 to 2.2 mm.Extremely strong shells of ostrich eggs make them very resistant to breakage during handling and transportation while also serving as a basis for the making of curios

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(Mushi et al., 2007). In a 1500 g ostrich egg,the mean weight of albumen, yolk and shell are 900 g, 317 g and 296 g, respectively. For a long time ostrich eggs have been consumed by humans and their shells used as containers and/or also made into beads.

Egg quality is defined as the characteristics of an egg that affect its acceptability to the consumers. Hence, egg quality is the more important price contributing factor in both table and hatching eggs, therefore the economic success of a laying flock solely depends on the total number of quality eggs produced (Monira et al., 2003). Ostrich eggs may vary from white to yellowish white. The egg is pitted with superficial pores of various shapes and sizes (Monira et al., 2003). Christensen et al. (1996) found the distribution of pores per square centimetre to be 20.2±2.0, 18.3±1.6 and 17.7±1.1 in the broad end, equator and sharp end, respectively. The weight and proportion of egg represented by albumen, yolk and shell vary significantly between the strains of birds. Shell thickness is significantly influenced by bird strain; also higher egg size may also influence shell quality (Monira et al., 2003).

Recent interest in ostrich farming has increased the demand for information about ratites and ratite management in a commercial environment (Miljković et al., 2009). However, basic information required to develop this industry is unavailable. While the chicken egg has been extensively studied for its internal and external qualities, as well as, for its composition, such information is not so well documented in other poultry species such as ostrich (Alkan et al., 2015). Therefore, the aim of the study was to evaluate the ostrich egg quality characteristics.

Materials and Methods:-

Study area:-

The experiment was conducted at Botswana University of Agriculture and Natural Resources (BUAN), Content farm, Sebele, which is located 10 km north of Gaborone, capital city of Botswana.

Experimental design:-

A total of 40 eggs were purchased at a government ostrich facility, Dibete Ostrich Multiplication Unit (DOMU), situated about 100 km north of Gaborone along the A1 highway. Eggs were weighed using an electronic scale, whereas length and width of individual eggs were measured using Vernier calipers (Benoît et al., 2014). Thereafter, eggs were opened using a saw in the Meat Science Laboratory at BUAN in order to remove the internal contents. The yolk and albumen were separated by pouring the internal contents of the egg on a flat surface and collecting the yolk enclosed by vitellinemembrane into a container. An empty container was weighed and used to weigh the yolk by collecting it into a container and thereafter weighing the container with the yolk. The weight of the yolk was obtained by subtracting the weight of the container from the weight of the container and yolk. Internal parameters measured were yolk weight, yolk height, yolk width, albumen height, albumen weight, shell thickness and shell weight. An electronic scale sensitive to 0.01 was used to measure the weight of albumen, yolk and shell while Vernier calipers were used to measure the height and width of albumen and yolk. Shell thickness was measured using micrometer screw gauge, whereas albumen weight was calculated by subtracting yolk weight and shell weight from egg weight.

After collection of these data, quality traits such as shell ratio, yolk ratio, albumen ratio, Haugh unit, egg surface area (ESA), shell percentage, shell volume, shell density, shell weight/surface area (SWUSA), egg specific gravity (ESG), egg volume, weight of egg contents and egg shape index (ESI) were evaluated according to El-Safty and Mahrose (2009) and Alkan et al. (2015) using the formulae below.

$$\text{Egg volume} = 0.51 * \text{egg length} * \text{egg breath}^2$$

$$\text{Egg surface area} = 39782W^{0.7056} \text{ where W is egg weight}$$

$$\text{Haugh unit} = 100 \log (H - 1.7W^{0.37} + 7.6), \text{ where H is albumen height and W is egg weight}$$

$$\text{Shell volume} = \frac{\text{Egg surface area(cm}^2)}{\text{Egg length (cm)}}$$

$$\text{Shell density} = \frac{\text{Shell weight}}{\text{Shell volume}}$$

$$\text{Shell percentage} = \frac{\text{Shell weight}}{\text{Egg weight}} * 100$$

$$\text{Egg specific gravity (g/cm²)} = \frac{\text{Egg weight}}{\text{Egg volume}}$$

$$\text{Egg shape index} = \frac{\text{Egg width}}{\text{Egg length}} * 100$$

$$\text{Shell ratio (\%)} = \frac{\text{Shell weight}}{\text{Egg weight}} * 100$$

$$\text{Albumen ratio (\%)} = \frac{\text{Albumen weight}}{\text{Egg weight}} * 100$$

$$\text{Yolk ratio (\%)} = \frac{\text{Yolk weight}}{\text{Egg weight}} * 100$$

$$\text{Yolk index} = \frac{\text{Yolk weight}}{\text{Yolk diameter}} * 100.$$

Statistical analysis:-

Data were analyzed using Statistical Analysis System (SAS) software (version 9.2) (SAS Institute System, 2008). The proccorrprocedure of SAS was used to calculate correlation coefficients. Significant differences among the means were tested by Duncan's Multiple Range Test.

Results and Discussion:-

External and internal quality traits of ostrich eggs:-

All external and internal physical quality traits except Haugh unit were not significantly (P>.05) different from each other (Table 1). The average egg weight for flocks A, B and C was 1.27 kg, 1.26 kg and 1.34 kg, respectively. The result on egg weight in this study is consistent with Mushi et al. (2007) and Brand et al. (2003) who found average weight of an ostrich egg to be 1321 g and 1455 g, respectively. Previous study of Benoît et al. (2014) reported average egg weight of 1370 g and 1200 g during the rainy and dry seasons, respectively.

On average albumen, shell and yolk in the current study were 60.5%, 13.36%, 26.04%, respectively. Koutinhouin et al. (2014) reported that the albumen, yolk and shell make up 57.1-59.4%, 21-23.3% and 19.6% of the egg, respectively. Selvan et al.(2014) found albumen, yolk and egg shell percentage to be 57.51 (825.35 g), 27.64 (396.76 g) and 14.83 (212.89 g), respectively. In the study of Di Meo et al. (2003) albumen, yolk and shell amounted to 57.1, 23.3 and 19.6%, respectively. El-safty (2015) reported slightly higher values of egg albumen, yolk and shell compared to the current results. Average yolk index reported in the current study was 32.9% which is consistent with El-Safty and Mahrose (2009) who found a value of 30.4%. However, a higher yolk index (44%) was reported by Al-Obaidi et al. (2012).

The average shape index (82.65%) in the current study is consistent withHorbańczuk et al. (2003), Nedomová and Buchar (2013), Benoît et al. (2014)andSelvan et al.(2014)who obtained shape indices of 83%, 82.49%, 83.5-83.86% and 82.86%, respectively. Similarly, Elsayed(2009) and Koutinhouin et al. (2014) found shape index values of ostrich eggs to be 80% and 83.5%, respectively. In this study, average egg specific gravity was 1.15897 g/cm^3. Similarly, Al-Obaidi et al. (2012) reported a value of1.15 g/cm^3 while Koutinhouin et al. (2014) reported a specific gravity of 1.13 g/cm^3 during the rainy season and 1.03 g/cm^3 in the dry season. The authorsfound average egg shell thickness values of ostrich eggs to be 2.2 to 2.24 mm in the equatorial regions which is slightly higher than 1.87 mm recorded in this study. Similarly, Mushi et al. (2007) reported shell thickness of 1.65 mm which is slightly lower than the value obtained in the current study. The study by Cooper et al. (2009)found that shell thickness of ostrich egg ranges from 1.6 to 2.2 mm. Similarly, Selvan et al.(2014) reported shell thickness of 1.92 to 2.4 mm, whereas Di Meo et al. (2003) found that average shell thickness ranged from 2.20 mm at the equator to 2.24 mm at the sharp end.

Table 1: Means ± SE of external and internal physical quality traits of ostrich eggs				
	Flocks			
Parameter	**A**	**B**	**C**	**ANOVA**
Egg weight(kg)	1.2758 ± 0.041	1.2636 ± 1.264	1.3408 ± 0.040	NS
Haugh unit	129.05 ±0.833	127.33 ± 0.771	137.23 ± 0.800	***
Shell thickness, (mm)	1.8658 ± 0.069	1.9207± 0.0640	1.8200 ± 0.066	NS
Shell weight (kg)	0.1750 ± 0.009	0.1707 ± 0.008	0.1715 ± 0.009	NS
Shell percentage (%)	13.8325± 0.574	13.4500± 0.531	12.8477± 0.551	NS
Egg contents weight(kg)	1.0992 ± 0.037	1.0929 ± 0.035	1.1692 ± 0.036	NS
Egg shape index (%)	83.1183± 0.784	81.8550 ±0.726	83.0762± 0.752	NS
Egg surface area (m^2)	4.7158 ± 0.107	4.6871 ±0.099	4.8877 ± 0.103	NS
Shell weight/unit surface area, (mg/cm^{2})	37.2617± 1.566	36.2107 ±1.449	35.1115± 1.505	NS
Albumen ratio (%)	60.3275± 1.205	59.5950 ±1.116	61.9038± 1.157	NS
Shell ratio (%)	13.8325± 0.574	13.4500 ±0.531	12.8477± 0.551	NS
Yolk ratio (%)	25.8392± 1.064	26.9543 ±0.985	25.2485± 1.021	NS
Yolk index	0.3217 ±0.0103	0.3379 ±0.009	0.3277 ± 0.010	NS
Shell volume (cm^3)	0.03000±0.0004	0.03000 ± 0.0004	0.03077± 0.0004	NS
Shell density (g/cm^3)	5.4358 ± 0.249	5.3386 ±0.230	5.2200 ± 0.239	NS
Egg volume (cm3)	1102.85 ± 34.678	1088.01 ± 32.106	1157.51± 33.318	NS
Egg specific gravity (gm/cm^3)	1.1567 ± 0.007	1.1621 ± 0.006	1.1577 ± 0.007	NS
NS: Non-significant; ***:p<0.001; ANOVA: Analysis of variance; SE: Standard error				

The average Haugh unit in the present study was 131.16. According to Pleti et al. (2009), Haugh unit>100 shows very good egg quality. Rath et al. (2015) stated that the higher the yolk index and the Haugh unit, the more desirable the egg quality which implies that Haugh unit and yolk index are indicators of internal egg quality. The Haugh unit varies greatly between the flocks which might imply differences in internal egg quality. The variation in Haugh unit values in the present study might be due to variation in the age of the birds and the differences in storage time of the eggs.

Correlations of egg physical characteristics:-

Table 2 shows the correlations between ostrich egg quality traits.Egg weight was highly and positively correlated with egg contents weight, ESA, albumen ratio and egg volume (r= 0.97884, 0.99958, 0.60295 and 0.98344, respectively) but highly and negatively correlated with yolk ratio (r= -0.60498) and weakly and positively correlated with shell weight, Haugh unit and shell volume(r= 0.4648, 0.36348 and 0.45506, respectively). Selvan et al.(2014) reported a significant correlation between albumen and yolk percentage with egg weight, but with a negative relationship for yolk and positive for albumen.

Alkan et al. (2015) reported a positive correlation between egg weight and shell thickness which is similar to what was found in the current study (Table 2). In disagreement with the present results, Benoît et al. (2014) found a non-significant correlation between shell thickness and egg weight of red-necked ostrich. For Monira et al. (2003), shell thickness is significantly influenced by bird strain which might be a reason for non-significant correlation in this study. According to Bobbo et al. (2013), egg weight has an indirect relationship with shell quality; however, egg shell thickness has positive significant correlation with shell weight.

Shell thickness was positively and significantly correlated with shell weight, shell percentage, SWUSA, shell ratio and shell density (r=0.48506, 0.51737, 0.53380, 0.51737, 0.50416 respectively; P= 0.0017, 0.0007, 0.0005, 0.0007, 0.0011, respectively). These results are consistent with El-Safty and Mahrose (2009) and Koutinhouin et al. (2014) who reported similar correlations. However, Bobbo et al. (2013) reported a negative correlation between shell thickness and shell weight for smooth feathered ostriches and frizzle but a strong positive correlation for naked neck. Shell weight was positively and strongly correlated with shell percentage and shell density. These results are in line with those reported by El-Safty and Mahrose (2009).

The Haugh unit was weakly and positively correlated with egg contents weight, ESA and egg volume (r= 0.40106, 0.36434 and 0.39206, respectively), whereas albumen ratio was negatively and significantly correlated with shell ratio, yolk ratio and yolk index (r= -0.48390' -0.88121, -0.57168 and p= 0.0018, 0.0001, 0.0001, respectively) (Table 2). El-Safty and Mahrose (2009) reported similar correlations in African black neck ostrich. According to Kontecka et al. (2012), an increase in the yolk weight results in a decrease in the percentage of albumen.

Egg specific gravity (ESG) was positively and significantly (r=0.43329; p=0.0059) correlated with shell volume. The current result indicates that an increase in shell volume increases ESG. This result is in line with Gryzinska and Batkowska (2014) who stated that as ESG declines the number of cracks generally increase; hence ESG indicates the quantity of shell relative to other components of the egg. The ESG usually declines over time partly due to the size of the egg increasing more rapidly than shell weight (Butcher and Miles, 2015). Therefore, the differences in ESG values among eggs of similar weights are mainly due to variations in the amount of shell.

Table 2: Correlations between egg physical characteristics of Ostrich at Dibete Ostrich Multiplication Unit

Traits	Egg weight	Shell thickness	Shell weight	Shell percent	Haugh unit	Egg contents weight	Egg surface area	SWUSA	Albumen ratio	Shell ratio	Yolk ratio	Yolk index	Shell volume	Shell density	Egg volume
Egg weight	-	0.03432	0.4648*	-0.147	0.36348*	0.97884***	0.99958***	0.06446^{ns}	0.60295***	-0.15475	-0.60498***	0.04200	0.45506*	0.30429	0.98344***
Shell thickness		-	0.48506*	0.51737***	-0.14840	-0.07268	0.03941	0.53380***	-0.24867	0.51737***	0.00475	0.15610	-0.04181	0.50416***	0.00527
Shell weight			-	0.79421***	-0.01014	0.27623	0.46856*	0.90741***	-0.0708	0.79421***	-0.34787*	-0.01611	-0.01252	0.97258***	0.46756*
Shell percent				-	-0.26434	-0.34991*	-0.15081^{ns}	0.97517***	-0.48390**	1.00000***	0.01273*	-0.07546	-0.26575	0.87783***	-0.14954
Haugh unit					-	0.40106**	0.36434*	-0.18652	0.12059	-0.26434	0.00511	0.24824	0.19098	-0.11052	0.39206**
Egg contents weight						-	0.97792***	-0.13814	0.66791***	-0.34991*	-0.57380***	0.05373	0.50257***	0.10773	0.95993***
Egg surface area							-	0.06882	0.59787***	-0.15081	-0.60131***	0.04974	0.44354*	0.30989*	0.98421***
SWUSA								-	-0.35933*	0.97517***	-0.11612	-0.05680	-0.19463	0.95712***	0.06919
Albumen ratio									-	-0.48390**	-0.88121***	-0.57168***	0.32027*	-0.18046	0.57412***
Shell ratio										-	0.01273	-0.07546	-0.26575	0.87783***	-0.14954
Y0lk ratio											-	0.69419***	-0.22195	-0.26791	-0.57489***
Yolk index												-	0.00239	-0.04324	0.06166
Shell volume													-	-0.10700	0.37412*
Shell density														-	0..31671*
Egg volume															-

* p≤0.05; ** p≤0.01; ***p≤0.001

SWUSA = Shell weight per unit surface area

Conclusions:-

Internal and external quality traits were not significantly different across the flocks except the Haugh unit. Egg weight wassignificantlycorrelated with most other quality traits showing a relationship between the traits. The current results suggest that ostriches of different ages should be reared separately although there is very little variation in quality traits.

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