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Levels of hygiene and microbial quality indicators among the eggs collected from different sources in gannavaram, Andhra Pradesh

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Abstract
A study was conducted to determine the shelf life of marketed table eggs collected from three different sources of gannavaram locality by evaluating internal, external and microbiological quality of eggs. The data obtained revealed that locally produced eggs had lower egg weight, albumen weight and yolk weight 51.1 ± 0.23 g, 29.55 ± 0.11 g and 16.08 ± 0.87 g where as albumen height is 0.58 ± 0.49 cm when compared with eggs collected from market and super markets. Mean values of Microbiological load i.e. Total viable count (TVC), Yeast and mould (Y&M) and Enterobacteriaceae count (EC) were 4.48 ± 0.05, 4.26 ± 0.05 and 1.15± 0.04 log cfu/egg (egg shell) were significantly (P<0.05) higher for eggs collected from farm source where as No significant differences was found in the eggs collected from market and supermarket eggs respectively. This study reviled that marketed table eggs from market and supermarkets of gannavaram locality were of good quality and had a higher cost. Whereas the farm eggs had lower quality traits due to unhygienic practices during egg collection, inadequate storage and cheap in cost when compared to eggs purchased directly from market and supermarkets.

Keywords: Table eggs, Microbial quality, Egg quality, Market, Supermarkets

1. Introduction
India is the third largest egg producing country in world, with an estimated count production of 70 billion eggs (in shell) numbers. Per capita availability and consumption is maintaining at 63 and 62 eggs respectively Gautham (2016) [1]. Eggs, a nutritious and inexpensive food, are an important part of human diets worldwide Mcnamara (2003) [2]. Moreover, their high quality protein, low caloric value and ease of digestibility make eggs valuable in many therapeutic diets for adults. Egg quality in general defines both internal and external quality of egg. External quality is focused on shell cleanliness, soundness of shell, texture, color and shape. These features are important to the processor as superior quality eggs arrive in a better condition for the consumer. The internal quality refers to egg white (albumen), relative viscosity of albumen, shape and firmness of yolk, strength of yolk, size of air cell and presence or absence of blood or meat spots. Yolk of a fresh lay egg is round and firm. As the yolk ages it losses quality by absorbing water and increasing in size and sometime rupturing occur. This absorption of water occurs from thin albumin surrounding the yolk, while the loss of carbon dioxide through egg shell causes thick albumin to be transparent and watery Benton and Brake (1996) [3]. The eggs are foods that are mostly sensitive to damage to the exterior and interior of the eggs caused by pathogenic bacteria. Most eggs have been found to be sterile when laid, but they have the potential to become occasionally contaminated with micro-organisms such as bacteria and fungi. These microorganisms can evade the defense mechanism of eggs and penetrate inside the egg, thus increasing the risk of food-borne illnesses or product spoilage. The rate of spoilage of egg depends on nutrient availability, temperature, storage and handling Al-Bahry *et al.* [4]. In India at least one out of every 30 eggs produced does not reach the consumer in good condition. Therefore, it is essential to maintain quality of eggs at all levels from the farm to the table. Therefore, the present study has been undertaken to determine levels of hygiene and microbial quality indicators among the eggs collected from different sources in gannavaram, Andhra Pradesh.

Material and Methods
Eggs collection
The study was conducted in the department of Livestock Products and Technology, NTR

College of Veterinary Science, Gannavaram. A total of 90 eggs were collected, 30 eggs from each source. Eggs were randomly selected and on average six eggs were sampled from single source (farm, retail outlet and super market) were utilized for the measurement of external and internal egg quality traits.

External egg quality

The weight of each egg, albumen, yolk and shell were recorded to the accuracy of 0.01g using a digital balance (EK200G).The longer and wider diameter of the egg and the length and width of the thick albumen and yolk were measured by vernier calipers. Shape index was worked out according to the formula of Shultz (1953) [5]. The specific gravity was calculated with help of egg weight (g) and volume of egg (ml). Specific gravity = Weight of the egg (g) / Volume of the egg (ml).

Internal egg quality

After breaking open the egg, the height of the thick albumen and yolk was measured to 0.01 mm accuracy using an "Ames tripod spherometer" and the width of the thick albumen was measured at two places using a vernier calipers with 0.05 mm accuracy and their mean width was arrived at. Albumen index was calculated according to the formula of Heiman and Carver (1936) [6]. Yolk index was calculated according to the formula of Sharp and Powell (1930) [7]. Haugh unit score Haugh (1937) [8] was followed. Yolk colour was visually compared to the colour numbers in the 'Roche yolk colour fan. The shell thickness was measured at three place namely, narrow end, broad end and equatorial region of the egg by using a shell thickness measuring gauge with 0.01mm accuracy and the mean shell thickness was calculated. The per cent albumen, yolk and shell was calculated in relation to egg weight and expressed as percentage. The egg shell percentage was calculated by using the following formula percentage of egg shell = Shell weight (g) / Egg weight (g) X 100

Microbial counts

A variety of methods have been developed for the recovery of microorganisms from eggshells. Determination of bacterial numbers on eggshells has been done using surface rinses. The rinse method adapted from Musgrove *et al.* (2005) [9] was employed to recover microorganisms from the shell of eggs. Briefly, the eggs were placed in zip lock covers containing 50 ml peptone water and surface-rinsed for 5 minutes. The surface rinsate was considered as the mother sample. Then several decimal dilutions were done using sterile peptone water in universal 10 ml test tubes. Standard Plate count, Yeast and mould and Enterobacteriaceae counts on egg shell were done by culturing 1 ml of each decimal dilution on Standard plate count agar, Potato dextrose agar and Violet Red bile agar plates respectively.

Statistical Analysis

Statistical analysis was performed using one way (ANOVA) to determine the differences between the quality traits of egg collected from super markets, farms and markets as per methods described by [10].

Results and Discussion

Egg weight: The mean value of egg quality (external and internal) characteristics of eggs collected from different sources is presented in Table 1. The mean egg weight was significantly ($P<0.01$) higher in eggs collected from super markets which is followed by market and farm eggs. The egg weight recorded in current study is in agreement with those reported by Baishya *et al.* (2008) Obaidi *et al.* (2011) [11, 12]. The farm eggs are mostly small in size with less weight when compared with egg from other two sources. The differences in egg weight amongst the different sources of egg collection might be due to the fact that egg weight is largely affected by factors such as environment, feed, chicken ecotype, age, genetic makeup and number of egg laid size of the bird, rate of laying management, nutrition and other environmental factors Msoffe *et al.* (2002) and Yakubu *et al.* (2008) [13, 14].

Egg length and width: The mean egg length and width obtained in this study is presented in (Table 1) the highest length and width were recorded for the eggs collected from supermarkets, followed by markets and farm. Hence the grading and selection of eggs were followed for supermarket eggs Tilki and Saatci (2004) [15] also reported similar results.

Specific gravity: Specific gravity is an indicator to determine the freshness of egg. Specific gravity of egg is effected by many factors like increased storage time, temperature and hen age Tumova and Gous (2012) [16]. The results obtained in the study reflect the freshness for the farm collected eggs (1.02) when compare to supermarket (0.97) and market collected eggs (0.91).

Shape Index: With respect to shape index, eggs collected from super market had highest value 81.38 followed by market eggs 76.76 and farm eggs 72.60. Hussain *et al.* (2013) [17] who reported similar shape index in eggs collected from different areas. Variation in shape index may be due to age of layers and system of management and genetic makeup of the breed.

Haugh Unit: The mean Haugh unit values were higher in eggs collected from super markets (87.16) followed by market (86.74) and farm eggs (84.88) similar observations was made by Hussain *et al.* (2013) and Baishya *et al.* (2008) [17, 11].The results showed that an increase in egg weight increases the haugh unit. The lower values of haugh units in case of farm eggs due of poor handling and storage conditions they can lose in quality. However the Haugh unit value is dependent on the strain of the bird, storage conditions and time lapsed during transit.

Shell Thickness: Good shell thickness is economically important trait in commercial egg production as it may help to reduce the percentage of broken eggs. The overall mean shell thickness of farm, market and supermarket were 0.44±0.05 mm, 0.34±0.05 mm and 0.47± 0.10 mm. These values in this study are comparable with results by Şekeroğlu and Altuntaş 2009 [18]. The mean value of shell thickness was comparatively higher in supermarket eggs but this difference was non-significant ($p>0.05$). An egg shell thickness of at least 0.33 mm has been estimated to be necessary for the eggs to have at least a 50% chance to withstand normal handling condition without breakage Stadelman and Cotterill (1995) [19].

Shell weight: A non-significant ($p>0.05$) difference was observed between egg shell weight although the percent shell of eggs from farm source was higher as compared to egg from

other two sources. The results are in agreement with Hussain *et al.* (2013) [17].

Albumen height: Albumen height differed significantly among the eggs collected from different sources. The higher values of albumen height were observed for supermarket eggs followed by market and farm eggs. 0.79±0.80cm, 0.66±0.65cm and 0.58±0.49cm the observed values in the experiment are within the range value for superior quality as mentioned by Faris *et al.* (2011) [20]. The higher albumen height in supermarket eggs may be due to the freshness of eggs and young age of hens.

Albumen and yolk weight: The average albumen and yolk weight differed significantly ($P<0.01$) amongst the groups of chicken eggs. Significantly higher values were recorded for the super market eggs followed by eggs collected from market and farm eggs. Contrary to the present value, higher albumen and yolk weights of farm and market eggs were recorded by Hussain *et al.* (2013) [17]. The differences in albumen and yolk weight in different groups of chicken may be attributed to the differences in genotypes, age of the birds, managemental and feeding regime.

Albumen index: The albumen index was significantly ($P<0.05$) different among the three different groups of chicken eggs. Farm chicken had higher albumen index (07.20), followed by supermarkets and market. This might be due to shorter storage period as there was a gradual decline in albumen index as the storage period increase. Lower albumen index in market chicken eggs might be due to vibrations in shaking during transportation causing deterioration of albumen quality and also due to the duration of the transit Baishya *et al.* (2008) [11].

Yolk index: The yolk index helps to determine the quality of an egg from the results represented in Table 1. It can be observed that the yolk index was significantly lower for eggs collected from market followed by supermarket and farm. Eggs from market and farm source are exposed to high temperature and low humidity, which will results in rapid decrease in egg quality. The yolk of a freshly laid egg has a firm round yolk and a strong yolk membrane Faris *et al.* (2011) [20]. As the yolk ages, it absorbs water from the albumen and increases in size. This weakens the vitelline membrane and gives the yolk a somewhat flattened shape on top and a general "out-of-round" shape Stadelman and Cotterill (1995) [19].

Percent yolk and albumen: The percentage of yolk found in current study was significantly lower ($p>0.05$), with subsequent higher percentage albumen in farm eggs comparative to eggs collected from market and supermarket collected eggs which is in accordance to previous findings Li-Chan *et al.* (1995) [21].

Yolk colour: The yolk colour obtained in the present study of eggs collected from farm eggs was recorded as medium yellow (4.25) and pale yellowish (2.65) in case of eggs collected from market and (3.35) supermarket. Yolk colour is one of the main criteria by which consumers judge the quality of eggs Beardsworth and Hernandez (2004) [22]. Although consumer perception varies a good, appeling egg yolk colour is generally linked to geographical location, culture and traditions. The variation in yolk colour among table eggs collected from different sources might be due to nutrition, age, system of management and genetic makeup Premavalli and Viswanagthan (2004) [23].

Total Viable Count: Microbiological quality of egg shells revealed total viable counts in the range of 4.48, 3.71 and 3.32 log cfu/g for farm, market and supermarket collected eggs respectively (Table 2). The high TVC counts observed in eggs collected from farm which can be attributed to lack of unhygienic practices, contamination during handling by retailers or during storage Cader *et al.* 2014 [24] Found that the shell surface of unwashed eggs harboured a high population of TVC exceeding 5 log cfu/egg. Indeed, washing and sanitizing eggs under optimal conditions has great potential in reducing the microbial load by 2-3 log cfu/egg Bell 2002 [25]. A microbial load of less than 2 log cfu/packaged egg is considered an excellent commercial standard Bell 2002 [25] whereas viable counts of 100,000 or more cfu/egg is considered unacceptable.

Yeasts and molds: Can proliferate on eggs under favorable conditions of high moisture and oxygen conducive for growth, thus accelerating egg spoilage Ansah *et al.* (2009) [26]. Optimal storage temperature and relative humidity can favour the growth of these microorganisms Joseph and Babatunde (2006) [27]. Results obtained from this study indicated a high Yeast and Molds count for farm eggs followed by market and supermarket 4.26, 3.81 and 3.15 log cfu/egg. The higher counts could suggest that the eggs were kept under relatively high humid conditions, which is in accordance with the results of Joseph and Babatunde (2006) [27]. Yeasts and molds have a lower minimum water activity requirement for growth than bacteria and can therefore grow to higher numbers on the shell.

Enterobacteriaceae: Low concentrations of Enterobacteriaceae were detected on eggs collected from supermarkets followed by markets and farm collected eggs. A Significant differences ($P<0.05$) were found between supermarket eggs 0.78, market 0.96 and farm 1.15 log cfu/egg. Eggs are a difficult product to accurately sample for microbial contamination, especially when attempting to evaluate the growth of organisms in specific segments of the egg Mayes and Takeballi (1983) [28]. The lower counts could suggest that commercial washing either at farm or processing plants eliminates many species of bacteria from the surface of table eggs which is in accordance with the results of Michael *et al.* (2004) [29]. Enterobacteriaceae isolates were found less often on washed eggs than on unwashed eggs.

Table 1: Mean (± SE) values of external and internal Quality parameters of chicken eggs collected from different sources (farm, retail outlets and super markets)

Parameters	Farm	Markets	Super markets
Egg quality			
Egg weight (gm)	51.15 ± 0.23[a]	55.04 ± 0.14[b]	58.41±0.05[c]
Egg width (cm)	4.16 ± 0.54[a]	4.23 ± 0.22[b]	4.81 ± 0.62[b]
Egg length (cm)	5.73 ± 0.96[a]	5.51 ± 0.15[b]	5.91 ± 0.11[b]
Specific gravity	1.02 ± 0.11[b]	0.91 ± 0.73[a]	0.97 ± 0.29[a]
Shape index (%)	72.60 ± 0.76[a]	76.76 ± 0.19[b]	81.38 ± 0.50[c]
Haugh unit score	84.88± 0.18[c]	86.74± 0.02[a]	87.16± 0.10[b]
Shell quality			
Shell thickness(mm)	0.44 ± 0.05[a]	0.34 ± 0.51[b]	0.47 ± 0.10[a]
Shell weight (g)	06.23 ± 0.11[a]	06.65 ± 0.34[a]	07.11 ± 0.65[b]
Percent Shell	12.17 ± 0.30[a]	12.08 ± 0.10[a]	12.17 ± 0.39[a]
Albumen quality			
Albumen height (cm)	0.58 ± 0.49[a]	0.66 ± 0.65[b]	0.79 ± 0.80[c]
Albumen width (cm)	08.05 ± 0.23[c]	7.09 ± 0.40[a]	7.55 ± 0.15[b]
Albumen weight (gm)	29.55 ± 0.11[a]	29.06 ± 0.88[a]	27.85 ± 0.43[b]
Percent Albumen	56.86 ± 0.55[c]	52.79 ± 0.36[b]	47.68 ± 0.05[a]
Albumen index (%)	7.20 ± 0.82[a]	9.30 ± 0.19[b]	10.46 ± 0.22[c]
Yolk Quality			
Yolk height (cm)	1.27 ± 0.29[a]	1.12 ± 0.23[a]	1.33 ± 0.37[b]
Yolk width (cm)	4.27 ± 0.33[a]	5.19 ± 0.91[c]	4.57 ± 0.79[b]
Yolk weight (gm)	16.08 ± 0.87[a]	19.33 ± 0.47[b]	23.45 ± 0.30[c]
Percent Yolk	31.37 ± 0.41[a]	32.72 ± 0.32[b]	32.75 ± 0.14[b]
Yolk Color score	4.25 ± 0.08[a]	2.65 ± 0.08[c]	3.35 ± 0.08[b]
Yolk index (%)	29.74 ± 0.32[a]	21.57 ± 0.51[b]	29.10 ± 0.71[a]

Figures in a row with at least one superscript in common do not differ significantly ($P<0.05$).

Table 2: Mean (± SE) values of Microbial analysis of chicken eggs collected from different sources (farm, retail outlets and super markets)

Source	*TVC*	*Yeast and Mould*	*Enterobacteriaceae*
Farm	4.48± 0.05[a]	4.26 ± 0.05[a]	1.15 ± 0.04[b]
Markets	3.71 ± 0.02[a]	3.81 ± 0.03[a]	0.96 ± 0.02[b]
Super markets	3.32 ± 0.02[a]	3.15 ± 0.02[b]	0.78 ± 0.05[c]

Figures in a row with at least one superscript in common do not differ significantly *(P<0.05).*

Conclusion

The present study provides the levels of hygiene and microbial quality indicators among the eggs collected from different sources in gannavaram and it can be concluded that in order to minimize the microbial load and to enhance the quality of eggs, one must adopt good hygienic practices at farm level as well as at markets. At farm level the post laying practices such as regular collection of eggs, inspection of cracks, egg washing and maintenance of proper storage conditions are important to maintain a lower microbial load of eggs. The market eggs need proper handling, refrigerated transportation and good storage facilities to ensure good quality and for better marketability of eggs.

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