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The effect of dietary garlic powder and a low temperature on the physical quality of stored eggs

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Abstract

Eggs are a rich source of protein having, a primary advantage in satisfying human nutritional needs. However, the loss in egg quality within a short time during storage calls for more research to improve their condition following storage. This study investigated the potential of garlic powder as a feed supplement and low temperature in maintaining physical egg quality during storage. Seventy two thirty-week old hens of the Dekalb white strain were used in the study. Hens were divided into three dietary treatment groups in a completely randomized design experiment. Three treatments were control (no garlic addition), 3%, and 5% garlic powder (GP) additions to a basal diet on a weight ratio basis. Birds were fed the experimental diets for seven weeks. Eggs (n = 108) were collected from days 43 to 45 of the trial and stored either at 8 ± 2 ºC or 25 ± 2 ºC for 21 days. Feeding GP in the hens' diet improved Haugh unit value by 11.9 HU and albumen height by 1.4 mm when eggs were stored at 25 ± 2 ºC. For eggs stored at a low temperature, GP supplementation had no affect on egg quality indicators. In comparison to values for fresh eggs, egg weight and albumen percentage were significantly reduced. An increase in yolk percentage was recorded in eggs stored at 25 ± 2 ºC. Similarly, changes were marginal for eggs stored at a low temperature. This study indicated that both dietary garlic powder and low temperature significantly maintained albumen quality of eggs stored during summer.

Keywords: Egg quality, garlic powder, layer hens, low temperature, storage
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Introduction

Egg safety and quality is a major concern for consumers because eggs have been linked to a number of diseases and food-borne illnesses (Jones *et al*., 2002). Acceptable interior egg quality relates to the integrity, aesthetics and microbiological contamination of albumen and yolk, which is essential to consumers who use eggs for baking and cooking (Koelkebeck, 2003). For these reasons, quality control standards have been established for retail/commercial markets in various countries for the purpose of consumer satisfaction and safety (USDA, 2000). However, as soon as the egg is laid, its internal quality starts to decrease, and its deterioration is enhanced by high temperature and age of the egg (Kirunda & McKee, 2000). This is caused by the escape of carbon dioxide and moisture through the eggshell pores, which consequently alters the albumen pH (Coutts & Wilson, 2006). The egg defence barriers are also weakened as the egg ages, resulting in an increased risk of bacterial contamination (D'Aoust *et al*., 1980).

The changes that occur in stored eggs, therefore, usually cause losses in quality and nutritional value, leading to lower consumer acceptability (Addis & Park, 1989). Since loss of carbon dioxide and moisture through the shell pores are key factors in quality deterioration, various methods of retarding these processes have been suggested in recent research. These include storage at relatively low temperature (Koelkebeck, 2003), cryogenic cooling with carbon dioxide (Curtis *et al*., 1995) and oiling of fresh eggs (Park *et al*., 2003). However, the obstacle to cold storage in many rural parts of South Africa is that access to a reliable and cheap electricity supply needed for cold storage facilities is poor and sometimes not available. Yet, many rural households suffer poor nutrition, poverty and diseases. Despite the relatively low price of eggs, the loss

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in quality within a short time owing to inadequate storage, calls for further experimentation on improving egg conditions prior to storage for the benefit of the entire egg industry. Garlic is rich in organosulphur compounds and selenium, which are all known for their antioxidant activities (Pappas *et al*., 2005). Supplementing hens' diets with garlic has been reported to improve egg quality (Mahmoud *et al*., 2006). There is, however, very little information on its efficacy in maintaining egg quality during storage. This study was therefore aimed at investigating the potential of dietary garlic powder in improving the keeping quality of eggs during storage, compared with low temperature.

Materials and Methods

The experiment was carried out at the Department of Animal Science Research Farm of the Mafikeng Campus of the North-West University. A total of 72 thirty-week old laying hens of the Dekalb white strain, kept in battery cages (50 x 46 x 45 cm) in an open-sided house, were used in a completely randomized design study. Cages were equipped with nipple drinkers and detachable feeding troughs. Six cages were randomly allotted to each of three dietary treatment groups, with each cage containing four birds as an experimental unit. The three treatments included a commercial layer mash (Opti) as the basal diet. This was enriched with 0% (control), 3% and 5% garlic powder on a weight ratio basis. The garlic powder was prepared from fresh garlic (*Allium sativum*) bulbs purchased from the Fruit and Vegetable store in Mafikeng town. The cloves were released, minced and oven-dried at 55 ºC until a constant weight was obtained. The dried garlic was ground into powder and added to the basal diet. The chemical composition of the experimental diets was determined using a proximate analysis procedure according to the AOAC (2000). Feed was supplied to birds according to the breed management guide whereas water was supplied *ad-libitum* with natural day length hours as lighting regimen.

Eggs were collected for storage from days 43 to 45 of feeding the experimental diets. During this period, eggs were collected within two hours of lay and immediately kept in a cold room at 4 ºC in order to maintain freshness. Six eggs per replicate, totalling 36 eggs per treatment, were carefully selected and candled to ensure intact shells. Eighteen eggs from each treatment group were stored at room temperatures that varied between 23 and 27 ºC, while the other 18 were stored in the cold room at a temperature range of 6 - 10 ºC for 21 days. Two other eggs from each replicate, totalling 12 from each treatment, were assessed for pre-storage quality (external and internal) on day one. For both pre- and post-storage sampling, the air cell size of each egg was measured using an air cell meter, after which the eggs were weighed. Each egg was then carefully broken onto a flat plate and the height of the albumen measured midway between the yolk and the edge of the albumen, using a tripod micrometer. The yolk was separated from the albumen and weighed, after which the albumen was transferred to a beaker and the pH measured. Haugh unit was calculated by comparing the measured height with egg weight (Doyon *et al*., 1986) using the following formula:

$$HU = 100 \log (H - 1.7w^{0.37} + 7.6)$$

where HU = Haugh unit, H = height of the albumen (mm) and W = weight of egg (g).

The eggshells were weighed after sun-drying for 72 hours. The egg components were calculated as percentages of the whole egg weight. All data generated were subjected to two-way analysis of variance using the General Linear Model procedure of SAS (2001). Storage type, dietary garlic treatment and their interactions were effects fitted in the analysis model. Treatment effect was considered significant if the computed probability value was less than 0.05. Tukey's procedure was used to separate the treatment mean difference of each response variable.

Results and Discussion

Results of dietary GP supplementation on production, egg weight and the percentages of egg component parts during high temperature storage are shown in Table 1. There was a decrease (P <0.05) in laying rate for 5% GP inclusion compared with the control. This indicates that a high dietary GP level can lead to a reduction in laying rate. Egg weight and the percentages of its component parts were not affected (P >0.05) by GP inclusion levels. Eggs from GP-supplemented groups maintained lesser air cell size by a non-significant value of 2.32 mm compared with the control group. No difference (P >0.05) was noticed in

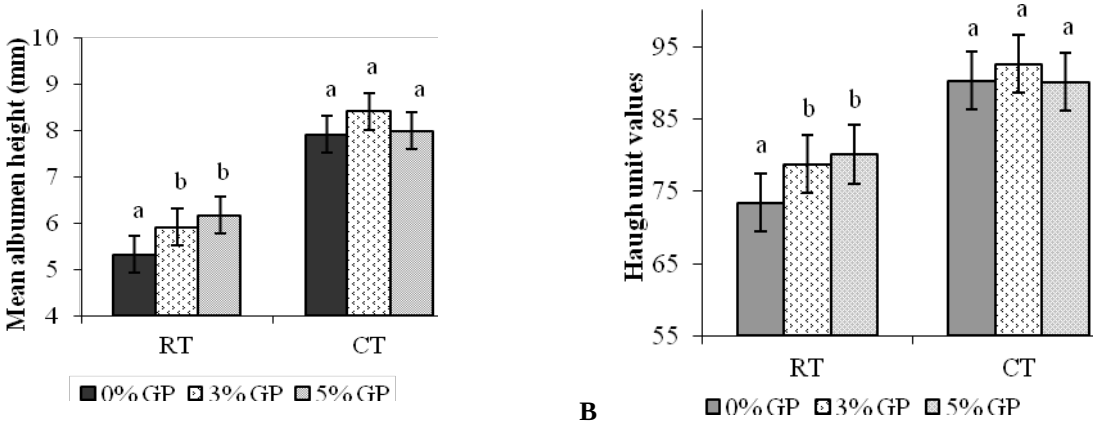
albumen pH of eggs from all the treatment groups. Similarly, all the egg quality parameters were not influenced (P >0.05) by dietary treatment during cold storage.

Table 1 Effect of dietary garlic powder on egg production, egg weight percentage egg components, air cell size and albumen pH of eggs stored in room temperature

Parameter	Garlic powder inclusion level			SEM	*P*-values
	0%	3%	5%		
Laying %	91.7[a]	90.2[ab]	85.6[b]	1.73	0.01
Egg weight	54.2	52.1	53.9	0.95	0.15
Shell %	10.8	10.7	10.3	0.22	0.22
Albumen %	57.8	57.9	59.5	0.82	0.14
Yolk %	31.4	31.5	30.4	0.72	0.31
Air cell size	11.2	10.0	10.0	0.60	0.39
Albumen pH	9.30	9.33	9.28	0.02	0.24

[a,b] Means within the same row with different superscripts differ significantly (P <0.05).
SEM: standard error of mean.

Eggs from GP-supplemented groups maintained a higher (P <0.05) Haugh unit value by 11.9 while albumen height tended (P = 0.06) to be higher by 1.4 mm respectively, over eggs from the control group at room temperature storage. No significant differences were noted among treatments in these parameters when eggs were stored at low temperature (Figure 1). This result indicates that garlic powder significantly maintained albumen quality of eggs at room temperature. Lim *et al.* (2006) similarly reported a linear increase in Haugh unit after two weeks of egg storage when garlic powder was fed to laying birds. Higher albumen height and Haugh unit values imply reduction in egg white liquefaction, which could also mean maintenance of egg freshness and albumen functionality.



A **B**

Figure 1 Effect of dietary garlic powder (GP) on mean albumen heights (A) and Haugh units (B) of stored eggs. RT: room temperature; CT: cold temperature. Bars with different letters differ (P <0.05).

In comparison to the values for fresh egg, a decrease (P <0.05) in egg weight and albumen percentage but increase in yolk percentage were recorded in eggs stored at room temperature. No significant changes were noted in these parameters during cold storage whereas shell percentage was not affected by any of the

storage conditions (Table 2). Air cell size and albumen pH of eggs from all the experimental groups increased significantly during storage, irrespective of storage temperature. Conversely, there were decreases in albumen heights and Haugh unit values, which were significant with increasing temperature. These observations (Table 2) represent signs of egg quality deterioration (Jacob *et al*., 2000) and are in accordance with previous reports on egg storage (Mahmoud *et al*., 2006).

Table 2 Effect of storage temperature on physical egg quality

Parameter	Storage			SEM	*P*-value
	Fresh eggs	CTS	RTS		
Egg weight (g)	56.5 [a]	55.6 [a]	52.7[b]	0.85	0.025
Shell (%)	10.4[a]	10.5[a]	10.7[a]	0.16	0.352
Yolk (%)	26.5[a]	27.3[a]	31.4[b]	0.38	0.001
Albumen (%)	63.1[a]	62.2[a]	57.9[b]	0.43	0.001
Albumen height (mm)	8.7[a]	8.0[a]	5.8[b]	0.20	0.001
Haugh unit	93.5[a]	90.6[a]	77.9[b]	1.17	0.001
Albumen pH	8.93[a]	9.10[b]	9.32[c]	0.02	0.001
Air cell size (mm)	5.4[a]	7.0[b]	11.3[c]	0.21	0.001

Means within same row bearing different superscripts are significantly different (P <0.05).
CTS: cold temperature storage; RTS: room temperature storage; SEM: standard error of mean.

A decrease in egg weight and albumen percentage with concomitant increase in yolk percentage during room storage suggests loss of moisture through the shell and movement of water from albumen into yolk. The latter is an indication of vitelline membrane weakness, which could cause the yolk to rupture when the egg is broken, subsequently contaminating the albumen. Storage by refrigeration, however, seems to curtail this process as observed in this study. Furthermore, ovalbumin, a major albumen protein, is easily converted to S-ovalbumin at high temperature and albumen pH (Lomakina & Míková, 2006). In this study, the increased albumen pH noted in eggs stored at room temperature indicates that a greater proportion of the eggs' ovalbumin must have been converted to S-ovalbumin, which reduces foam stability. The results of this study are therefore in agreement with previous assertions that egg storage by refrigeration helps in preserving its quality.

Conclusion

This study indicates that dietary GP and low temperature separately maintained albumen stability of eggs stored at room temperature during summer. Dietary GP had no significant influence on albumen stability of eggs in cold storage, perhaps due to the effectiveness of low temperature in retarding deteriorative processes in the stored eggs. Garlic powder should perhaps be further explored for its possible influence on the chemical quality of stored eggs.

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