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Effect of Vinegar as Disinfectant on Local Guinea Fowl Egg Hatchability and Keets Growth Performance

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ABSTRACT

Background and Objective: The low guinea fowl egg hatchability and the high keet mortality are the main constraints that limit guinea fowl production. The effects of vinegar as a disinfectant on the egg hatchability and keets growth performance were evaluated through experimentation at CERRA Maradi (Niger). **Materials and Methods:** Bleach at 10% (B10), vinegar at 10% (V10) and vinegar at 15% (V15) were used for egg disinfection. One hundred and twenty eggs from local guinea fowl were divided into three groups. Each group was disinfected with one of products. Eggs were incubated for 28 days with 4 replicates. Keets from each group were divided into three replicates to assess growth performance for 5 weeks. Statistical analysis was performed with R 4.1.0. **Results:** Results showed that V10 had a 2.7 and 3.32% higher hatchability than B10 and V15 groups respectively with non-significant differences ($p = 0.89$). The mortality was recorded in keets of B10 and V10 groups. No mortality was recorded in V15 group. Feed intake, live weight, daily weight gain and feed conversion ratio were not statistically influenced ($p>0.05$) by the type of disinfectant through experimentation. **Conclusion:** Compared to bleach, vinegar appears to be a new alternative for guinea fowl egg disinfection for incubation. At 10% is best suited for local guinea fowl egg hatchability and at 15% for keet survival and growth performance.

KEYWORDS

Egg disinfection, egg hatchability, keet performance, local guinea fowl, vinegar

INTRODUCTION

Guinea fowl has a higher market value compared to chicken in Niger[1]. However, the productivity of local guinea fowl is very low to meet consumer demands throughout the year[2]. Numerous constraints handicap the optimizing efficiency of guinea fowl farming[3]. Indeed, guinea fowl breeding has not been sufficiently studied to develop technical recommendations for the management of all the constraints of this breeding[4]. The research carried out has shown that the main production constraints for local guinea fowl are low egg hatchability and keet survival. Guinea fowl mortality, especially the keet survivability was the main problem in guinea fowl farming and often caused discouragement[5]. Unbalanced feed, humidity,

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temperature and disease have been cited as causes of mortality in guinea fowl from 0 to 90 days of age. This situation is mainly linked to breeding practices because rearing keet in a controlled environment has drastically reduced this mortality[6]. The hatchability of guinea fowl eggs in artificial incubation is lower than that of chickens[7], the hatched egg weight[8], the storage duration before incubation[9], the egg sanitary quality[10], the eggshell[11,12] were considered as the main factors that act on the egg hatchability. Information exists to overcome the first two constraints. Little information was available on the two last parameters for guinea fowl. The eggshell is an ordered structure that provide a protection of the embryo against mechanical, damage, microbial contamination and solar radiation. It also regulates gas flow, temperature variation and water exchanges with the environment during embryonic development[13]. Failure to sanitize hatching eggs results in contamination and subsequent growth of bacteria during the incubation process, which can ultimately lead to reduced egg hatchability, poor chick quality, poor growth performance and increased mortality during rearing period[14]. Fumigation, spraying, washing and ultraviolet rays are used for the disinfection of hatcheries and hatching eggs[15]. Spraying eggs with per-acetic acid and using ultraviolet light significantly reduced the plaque of aerobic bacteria compared to the control group. In addition, eggs disinfected with per-acetic acid had lower numbers of enterobacteriaceae than control groups[16]. Using vinegar solution as chicken egg disinfection has been a good way to reduce bacterial contamination of the shell and improve embryonic development, hatchability and chick performance[17]. The objective of this study was to improve the hatchability of guinea fowl eggs and keet growth performance by using vinegar as a disinfectant.

MATERIALS AND METHODS

Study area: The research was carried out at the Poultry Section of the Department of Animal Production of Regional Center of Agronomic Research of Maradi, National Institute of Agronomic Research of Niger, from August to October 2022. The center is situated at latitude 13°27.560'N and longitude 7°6.230'E, 350 m above sea level. The climate is marked by distinct dry and rainy seasons, with annual rainfall varying from 350-500 mm on average. The temperature fluctuates from 18-45°C depending on the season, with a relative humidity of 14 and 60% in the dry and wet seasons, respectively.

Materials

Biological materials: Local guinea fowls rared at the center, eggs and keets constituted the biological materials. Local guinea fowls were used as breed for the eggs production for incubation. They were 68, including 51 females and 17 males, i.e., a sex ratio of 1/3. One hundred and twenty eggs from these guinea fowls, were collected and used to assess the effect of vinegar on local guinea fowl egg hatchability. Day-old keets from these eggs were used for growth performance.

Incubation and housing: The cimuka incubator CT120 (Turkey) with a capacity of 120 eggs was used. The incubation temperature was set at 37.8°C throughout the incubation period. The humidity was 50% from the 1st to the 23rd day of incubation and rose to 70% from the 24th to the 28th day. The egg turning was automatic. It was programmed every 2 hrs from the 1st to the 23rd day and stopped on the remaining days. A 19.25 m^2 (5.5×3.5 m) guinea fowl starter chicken coop was used during the keet growth performance experimentation. The temperature was maintained at a range of 28 to 33°C. It was partitioned into nine batches with wire mesh.

Methods

Egg disinfection and incubation: The 120 eggs with an average weight of 39.03 g were divided into three groups of 40 eggs. Each group was disinfected with one of the three solutions. The three treatments consisted of a solution of 10% of bleach (B10), 10% of vinegar (V10) and 15% of vinegar (V15). Three days before, the incubator was cleaned and disinfected with 10% bleach. Before the introduction of the eggs, the incubator was empty to enable it to stabilize the temperature at 37.8°C and the humidity at 50%. The eggs were marked and distributed randomly over the four rows of the incubator with 10 eggs per row per

treatment. The first hatch examination was performed at 9 days of incubation to determine the egg fertility and the second at 23 days to determine the embryologic mortality. The eggs were grouped by treatment and placed in the hatcher basket immediately after the second hatch examination. Incubation was stopped on day 28 and the day-old keets were used for growth performance evaluation per treatment.

Keet rearing management: The experiment lasted five weeks, with two phases. The starter phase from 0 to 4 weeks and the grower phase from 4 to 5 weeks. All the keets were weighed per treatment and randomly divided into the 9 blocks with three repetitions per treatment. Water and feed were *ad libitum*. The keets were fed commercial broiler feed for 5 weeks. The feed was in pelleted form and contained 3200 kcal of metabolizable energy per kg of dry matter, 22% of crude protein, 1.2% of calcium, 0.65% of phosphorus, 1% of methionine, 1% of lysine and 4.3% of crude fiber as indicated on the notice. No antibiotics or vaccines were administered to the keets during the five weeks of experimentation. However, they received the sugar in drinking water on the first day, followed by two days of anti-stress (amin total). Each week, one day before and the day of weighing, the amin total was given as an anti-stress in drinking water with a concentration of one gram per liter (1 g/L).

Data collected and calculated: Fertility, gross hatchability and real hatchability were used to assess the effect of vinegar on local guinea fowl egg hatching parameters. The egg fertility rate per treatment was determined after the first hatch examination. It was calculated by taking the ratio between the fertile eggs and the total eggs introduced into the incubator through the formula below[2]:

$$\text{Ferttility (\%)} = \frac{\text{Total number of fertile eggs}}{\text{Total number of eggs set}} \times 100$$

The gross hatchability rate was calculated by taking the ratio between hatched eggs and eggs introduced into the incubator by the formula below[4]:

$$\text{Gross hatchability (\%)} = \frac{\text{Total number of keets hatched}}{\text{Total number of eggs set}} \times 100$$

The real eggs hatchability rate was calculated by relating the hatched eggs to the fertile eggs by the following formula[9]:

$$\text{Real hatchability (\%)} = \frac{\text{Total number of keets hatched}}{\text{Total number of fertile eggs}} \times 100$$

Mortality, feed intake, live weight, average daily gain (ADG) and feed conversion ratio (FCR) were the parameters used to evaluate the effect of vinegar on guinea keet growth performance. Throughout the experiment period, all dead keets were recorded. The mortality rate per treatment was calculated by the ratio of the number of guinea keet dead during the period and the number of guinea keet at the start of the experiment. It was calculated by the following formula[2]:

$$\text{Mortality (\%)} = \frac{\text{Number of keet dead at the period}}{\text{Number of keet dead at the start of period}} \times 100$$

The feed was distributed and the refusals were recorded daily by batch. The feed intake in grams per day (g/d) per guinea keet was obtained by the difference between the feed distributed (Fd) and the refusal (Fr) related to the number of guinea keet (Nk) through the formula adapted from Kyere *et al.*[18]:

$$\text{FI (g / d)} = \frac{\text{Fd - Fr}}{\text{Nk}}$$

The initial and final keets weight during the experiment was determined through individual weighing per batch and treatment. Thus, the average live weight (LW) in grams (g) was determined by the ratio of the total weight (TW) of the guinea keets and the total number (TN) of the keet according to Kyere *et al.*[18]:

$$\text{PVM (g)} = \frac{\text{TW}}{\text{TN}}$$

From the live weight, the ADG in g/d per guinea fowl and per treatment was calculated by the difference between the final live weight and the initial weight related to the period of the experiment according to Kyere *et al.*[18]:

$$\text{ADG (g / d)} = \frac{\text{Final live weight - Initial live weight}}{\text{Period experiment}}$$

The FCR was calculated by the ratio of the total feed intake in grams per guinea fowl and its weight gain in grams over the period of the experiment[2]:

$$\text{FCR} = \frac{\text{Total feed intake (g)}}{\text{Keet weight gain (g)}}$$

Statistical analysis: The data collected were entered into Microsoft Excel 2010 software. The calculation of the average and the one-factor analysis of variance were carried out with the R4.2.1 software. The means were compared at the 5% level, i.e., for probability values (p-value) less than 0.05, the difference between treatments was considered to be statistically significant.

Ethical consideration: The experiment was conducted in compliance with current standards for conducting experiments with animals of the National Institute for Agronomic Research of Niger. Ethical issues such as plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission and redundancy have been checked by all the authors.

RESULTS

Egg hatching parameters: The average egg weight of the different treatments was reported in Table 1. Eggs disinfected with 10% of bleach (B10) weighed more and exceeded by 1.19 and 0.74 g, respectively eggs were disinfected with 10% of vinegar (V10) and 15% of vinegar (V15). The egg weight of the V15 groups was 0.45 g higher than those of the V10 groups. However, these differences were not statistically significant ($p = 0.12$) at 5%.

The egg fertility, which expresses the percentage of fertile eggs close to giving keets was recorded during the 9th day of incubation. B10 and V10 eggs had the same fertility and were 5% higher (Table 1) than the fertility of V15 eggs without a statistical difference ($p = 0.68$).

Eggs from the V15 treatment had the lowest gross hatchability (Table 1) and were outperformed by those from V10 and B10 by 7.5 and 2.5%, respectively. The gross hatchability of V10 was the highest and exceeded the B10 groups by 2.5%. These differences were not also statistically significant between the treatments ($p = 0.68$).

The real egg hatchability was on average 89.88% in this study. The V10 showed higher real hatchability than the two others (Table 1) with a difference of 2.7 and 3.32% respectively for B10 and V15 groups, but these differences were not statistically significant ($p = 0.89$).

Table 1: Effect of vinegar on local guinea fowl egg hatching parameters

Parameter	B10*	V10*	V15*	p-value**
Egg weight (g)	40.68	39.49	39.94	0.12
Egg fertility (%)	92.50	92.50	87.50	0.68
Gross hatchability (%)	82.50	85.00	77.50	0.68
Real hatchability (%)	89.88	91.89	88.57	0.89

*B10, V10 and V15: Guinea fowl egg treated with a solution of 10% bleach, 10% vinegar and 15% vinegar, respectively and **p-value: Probability and means of the same line having probabilities <0.05 are not statistically different

Table 2: Effect of vinegar as egg disinfectant on keet mortality

Mortality	B10*	V10*	V15*	Mean
0-4 weeks (%)	9.09	8.82	0	5.97
4-5 weeks (%)	0	0	0	0
0-5 weeks (%)	9.09	8.82	0	5.97

*B10, V10 and V15: Guinea fowl egg treated with a solution of 10% bleach, 10% vinegar and 15% vinegar, respectively

Table 3: Effect of vinegar as egg disinfectant on keet feed intake

Feed intake	B10*	V10*	V15*	p-value**
0-4 weeks (g/d)	10.09	10.48	10.39	0.98
4-5 weeks (g/d)	21.65	21.43	21.55	0.86
0-5 weeks (g/d)	12.39	12.67	12.64	0.99

*B10, V10 and V15: Keet from guinea fowl egg treated with a solution of 10% bleach, 10% vinegar and 15% vinegar, respectively and **p-value: Probability and means of the same line having probabilities <0.05 are not statistically different

Table 4: Effect of vinegar as egg disinfectant on keet live weight

Live weight	B10	V10	V15	p-value**
Live weight at d1 (g)	24.97	24.88	25.50	0.40
Live weight at d28 (g)	142.47	148.22	146.13	0.65
Live weight at d35 (g)	189.47	192.97	203.80	0.30

*B10, V10 and V15: Keet from guinea fowl egg treated with a solution of 10% bleach, 10% vinegar and 15% vinegar, respectively and **p-value: Probability and means of the same line having probabilities <0.05 are not statistically different

Growth performance: Egg treatment influenced the mortality of keets. Guinea keet mortality was recorded between 0-4 weeks of age (Table 2). The overall mortality rate was 5.97%. Until the end of the experiment, no mortality was recorded in the V15 groups. The B10 recorded more mortality (Table 2). They exceeded the V10 by 0.27%.

In the interval of 0-4 weeks of age greatest feed intake was recorded with V10 treatment and in 4-5 weeks, B10 keets had the highest feed intake (Table 3). All of these differences were not statistically significant ($p>0.05$). During five weeks of experimentation, guinea fowl ingestions were similar. The V10 guinea fowl only exceeded those resulting from B10 and V15 treatments by 0.28 and 0.03 g/d respectively. There was no significant difference ($p = 0.99$) at the 5% (Table 3).

Guinea keet from V15 group had the highest live weight at starter and those from V10 at 28 days (Table 4). At the end of five weeks, the V15 keets presented the greatest live weight (Table 4). They were 10.83 and 14.33 g higher than the V10 and B10 keets, respectively. Guinea keet from V10 had a higher live weight than those from B10 by 3.50 g. These differences with a trend of increasing live weight of keets with increasing vinegar concentration were not statistically significant ($p = 0.30$) at the 5%.

The average daily gain (ADG) of the V15 keets was higher by 0.83 and 0.71 g/d compared to the ADG of the V10 keets and those of the B10, respectively between 0 and 5 weeks. The treatment used did not have statistically significant effects ($p = 0.74$) on guinea keet ADGs during the 5 weeks of experimentation (Table 5).

The feed conversion ratio (FCR) was higher in V10 keets (Table 6) than in B10 and V15 by 0.16 and 0.42 kg, respectively. The keet FCR from B10 was higher than from the V15 treatment of 0.26. The difference between keet FCRs was not statistically significant ($p = 0.63$) during the five weeks of the experiment, according to the product used in egg disinfection.

Table 5: Effect of vinegar as egg disinfectant on keet average daily gain

Avarage daily gain (ADG)	B10	V10	V15	p-value**
0-4 weeks (g/d)	4.20	4.43	4.32	0.26
4-5 weeks (g/d)	6.94	6.47	8.24	0.46
0-5 weeks (g/d)	5.57	5.45	6.28	0.74

*B10, V10 and V15: Keet from guinea fowl egg treated with a solution of 10% bleach, 10% vinegar and 15% vinegar, respectively and **p-value: Probability and means of the same line having probabilities <0.05 are not statistically different

Table 6: Effect of vinegar as egg disinfectant on keet feed conversion ratio

Feed conversion ratio (FCR)	B10	V10	V15	p-value**
0-4 weeks	2.30	2.27	2.25	0.96
4-5 weeks	3.22	3.56	2.75	0.50
0-5 weeks	2.76	2.92	2.50	0.63

*B10, V10 and V15: Keet from guinea fowl egg treated with a solution of 10% bleach, 10% vinegar and 15% vinegar, respectively and **p-value: Probability and means of the same line having probabilities <0.05 are not statistically different

DISCUSSION

Hatching parameters: All of the hatching parameters were not statistically influenced by the egg treatment. All eggs were subjected to the same conditions, from guinea fowl feeding, sex ratio and conservation. The egg weights used in this experiment were within the range of weights indicated for better hatchability[19]. The egg weights were similar because they came from the same local guinea fowl breeder. Indeed, variety[20], breeder age[21] and egg storage duration[9] were the variation factors of the local guinea fowl egg weights.

Vinegar did not affect the egg fertility of guinea fowl as well as quail eggs[13]. The egg fertility is more influenced by the sex ratio of the breeder and the egg weight. The fertility of guinea fowl eggs increased from 56.5% for a sex ratio of 1 male to five females[22] to 58% for a sex ratio of 2.3[21] and 70% for a sex ratio of 1 male for two females[4]. For these authors, eggs weighing more than 35 g were more fertile. The fertility recorded in this study was the range of eggs weighing more than 35 g[23].

Vinegar increased chicken[17] and quail[13] eggs hatchability. The hatchability decreased from 15% of vinegar in this study. It could be the optimum rate for using vinegar to treat local guinea fowl eggs. The hatchability observed by Kouame *et al.*[9], Saina *et al.*[24] was lower than the rate in this study. It can be influenced by the proportion of infertile eggs. The infertility of guinea fowl eggs can be linked to the age of the breeders[21], sex ratio[4,21] and the storage duration before incubation[25].

Keet growth performance: Keet mortality decreased with increased vinegar[17] due to some haematological parameters such as crude protein, lipid, hormone, calcium and phosphorus levels in chick blood increased with increasing vinegar level. However, a non-significant difference in quail mortality was not observed[13]. Indeed, rearing temperature, feed and sanitation have an influence on keet mortality[23,26,27]. The mortality rate observed by Sanfo *et al.*[6] in a controlled environment was similar, but that recorded by Naandam *et al.*[28] in a non-controlled environment was higher than the rate recorded in this study.

Egg treatment did not influence the keet feed intake. Variations in guinea fowl feed intake have been reported with feeds varying in their composition, especially in energy and crude protein[29]. The variation in the protein level from 16 to 20% in their feed did not significantly modify the ingestion by maintaining energy at 3000 kcal[30].

The use of vinegar as egg disinfectant did not statistically improve the keets' live weight. The same observation was made with quail[13]. The nutritional quality of the feed[31] was more indexed to significantly influence the live weight of the keets. This is why the keets' live weight at 28 days reported

by Sanfo *et al*.[4] was lower than the weights recorded in this study and the keets have decreased with feed containing 10 and 15% of baobab seed in the diet compared to those consuming the control feed and that containing 5% of baobab seeds[32].

Vinegar used as a disinfectant improves keets weight gain. ADG was increased with increasing vinegar due to the hematological quality of the chick[17] and quality feed[1].

However, the feed conversion ratio of chicks decreased with increasing vinegar to treat eggs, also chicks from eggs treated with vinegar showed better feed conversion ratios than chicks from other treatments[17].

The 10% vinegar improves the hatching rate, but this rate decreases at 15% to promote the survival of the guinea fowl. It will be necessary to study the physical, biological and physiological mechanisms of eggs and guinea fowl after treatment. The resistance of the shell can be studied after treatment and upon hatching, as the hematological parameters and the stress resistance of the guinea fowl. It will also be necessary to use other natural sources such as lemon to improve the hatching rate of local guinea fowl eggs.

CONCLUSION

The use of vinegar in the range of 10 to 15% as a disinfectant before incubation did not statistically influence the local guinea fowl egg fertility and hatchability compared to the use of bleach at 10%. However, no guinea keet mortality was recorded in the V15 batches. The V15 improves without significant difference in the live weight, the average daily gain and the feed conversion ratio of keets compared to the V10 and B10. Further studies will be needed to determine the optimal dose of vinegar as a disinfectant and the involvement of vinegar in improving the growth performance of keets.

SIGNIFICANCE STATEMENT

The guinea fowl eggshell was another factor that affected egg hatchability which needs to be studied. The objective of this study was to evaluate vinegar as an egg disinfectant on hatching parameters and keet survival. Results showed that vinegar used at 10 to 15% of solution for guinea fowl egg disinfection improved hatching parameters and keet growth performance with non-significant difference. Vinegar compared to bleach can be used as a disinfecting material and cuticle removal to improve guinea egg hatchability. It can be used also for keets survival amelioration. However, it is necessary to determine the effective contribution and the optimal dose of vinegar in egg hatching parameters and keet performance.

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