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Article

Comparison in the quality of eggs obtained in an outdoor pen production system and those produced in a cage system

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Abstract:

Mexico is the main consumer of eggs worldwide with more than 23.22 kg of egg per capita per year. In recent years, production systems have diversified with the introduction of systems that promote animal welfare. The present study was carried out with the aim of comparing the quality of eggs produced in an outdoor pen system against those of a semi-technified cage system. The internal and external physical characteristics of the eggs were evaluated at 3 and 15 d after laying. The results of the present study showed that the egg produced in an outdoor pen system has less cleanliness (P<0.001), and lower quality (P<0.005) than eggs produced in the cage system, according to the classification of the Mexican Standard of "Poultry Products -fresh chicken egg- specifications and test methods" (NMX-FF-127-SCFI-2016). Finally, the storage time significantly decreased the quality of the egg produced in the outdoor pen system (P<0.001), but not that of the eggs from the conventional cage system. In conclusion, under the conditions of the present work, the quality

of the egg from conventional systems is better than that of the egg produced in outdoor pen systems, especially after 15 d of storage. These results suggest that more studies are needed to evaluate the effects of management practices, preventive medicine and the environmental conditions of cage-free systems on animal health and final egg quality.

Key words: Egg, Quality, Cage production, Cage-free production.

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Introduction

In Mexico, poultry farming represents 63.3 % of livestock production, of which 34.9 % is table chicken, 28.2 % egg, and the remaining 0.2 % represents turkey production[(1)]. Mexico is the world's leading egg consumer with more than 22.3 kg (360 to 370 eggs) per capita and is fourth among the countries with the highest production, below China, the United States and India. In 2017, egg production in Mexico was 2,718,476 t, with a value of $49,505 million pesos, with the main producing states being Jalisco with 55 % of production and Puebla with 15 %[(1)].

As poultry farming has evolved towards large-scale productions, conventional intensive farming systems have been developed, where birds are kept confined, allowing a greater number of animals to be kept in a small space, as well as greater mechanization and technification[(2)]. In recent years, interest has been placed in the welfare of production animals, and to improve this, the use of alternative or unconventional systems in which animals are free has been suggested[(3)]. The consumption of products generated under these systems is increasing worldwide, mainly in the European Union, the United States and Japan[(4)].

In Mexico, egg production in outdoor pen or grazing systems has had a slow increase, as a sector of the population of the upper middle socioeconomic class seeks a better diet by consuming products that are marketed as natural and of higher quality[(5)]. Additionally, companies in the food sector are committed to animal welfare, even companies such as Alsea, Bimbo, CMR (Corporación Mexicana de Restaurantes) and Marriot International have stated that by 2025 they require that their inputs come from cage-free production systems[(6)].

The production parameters of the cage-free system are not comparable to those of intensive production. Although the requirement for facilities is lower, the low population density per square meter increases the cost per bird. Additionally, the expenses for labor and food are higher, because birds, having more space, raise energy expenditure and require greater consumption of feed to cover their maintenance and production needs. Thus, the cost of production per kilogram of egg in the cage-free system is between 50 and 70 % higher than that of intensive production, therefore the competition of these systems lies in the quality of the final product and not in the selling price[7,8].

When talking about egg quality, reference is made to certain internal and external physical properties that influence the acceptance of the product by the consumer. According to the NMX-FF-127-SCFI-2016[9], the egg is classified into four quality categories, which are Mexico extra, Mexico 1, Mexico 2 and out of classification. Mexico's classification categories have equivalents to the classification used in the United States (Table 1). Internal quality tends to decrease from the time the egg is laid, and is affected by age or freshness, diseases in the flock, handling, temperature and storage humidity[10,11]. To measure the freshness of the egg, the Haugh Units (HU) are used, which relate the total weight of the egg with the height of the albumen, these units decrease as the product ages[9,10].

Table 1: Mexican classification of the egg according to the standard NMX-FF-127-SCFI-2016[9], and its equivalents in the United States (USA) and in the Haugh Units (HU)

	USA	**HU**
Mexico Extra	AA	> 79
Mexico 1	A	55 to 78
Mexico 2	B	31 to 54
Out of classification	C (out of classification)	< 31

In external quality, the shape of the egg is evaluated, the cleanliness in which it should not have stains of blood, excrement or dust, while the shell should not have alterations such as wrinkles or stretch marks, or perforations, cracks or breaks[10].

The objective of this work was to compare the quality of eggs produced in an outdoor pen system against those produced in a cage system. The physical characteristics of quality, internal and external, were evaluated at 3 and 15 days after laying. The hypothesis of the work was that the quality of the chicken egg produced in an outdoor pen system is better than that of those from the cage production system, regardless of the storage time.

Material and methods

Leghorn hens in their first laying cycle were used, fed with the same concentrate, made at the FMVZ. The samples were taken from two centers of the Faculty of Veterinary Medicine and Zootechnics, of the National Autonomous University of Mexico, both with natural environment houses with manual egg collection, twice a day. The egg of the cage system (n= 60) came from the Center for Teaching, Research and Extension in Poultry Production, located in Tláhuac, Mexico City, in the Mexican highlands; while the eggs produced in the outdoor pen system (n= 60) were produced at the Agro Silvo Pastoral Teaching, Research and Extension Center, located in Chapa de Mota, State of Mexico. The traditional production is carried out in California-type cages of 40 cm front by 45 cm deep for three hens, while the production in outdoor pen is on a dirt floor with sheet metal nesting boxes and wooden perches, at a rate of a nest for five hens, and having a total of 1 m^2 for four hens.

For this study, the egg collection was carried out on the same day in both centers in the afternoon and the eggs were immediately transferred to the Faculty for identification and storage until the day of analysis. In the case of samples from outdoor pen production, only eggs that were found in the nests were included.

Thirty (30) eggs from each system were evaluated three days after laying, while the remaining 60 eggs were stored in refrigeration at 4 ºC, with 60 % humidity, to be evaluated 15 d after laying.

The parameters evaluated were: weight in grams, length and width in millimeters, shell thickness in millimeters, shell cleanliness (determining 4 categories (0) clean, (1) slightly dirty, (2) moderately dirty and (3) very dirty), yolk color using the Roche colorimetric fan. To measure the freshness of the egg, the Haugh Units (HU) were used, which decrease as the product ages[9,10]. These HUs are calculated with the formula HU = 100 X log [(AH-(1.7 X EW) + 7.57], in which AH is the albumen height in mm and EW is the egg weight in grams. With the above evaluations, the eggs were classified according to the official Mexican standard (NMX-FF-127-SCFI-2016) in Mexico Extra, Mexico 1, Mexico 2 and without classification.

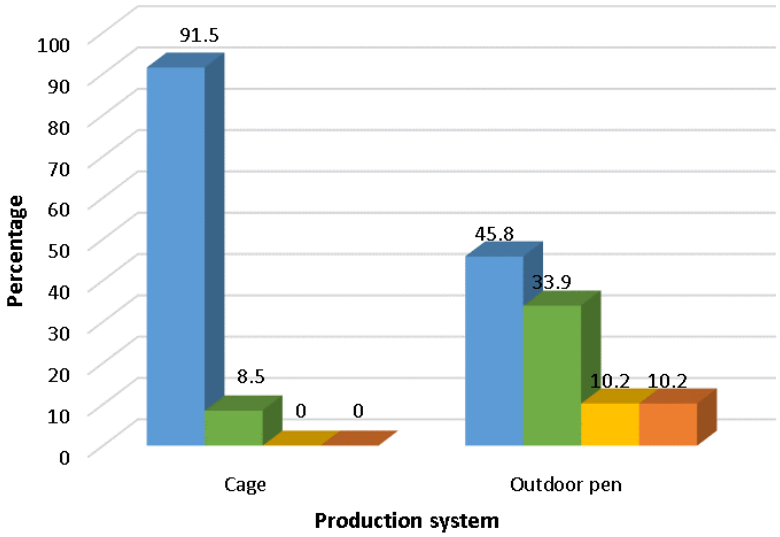
For the effect of the type of production on the cleanliness of the egg and the yolk color, the Wilcoxon rank sum test was used. The difference between Haugh Units due to the type of production was analyzed with Student's T, while the external characteristics of the egg were evaluated by an analysis of variance. To analyze the effect of storage time on the percentage of eggs in the different categories of the Mexican classification, a Chi-square was used.

Results

Eggs produced in the cage production system were heavier than those produced in the outdoor pen system (62.3 *vs* 58.5; $P<0.01$). There were no significant differences ($P>0.05$) in the width (23.8 ± 3.7 mm) and length (28.6 ± 4.8 mm) of the egg, nor in the thickness of the shell (0.37 ± 0.008 mm) the external physical characteristics of the eggs due to the type of production.

When the egg cleanliness was evaluated, it was found that it was significantly better ($P<0.001$) in the egg produced in a cage system, since 91.5 % of the egg produced under this system was classified as clean, against 45.8 % of the outdoor pen egg. Additionally, in the cage system, there were no eggs in the categories moderately dirty and very dirty, while in the outdoor pen system, 10.2 % of the eggs were classified as moderately dirty and very dirty ($P<0.001$) (Figure 1).

Figure 1: Percentage of Clean, Slightly dirty, Moderately dirty and Very dirty eggs, according to the production system (cage or outdoor pen)



The percentages of all cleanliness categories show differences ($P<0.001$) between the types of production.

Within the internal physical characteristics, the color of the yolk was not different between productions ($P>0.05$), nor was it affected by the storage time. No differences were found between treatments in albumen height on day 3 postoviposition ($P>0.05$), however, the storage time of the egg did affect it, significantly decreasing it ($P<0.01$), and this reduction was greater in eggs laid in cage-free pens (interaction: type of production by storage time, $P<0.001$) (Table 2).

Table 2: Characteristics of freshness of the egg produced in an outdoor pen system or in California-type cages, and effect of storage time (3 or 15 days)

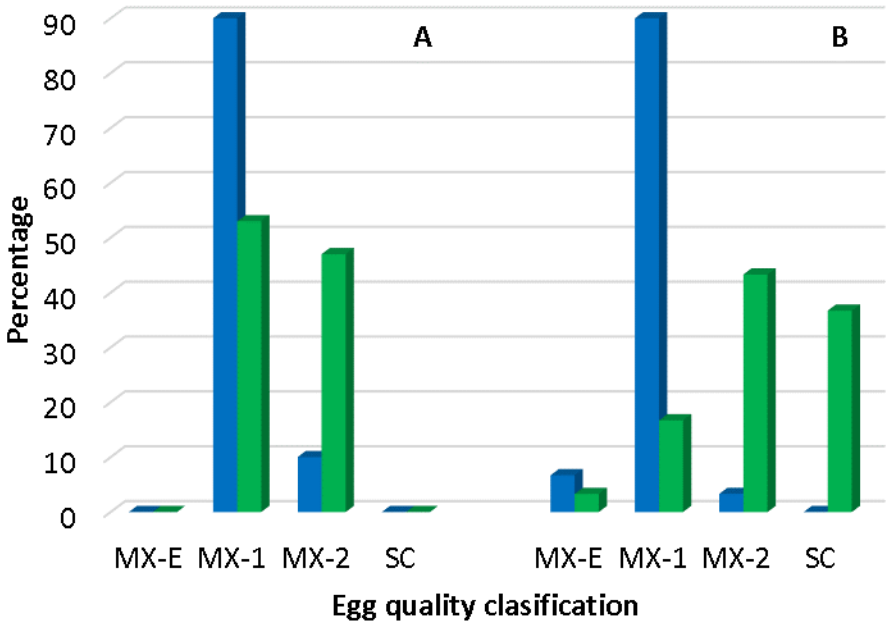
	Type of production				Standard error
	Cage		Outdoor pen		
Storage days	3	15	3	15	
Albumen height, mm	4.6 [a]	3.9 [b]	5.3 [a]	2.6 [c]	0.2
Haugh Units	63.9 [a]	54.0 [a]	69.4 [a]	36.4 [b]	3.1

[ab] Different literals within the same egg quality variable indicate significant differences ($P<0.01$).

Egg freshness, measured in Haugh Units, decreased with storage time ($P<0.001$). However, the storage time affected more (interaction $P<0.05$) the egg from free-range hens, so that the more storage days the lower the Haugh Units (Table 2).

When the egg quality was evaluated, it was found that the egg produced in cages was of better quality ($P<0.005$), and this quality was better preserved ($P<0.001$) with storage time (Figure 2). One hundred percent of the eggs produced in cages had classifications Mexico 1 and Mexico 2 at 3 and 15 d of storage, while, in the egg produced in outdoor pens, of the 90 % of the eggs that were in category 1 to d 3, only 6.7 % remained in it at 15 d, the percentage of eggs in category Mexico 2 increased from 3.3 % to 43.3 %, and 36.7 % of the eggs left the classification.

Figure 2: Egg quality classification, after 3 ■ 15 ■ days of storage, where: MX-E = Mexico extra, MX-1 = Mexico 1, MX-2 = Mexico 2, SC = without classification



Panel A = cage production; panel B = outdoor pen production.

Discussion

The results of the present study show that the egg produced in cage systems has better quality after 15 days of storage, when compared to the egg obtained in an outdoor pen system.

The current trend towards the consumption of food produced in systems similar to those of free-living has favored the increase of egg production systems with free-range hens, and one of the arguments is that the quality of the egg is better[12]. However, in studies conducted to determine differences in egg quality according to the layers' housing systems, very variable and inconsistent results have been found[13]. The present study shows that the initial quality of the egg does not differ, but production in outdoor pen systems negatively affects the quality when the egg is stored for 15 d, even after standardizing the lineage and diet of the hens.

The internal and external characteristics of the egg in both systems were similar in the fresh egg (3 d after laying). However, after 15 days of storage, a higher proportion of eggs from the outdoor pen system were classified in category Mexico 2, and there were even eggs out of classification, which indicates a decrease in egg quality over time. Among the factors associated with the decrease in the internal quality of the egg (Haugh Units) is the loss of water and CO_2[14,15,16], consequently, the pH of the egg increases (changes to basic), which results in an aqueous white due to the loss of structure of the dense albumen protein[14,17,18]. Previous studies have reported that such changes begin to be observed after 5 d of storage, which even affects the taste of the egg[10]. This would explain the decrease in HUs after 15 d of storage that was found in this study.

Another factor that can also affect the internal quality of the egg is the ambient temperature[19,20,21]. In this study, the eggs of both systems were stored in the same place and the storage temperature was the same for the following 15 d; however, it is possible that there has been a variation in it from the time of laying to the transfer to the laboratory. Cage production systems may have controlled air systems, which prevent temperature variations, which is not observed in outdoor pen productions[22]. Thus, it has been observed that the quality of albumen is affected if the eggs are not immediately collected in a house with an elevated ambient temperature[23,24]. Additionally, in outdoor pen systems, the hens have the availability of nests with bed, which can delay the loss of heat from the egg[23,25], which does not occur in the cage system, since the egg comes out towards the collection band immediately after laying, favoring the decrease of its temperature in less time. The results of the present work show an interaction between the production system and the storage time, the latter affecting more negatively the quality for the outdoor pen system.

On the other hand, the interval between egg collections in cage system is smaller than in outdoor pens systems, so the egg spends less time at the production site[25]. Data provided by Macindoe[16] indicate that Haugh Units decrease considerably at a greater interval between egg collections. However, the results showed that the quality of the eggs from the outdoor pen system is even lower when the collection time was not different between systems.

Finally, the cage egg had a percentage of cleanliness higher than that of the egg from the outdoor pen system. This is attributed to the fact that, in this last system, a part of the eggs is laid on the floor and the other in communal nests, which implies the contact of the eggs with dirty surfaces. In addition, eggs produced in cage-free systems have been shown to have greater bacterial contamination with staphylococci, streptococci and *E. coli*[24,26]. This may explain the reduction in quality observed in this study when the eggs were kept for 15 d, since a greater number of bacteria in the shell increases the risk of contamination and therefore decreases the internal quality[23,24].

The results show that the quality of the egg produced in an outdoor pen system is lower than that of eggs produced in conventional systems, and are consistent with what Wells and Belyavin[24] suggested, who mention that eggs produced in cage-free conditions do not present real advantages to the consumer in terms of composition and physical properties of the egg. They even suggest that eggs from outdoor pen systems have lower microbiological quality, so they consider that modifications in egg characteristics are not the arguments that should be used to support the change from traditional production systems. Additionally, the cost benefit must be evaluated, since, in general, in grazing systems mortality is higher and the production cost is higher due to the lower number of eggs produced and marketed.

Conclusions and implications

In conclusion, it can be said that both production systems have advantages and disadvantages; however, the quality of the egg from conventional systems is better than that of the egg produced in outdoor pen systems. Further studies are required to evaluate the effects of management practices, preventive medicine and the environmental conditions of the outdoor pen system on animal health and final egg quality.

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