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RESEARCH ARTICLE

FACTORS AFFECTING EGG QUALITY AND FUNCTIONAL PROPERTIES

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Abstract

Egg external and internal quality attributes are of great importance for egg industry worldwide. The current bibliographical analysis and review covers egg composition and factors affecting egg quality. Egg quality is generally measured as its shell quality and internal quality. The analysis of egg shell quality includes egg shell color (CIE L*, a*, b*), size, egg specific gravity, shell deformation, shell breaking strength, shell weight, shape index, shell percentage, shell thickness, and shell ultrastructure. The egg internal quality is measured as albumen quality, Haugh Unit, yolk color, the integrity of the perivitelline membrane, chemical composition of egg components and the egg functional properties. Factors that influence egg shell quality and egg internal quality are reviewed herein. Egg external quality can be affected by the strain and age of the avian resource, moult, feeding, feed quality, stress, disease, rearing system, or addition of food residues of egg producer to the diets. The egg internal quality depends on storage, avian species, strain, age, moult, nutritional condition, production system, disease and agro climatic conditions. A better knowledge and control of this range of factors that affect egg external and internal quality is very important and critical for good quality eggs production and egg product quality.

Introduction:-

The poultry egg is an excellent source of macronutrients andmicronutrients widely adoptedforhumanconsumption (Tougan et al., 2020;Mulatu, 2023). This avian product plays an undeniable role in the food security and gastronomy worldwide (García et al., 2015; Valverde et al., 2016) and the production of healthy diet as well. The great nutritional value of this excellentdietary protein source readily accessible is recognizedworldwide in human nutrition and health sciences (Yu et al., 2023; Pal and Molnár, 2021).

However, several defects can affect egg quality. Egg quality is defined as thesum characteristics of an egg that can affect user or consumerpreference and acceptability. According to Chukwuka et al. (2011) the main defects associated with egg quality are egg shell defect and egg internal defects which can be categorized into three groups namely: defects affecting yolk quality, defects affecting albumin quality and defects affecting overall quality. There are five main types of shell defects: cleanliness, integrity, texture, shape, and color (Chukwuka et al., 2011). If egg

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quality defects are reported to be usually easily resolved (Chukwuka et al., 2011), but can be very expensive if not addressed immediately. Due to the great variability in the main uses of avian eggs and the subsequent consumer and egg processing industry needs, eggquality may be very important for egg producers.

The assessment of internal quality of egg is mainly based on the size of the air cell size, the height or thickness of albumen, the Haugh Unit, the yolk quality, the presence of meat and blood spots and the chemical composition of each egg component. As for external quality, it is assessed by determining the egg size, the shell weight, the shell color, the shell thickness, the shell percentage, the shell breaking strength, shell deformation. All these internal and external egg quality traits have a genetic basis, but they are also affected by the age of the laying hens and by the hen's housing system, medical follow-up, feeding, water quality, disease, temperature, oviposition time, storage time and environment (Hossain et al., 2024; Singh et al., 2009; Tougan et al., 2019; Tougan et al., 2021).

Therefore, the aim of this review is to make a bibliographical analysis on egg quality and techno functional properties assessment and variation factors. An understanding of these multiple factors that influence egg quality isimportant and essential for the production of eggs and egg products of excellent quality.

Material and Methods:-

The current review articlewas made by following the research steps given in the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Page et al., 2021; Moher et al., 2009). For this goal, an evaluation of papers published last 20 years (between 2000 and 2024), focusing mainly on the factors affecting egg quality and functional properties and abstracts of those articles was followed. English language was preferred for article selection. Only research papers were considered to ensure quality for information. Noexpert opinions, dissertations, chapters of books, lectures, were considered. The article was considered relevant when: (i) it contains information about criteria of egg quality evaluation and egg quality defects; (ii) it includesdata about variability of egg composition, sensory attributes, processing abilities and nutritional quality; (iii) evaluated internal and externalquality of egg during laying cycle of different genetic types of avian resources kept under different production systems; (iv) it contains techno functional properties and egg product characteristics and their variability factors ; (v) the research was conducted as an original research manuscript.

The bibliography selection was based on different databases such as Scopus, Science Direct, Wiley Online Library, PubMedand CAS, ICI and web of science. The collection and screening for eligible papers were carried out from September 2023 until Jun 2024. The keywords used for the investigation was: "egg" AND "quality" AND "variability" AND "factors" OR "techno functional" AND "properties" OR "abilities" AND/OR "processing" AND/OR "traits" OR "evaluation" AND/OR "defects" OR "egg product" AND/OR "composition."

A total of 1731articles were identified as potential scientific material for this review article. These articles were screened and 137of them were selected for eligibility. From them, 100 articles were selected as suitable for this review article.

Results and Discussion:-

Egg quality concept et egg composition

The concept of quality of egg quality includes both internal and external quality.This comprehensive concept encompasseseggshell color, egg shape index, eggshell thickness and eggshell strength as external quality traits, while internal quality of egg refers to albumen height, egg yolk color CIE L* a* b*),Haugh unit, the chemical composition and functional properties of each component.According to Jacob et al. (2000), color, firmness,texture and smell of the yolk are the main indicators of yolk quality.

The components of avian eggs are mainly the shell, the white, and the yolk. The composition of whole egg of an average weight of56 g is of 12% shell, 58% of white, and 30% of yolk. Protein of egg is found in both the egg white and egg yolk, whilethe egg yolk contains almost all of the fat content (Tables 1 and 2).

Nutritionally, avian eggs are highly nutritious food, not expensive and provide balanced nutrients that improve human health (Tougan et al., 2021; Tougan et al., 2019; USDA, 2015; 2011). This avian product containsenough essential proteins, minerals, lipids, vitamins, and bioactive compounds. USDA (2015; 2011) indicates that the nutrients to energy density ratio of one egg is important with several essential nutrients. According to this author, a boiled egg of 50 g can provide 78 kcal of energy, 6.29 g of protein, 0.56 g of carbohydrate, and 5.3 g of total fat which includes 1.6 g of saturated, 2.0 g of monounsaturated, 0.7g of polyunsaturated, and 186 mg of cholesterol. About micronutrients, egg contains several minerals such as calcium, iron, magnesium, phosphorus, potassium, sodium, and Zinc and many vitamins including thiamin, niacin, vitamin B6, riboflavin, folate, vitamin B12, vitamin E, vitamin D, vitamin A, and vitamin K.

Functional propertiesofeggwhiteandegg yolk

Several authors had investigated the functional properties of egg internal parts (egg white and egg yolk). The characterization of the functional properties of egg yolk by Patil et al. (2022); Liet al. (2018) revealed its physicochemical and interfacial properties, swelling and hydration behavior, aggregation behavior, foaming, and phase separation behavior. Anton and Gandemer (1997) had also reported the excellent emulsifying properties and sensorial attributes of egg yolk. These characteristics of emulsion or foaming can be affected by surface hydrophobicity and solubility of proteins and also the processing conditions (composition, temperature, …). According to Liet al. (2018), the interfacial properties of egg yolk like foaming and emulsifying areassociated with the physicochemical properties such as surface tension, the pH, and the zeta potential (electrostatic) and processing conditions.

As for egg white, in addition to the nutritional valuesoftheirproteins, egg white possessessome great functional properties widely used in the Agrofood industry (Razi et al., 2023). The main techno-functional properties of egg whiteare gelling, foaming, and emulsifying. Egg white gelation property has several applications in egg technology and in various food products includingdessertsandpuddings. Foaming is an important parameter in the manufacture of cakes, bread, meringues, and cookies (Razi et al., 2023; Li et al., 2019).

Factors of egg quality variations

The characteristics of egg quality are affected by several factors. There are intrinsic factors: the genotype, the age of the hen (Ademola et al.; 2023; Barrett et al., 2019; Liu et al., 2018; Tůmová et al., 2007; Travel et al., 2011) and extrinsic factors: nutrition, the period of oviposition (Tůmová et al., 2007) the breeding mode and system, pathologies and storage and transport (Saleh et al., 2024; 2021; 2020; Tougan et al., 2021; Ledvinka et al., 2000; Leyendecker et al., 2001; Vits et al., 2005; Tůmová et al., 2007).

Genotype

Several studies have been undertaken to highlight the genetic determination for egg external and internal quality (Table 1 to table 9). Liu et al. (2018) and Hu et al. (2016) found that, there are currently 430 QTLs associated with egg quality in the avian resources QTL database.

Lordelo et al. (2020) found superior egg shape and Haugh unitin four native breeds of hen in Portugal comparatively to hybrid breeds. According to Alipanah et al. (2013), the heritability of albumen height, Haugh unit and egg weight were respectively 0.42,0.46, and 0.32 in brown-egg dwarf layers originating from 44 sires. Similar heritability of various egg quality traits in zhazak layers were also reported by Zhang et al. (2005).

In Rhode Island Red and White Leghorn hens, Bécot et al. (2023) had found heritability of egg weight and albumen height of 0.45, and 0.17; and of 0.24 and 0.23 respectively.

The genotype primarily affects the weight and shell of the egg. Several studies have shown heavier eggs in brown hens than in white hens (Ledvinka et al., 2000; Leyendecker et al., 2001; Vits et al., 2005; Travel et al., 2007; Travel et al., 2011). Egg shape index can also be affected by genotype (Ledvinka et al., 2000; Leyendecker et al., 2001; Vits et al., 2005; Tůmová et al., 2007). The quality of the eggshell is given by its weight, percentage, thickness and mechanical strength. The main differences in eggshell quality depend not only on the breeding method, but also on the genotype (Tůmová et al., 2007; Travel et al., 2011). However, Basmacioglu and Ergul (2005) report no significant effect of genotype on percentage and shell thickness. On the other hand, Ledvinka et al. (2000) reported that eggs from brown hens had a thicker eggshell than white hens, while Leyendecker et al. (2001) reported a thinner shell in brown eggs with a technological deformation of the eggshell of 35.7 mm in brown eggs versus 32.6 mm in white eggs. However, higher shell strength has been reported in white eggs (Ledvinka et al. 2000).

Leyendecker et al. (2001) showed a significantly higher yolk weight in hens with white eggs compared to the traditional Lohmann brown. Furthermore, the genotype significantly affects the yolk index (Tùmová et al., 2007).

Vits et al. (2005), Tůmová et al. (2007) and Travel et al. (2011) observed that hens of heavy lines lay eggs with a darker yellow than those of light lines. The quality characteristics of the albumen in this case the Haugh unit vary significantly by genotype (Tůmová et al., 2007).

Egg shell color is primarily determined by the genotype of the layingbird. In chicken species (Gallus gallus), hen with white feather lays white eggs whilebrown eggs are laid bybrown feathered laying hens (Jacob et al., 2000). During the egg shell formation, the color of the egg is determined bythe quantity of pigment in the cuticle (Butcher and Miles, 2003). Therefore, any factor which limits the ability of the laying birds to synthesize pigment will affect the egg shell color (Age of laying bird, Stress, avian Disease, avian drug, …).

Ademola et al. (2023) had undergone a study on egg production and egg qualitycharacteristics of Yoruba, Sussex, and Goliathchickens and their crossbred progenies under humid tropical climate. It appears from their study that eggparameters were significantly higher ($p < 0.05$) and maturity occurred earlier (154 days) in Yoruba Ecotype ChickenxSussexthan in Yoruba Ecotype ChickenxYoruba Ecotype Chicken (146 days), and other Yoruba Ecotype Chickencrosses. The study concluded that crossbreedingimproved the egg production of Yoruba Ecotype ChickeninNigeria.

Age of layingbird

The age of the birds influences the physical composition and quality of the eggs. The egg weight ranges from 45 to 75 g mainly with the laying hen age and secondarily with the genotype. The egg weight increases gradually during the production cycle but depend on the hen line in relation with its body weight. According to Beaumont et al. (2010) and Travel et al. (2010), the egg weight of young hen at 26 weeks reaches 60 g, tends to stabilize at 65 g from the 50^{th}weekandincrease toapproximately 68 g at the age of 20 months. Similarly, Barrett et al. (2019) reported a significant increase in egg weight between the first 2 weeks. Kraus et al. (2021) showed a progressive increase of egg weight with age in Czech golden spotted hens kept under cage production system. Important differences in egg weight, HaughUnit, and albumen pH between 26 and 51 weeks of age were reported byVlčková et al. (2019). Sirri et al. (2018) revealed an increase of egg weight and egg surface area in commercial poultry from 31 to 81 weeks.

Egg Shell shape index calculated as height/length of egg mainly increases with age of the bird (Travel et al., 2010; Nys2008). The brown eggShell color is reported to become lighter with the age of the laying hens. Defects in egg shell may be most observed in young hens at the beginning of the laying cycle. The rate of cracked eggs increases during the laying cycle (Nys2008).

Furthermore, the egg weight and the weight of the thick white increase during the laying cycle while the internal liquid white quality decrease. The Haugh unit that reflects average quality of albumen declines with the age of the laying bird (Quan et al., 2021) (Figure 1). A decrease in yolk membrane resistance from 2.33 to 1.92 g between the beginning and end of laying was observed by Curtis et al (2005). Kerth et al. (2005) observed that the age of hens reduces the emulsifying property of yolk with subsequently a loss in quality of albumen and shell.

Lukáš et al. (2008) showed that the weight of whole eggs, the weight and the proportion of the yolk increase with age regardless of the genotype of the hen. Baumgartner et al. (2007) reported a significant effect of age on egg weight in Leghorn-type hens. Suk and Parc (2001), Van den Brand et al. (2004), Tůmová and Ledvinka (2009) confirmed that the weight of the yolk and its percentage increase significantly with the age of the hens. According to Van den Brand et al. (2004) and Rizzi and Chiericato (2005), the percentage of albumen decreases with the age of the hens while the values of Haugh units increase with the age of the hens. Lukáš et al. (2008) reported that the percentage of eggshell declines with the age of hens regardless of genotype. However, Van den Brand et al. (2004), however, found no effect of age on eggshell thickness, but indicated that the egg shape index decreases with age. For Leyendecker et al. (2001), the intensity of eggshell color decreases with age regardless of genetic type. Odabasi et al. (2007), Tůmová and Ledvinka (2009) also reported a decrease in eggshell pigmentation with age. Eggshell traits can also be affected by interactions of age and race (Campo et al., 2007).

The moult

Moulting is a physiological natural phenomenon of plumage renewal in birds. This physiological phenomenon called moult is accompanied by a laying stop in the laying bird. In laying hens, changes in the egg composition (proportion of the egg compartments) are accentuated after moulting. The reduction of the white/yellow ratio is more important during the second production cycle. Moreover, the eggs of second laying are reported to be relatively richer in yolk. Albumin quality also improves after moulting but deteriorates more quickly during the second cycle (Sauveur 1988). Severalarticles show an improvement in egg shell quality after moulting, (Bell, 2003).

Extrinsicfactors

Feeding

Several studies have shown that diet influences the physicochemical composition and technological quality of eggs (Ledvinka et al., 2012; Sarica et al., 2008; Singh et al., 2009; Travel et al., 2011). The calcium content of the diet has an impact on the strength of the shell (Ledvinka et al., 2012; Travel et al., 2011). Coetzee (2002) found that South African laying hens supplied an additional 200 mg of calcium per litre of drinking water laid eggs with the best mean shell strength.

Nevertheless, it is also possible to act on the strength of the shells by reducing the concentration of chloride ions in the ration and by providing sulphates and bicarbonates as a replacement (Keshavarz et al., 2003) or by enriching the diet with diglycerides (Mabe et al., 2003). The favorable effects of the decrease in chlorine ions and the increase in sulfate ions are unfavorable to the white quality judged in Haugh Unit (Roberts and Ball, 2004). In addition, a moderate deficiency in lysine or methionine reduces the weight of the albumen (Bourre, 2005). Studies on methionine or lysine deficiency have confirmed a decrease in powdery mildew (Roberts and Ball, 2004). On the other hand, replacing starch with sucrose improves the proportion of yolk (Leclercq, 1971). It is the yolk coloring that remains the most sensitive to food intake. The nitrogenous elements of the ration intervene in the lowering of the protein level which is responsible both for the reduction in the weight of the eggs and especially the weight of the egg white (Keshavarz et al., 2003; Mabe et al., 2003; Roberts et al. Ball, 2004).

Zhang et al. (2021) found that vegetable oil adding into the diet of laying hens improve the quality of eggs. Nevertheless, oxidized lard use in the formulation of the diet reduced egg quality and altered the egg yolk microstructure.

A strong dietary overload of oleic acid does not affect the linoleic acid content of the egg much, but reduces that of saturated fatty acids (Bourre, 2005). Likewise, the enrichment of rations with polyunsaturated fatty acids increases the content of egg lipids in these acids and in cholesterol to the detriment of oleic, stearic and palmitic acids (Bourre, 2005).

Cottonseed oil causes an abnormal enrichment of the yolk in stearic acid, and modifies its physical and obviously nutritional properties (Bourre, 2005). The use of cottonseed meal can also cause unpleasant staining with the presence of mottling (Keshavarz et al., 2003; Mabe et al., 2003; Roberts and Ball, 2004).

The variations in the macro-mineral content of the egg are relatively small. Magnesium supplementation of the diet increases the content of white in this element. The same is true when supplementing with manganese, zinc, iodine and selenium, when the amount of iron is more stable (Keshavarz et al., 2003; Mabe et al., 2003; Roberts and Ball, 2004). Experimental alterations in the acid-base balance of the hen, induced by the incorporation of ammonium chloride in the ration also result in strong increases in transfer to the white of calcium, magnesium and chlorine at the expense of sodium and bicarbonate (Bourre, 2005).

Vitamins are certainly the part of the egg that is most prone to variations in response to food intake; this is particularly true for riboflavin and vitamin B12 and to a lesser extent the other vitamins of the B group (biotin, folic and pantothenic acids). The levels of carotenoids and fat-soluble vitamins in the yolk (A and D) reflect even more dietary intake (Keshavarz et al., 2003; Mabe et al., 2003; Roberts and Ball, 2004).

Production system

Several research findings have indicated the influence of production systems on external and internal egg quality and chemical composition (Tougan et al., 2021; Tougan et al., 2019; Hidalgo et al., 2008; Vlcková et al., 2019). According to Roshdy et al. (2010), this factor represents a significant non-genetic factorsinfluencingnot only egg quality but also birds' production capacity, behavioral, health, reproductive and productive parameters.

Laying avian resources are kept under different egg production systems around the world. The breeding system can affect the yolk color (CIE L* a* b*), physico-chemical composition and functional properties of egg. Yolk color may carefully be controlled by egg producers, since it strongly affects consumer's preference. The egg acceptability and desirability mainly depend on its appearance (Saleh et al., 2024; 2021; 2020). The determination of egg yolk color is generally carried out by photocolorimetric methodology based on the CIELAB system (Figure 2). Corn is a poultry feed ingredient widely used as a source of energy in laying hen diets. Despite it has a weak concentration of carotenoids compared to other foodstuff, it is considered a source of egg yolk pigmenting substances (Fassani et al., 2019).Kljak et al. (2021)found that laying hen fed with diet hybrid in carotenoids, presented the most important score of yolk yelowness(10.8) by using the coloring range scale.The study of Touganet al. (2021) on the physical traits, technological quality and proximate composition of eggs of Bonaparte guinea fowl of Benin reared with or without outdoor access showed significant different between yolk color with the best color intensity found in guinea fowl kept with outdoor grazing acces. Similarly, the results of the study of Tougan et al. (2019) on the influence of follar organic fertilizer Di Grow on the physicochemical and nutritional characteristics of Lohman Brown eggs reared inSokode (Togo) indicated that follar organic fertilizer Di Grow increase yolk color intensity and hue value.

Several studies have shown that apart from the technological and organoleptic quality of eggs, the physical composition of eggs is not affected by the production system. The fatty acid composition of eggs produced on a large scale is different from that of eggs produced on a small scale (Mabe et al., 2003; Roberts and Ball, 2004). The high density of the cages leads to a reduction in the weight of the eggs, an increase in the mortality rate and a degradation of the quality of the eggs with the corollary of the increase in the number of cracked or dirty eggs (Lakehal, 2006).

About the fattyacids composition of eggs, Anderson (2011) reportedthateggfromhensrearedunder free-range system maycontain more n-3 fattyacidsthaneggsproduced by battery-cagedbecause of the foragingbehavior of the chickens (Hidalgo et al., 2008). Chemical composition of egg can beaffected by rearing system changes (Vlčková et al., 2019). Eggsfromorganicrearingsystemcontainlower dry matter content, proteins content, and lipidscontentthanthoseproducedunder cage rearing system (Rakonjac et al., 2014).

Nevertheles, Hossainet al. (2024) foundthat the housing system did not significantlyaffect the chemical composition of eggyolkandegg white. Similarly, Matt et al. (2009), didn't findanysignificanteffect of breeding system (cage and floor-rearingsystems) on the fattyacid, protein, or dry matter content of eggswhile Dong et al. (2017) mentionedverylittleinfluence of production system on the quality of heneggs.

The oviposition time

Several studies have shown that eggs laid early in the morning are heavier than eggs laid later in the day (Ledvinka et al., 2002; Pavlovski et al., 2000; Tùmová and Ebeid, 2005). Likewise, some studies (Ledvinka et al., 2002; Pavlovski et al., 2000; Tùmová and Ebeid, 2005) have shown that eggs laid in the afternoon have better shell quality than morning eggs. The period of oviposition also influences yolk weight and albumen quality (Pavlovski et al., 2000; Tùmová and Ebeid, 2005).

Pathologies

Several avian pathologies affect the external and internal quality of eggs. Viral diseases affecting the reproductive system led to pale eggshells, while environmental constraints result in a higher density of spots (Butcher and Miles, 2003a). The effects of infectious bronchitis on egg quality are well known: decrease in pigmentation and shell strength, significant liquefaction of albumen, increase in the percentage of inclusions and the percentage of eggs with deformed shells (Butcher and Miles, 2003a; Cavanagh and Naqi, 2003; Jones, 2006).

When the shell is no longer intact, it promotes the penetration of various bacteria including Escherishia Coli and Salmonella (Cavanagh and Naqi, 2003; Jones, 2006). These living organisms can also affect the internal contents of the egg by deposition in the egg during its formation before the addition of the shell in the uterus (Okamura et al., 2001) and through invasion. through the pores of the shell during egg laying (Messens et al., 2005). Salmonella typhimurium and Heidelberg Salmonella (Hennessy et al., 2004) have also been implicated in human manifestations of salmonellosis due to consumption of eggs.

In general, avian pathologies, such as certain cases of egg drop syndrome, cause a significant decrease in the consistency of the albumen with the corollary of the decrease in the value of the Haugh Unit (Jacob et al., 2000). Newcastle disease and infectious bronchitis not only cause egg loss, but also affect the quality of the shell, which becomes abnormal and pale (Beyer, 2005; Butcher and Miles, 2003b).

Storage duration and condition

Freshness is an importantindicatorof egg quality. The conditions ofstorageinfluence the egginternal quality. Theegg quality characteristics are those that affect directly its

Acceptability and preference to the consumers (Rath et al., 2015). During the egg storage, some important changescan occur (an increase in the eggair cell, the flattening of the egg yolk, and the thinning ofthe egg white surrounding the yolk). The changes that occur in egg air cellsduringstorageare due toloss of moisture and the common pH increase from 7.6 to 9.7due tocarbondioxideescape. During this pH increase, eggalbumin loses its shape and flows easily and water movesfrom white to yolk and subsequentlyconcentration of fluid of egg yolk increases. Therefore, egg quality defects during storage are due to the water migration fromthickalbumen. The functional properties of eggs that are influenced byprocessing technics and conditions ofstorage should betaken into account to preserve the quality of frozen anddehydrated egg products (Fatenet al., 2023; Long et al., 2023; Soareset al., 2021).

Samli et al. (2005) observed in the study on the effects of storage time and temperature and their interaction on egg quality parameters as albumen size, Haugh unit, albumen pH and yolk, the density and size of the air cells were significantly influenced by storage time and temperature (Figure 3). According to the above-mentioned authors, the pH of the albumen is between 7.8 and 8.2 the day after laying and increases with the aging of the egg (Kim et al., 2024).HU value is calculated from egg weight (W) and albumen height (H), using the following equation described by Eisen et al (1962): **HU = 100 log (H – 1.7 $W^{0.37}$ + 7.6)**(Kim et al., 2024).

The pH value ofalbumen is one of most importanttechnologicalparametersof egg quality. The pH of fresh egg albumen ranges from 7.6 to 9.7. The pH of albumen increases significantly with the storage time, probably because of the evaporation of egg moisture and the release of CO_2 (Yimenu et al., 2017).

Environmental factors

Egg quality is greatly affected by environmental conditions including temperature, lighting cycle and season (Travel et al., 2011). High ambient temperature (> 30°C) elicits in hens changes in acido-basic balance and in feed consumption. These changes reduce egg production, egg weight and eggshell strength. Lighting programs applied during the rearing and production periods of hens influence egg production (Travel et al., 2011).Great temperatures can lead to heat stress which promote a decrease in egg qualityandproduction. Moreover, moisture content of eggs can be affected by great humidity levels. This factorand can lead on bacterial growth in the eggs.

Table 1:- Chemical Composition of edible parts of a chickenegg of 60 g.

Variables	**Weight in g per egg**			**Content in g/100 g of eachegg part**		
	Entire	**White**	**Yolk**	**Entire**	**White**	**Yolk**
Weight	53.5 – 55	35 – 37	17 - 18.5	100	100	100
Water content	39.5 - 41.5	30 – 33	8.0 - 9.2	74.0 - 75.5	87 - 89	46.5 - 49
Dry matter content	13 - 14.3	3.8 - 4.5	8.7 - 10	24.5 - 26	11.0 - 13	51.0 - 53.5
Protein content	6.4 - 7	3.3 - 4	2.7 - 3.2	12.0 - 12.8	9.5 - 11.5	16 - 17
Fat content	6.1 - 6.9	--	6.0 - 6.8	11.8 - 12.3	--	33 - 34
Saturatedfattyacid	2.3 - 2.5	--	2.1- 2.4	4.3 - 4.5	--	11.2 - 11.7
Unsaturatedfattyacid	3.5 - 4	--	3.3 - 3.8	6.7 - 7.0	--	18.2 - 19
Cholesterol content	0.24 - 0.27	--	0.24 - 0.27	0.47 - 0.5	--	1.31 - 1.38
Carbohydrate content	0.15 - 0.20	0.12 - 0.16	0.03 - 0.05	0.3 - 0.4	0.4 - 0.5	0.15 - 0.25
Ash content	0.45 - 0.55	0.16 - 0.24	0.2 -0.3	0.8 - 1.0	0.5 - 0.7	1.1 - 1.6

-- : Traces

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 2:-Weightofegg components (Yolk, White, Shell) of differentavianspecies.

Species	Egg weight	Yolk weight	White weight	Shell weight
Hen	51.5 ± 0.43	11.8 ± 0.37	35.1 ± 0.39	5.2 ± 0.16
Faisan	25.79 ± 2.17	9.31 ± 1.05	14.34 ± 1.10	2.22 ± 0.39
Partridge	19.16 ± 1.17	6.52 ± 0.95	10.97 ± 0.61	1.67 ± 0.22
Quail	10.34 ± 0.93	3.25 ± 0.40	6.33 ± 0.59	0.76 ± 0.01
Guineafowl	46.65 ± 1.79	14.26 ± 0.74	26.08 ± 0.92	6.31 ± 0.65
Turkey	76.25 ± 0.74	21.67 ± 0.27	43.31 ± 0.46	13.9 ± 0.14
Duck	67.59 ± 0.46	20.70 ± 0.34	30.28 ± 0.46	9.46 ± 0.16

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 3:-Shape index of egg of differentavianspecies.

Species	Height (mm)	Length (mm)	Shape Index (Height/Length × 100)
Hen	38 ± 0.02	51 ± 0.04	77.2 ±0.66
Faisan	33.65 ± 0.93	42.30 ± 1.57	79.63 ± 2.78
Partridge	30.21 ± 0.43	39.23 ± 1.85	77.30 ± 3.32
Quail	24.62 ± 0.96	31.30 ± 1.05	78.93 ± 3.75
Guineafowl	40.18 ± 0.77	50.53 ± 1.25	79.57 ± 2.71
Turkey	48.1 ± 0.57	61.35 ± 1.75	78.23 ± 2.15
Duck	40.54 ± 1.23	52.06 ± 1.65	77.87 ± 2.19

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 4:-Proportion of egg components (Yolk, White, Shell) of differentavianspecies.

Espèces	Proportion du jaune	Proportion du blanc	Proportion de la coquille	Proportion du jaune / Proportion du blanc
Hen	22.6 ± 0.62	67.2 ± 0.65	10.1 ± 0.25	0.35 ± 0.09
Faisan	35.7 ± 2.34	55.6 ± 2.55	8.7 ± 0.94	0.65 ± 0.07
Partridge	33.9 ± 3.60	57.4 ± 3.87	8.7 ± 0.72	0.60 ± 0.10
Quail	31.4 ± 1.98	61.2 ± 2.32	7.3 ± 0.69	0.52 ± 0.05
Guineafowl	30.6 ± 0.75	55.9 ± 1.54	13.5 ± 1.07	0.55 ± 0.02
Turkey	28.41 ± 0.46	56.8 ± 0.31	18.22 ± 0.43	0.5 ± 0.03

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 5:-Shell traits of egg of differentavianspecies.

Espèces	Epaisseur de la coquille (μm)	Surfaces (cm^2)
Hen	350 ± 21	73.52 ± 2.8
Faisan	241.5 ± 35.0	47.31 ± 9.12
Partridge	231.8 ± 31.7	40.16 ± 1.87
Quail	174.8 ± 15.5	25.97 ± 1.50
Guineafowl	462.8 ± 39.1	73.13 ± 1.90
Turkey	510.2 ± 31.7	85.95 ± 1.67
Duck	370.15 ± 12.3	81.52 ± 3.83

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 6:-Internalquality of egg of differentavianspecies.

Espèces	Indice du jaune	Epaisseur du Blanc (mm)	Haugh unit
Hen	0.51 ± 1.12	7.19 ± 0.16	87 ± 1.02
Faisan	0.46 ± 0.03	4.46 ± 0.15	79.64 ± 1.23
Partridge	0.48 ± 0.02	4.04 ± 0.40	80.27 ± 2.02
Quail	0.46 ± 0.05	3.50 ± 0.67	84.19 ± 4.91
Guineafowl	0.53 ± 0.03	5.74 ± 0.42	80.87 ± 3.14
Turkey	0.46± 0.007	7.61± 0.28	92.22± 0.41
Duck	0.46 ± 0.04	4.90 ± 0.13	75.95± 1.32

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 7:-ChemicalComposition of eggofdifferentavianspecies.

Species	Moisture content (g/100g)	Protein content (g/100g)	Fat content (g/100g)	Ash content (g/100g)
Hen	74.25 ± 0.41	12.8 ± 0.48	11.8 ± 0.45	0.9 ± 0.10
Faisan	74.27 ± 0.59	12.77 ± 0.56	10.90 ± 0.72	1.06 ± 0.18
Partridge	74.50 ± 0.73	12.60 ± 0.72	11.00 ± 0.46	1.02 ± 0.10
Quail	74.26 ± 0.45	11.98 ± 0.58	11.91 ± 0.65	1.04 ± 0.12
Guineafowl	74.47 ± 0.43	12.77 ± 0.38	10.83 ± 0.75	1.10 ± 0.18
Turkey	75.72 ± 0.05	13.05 ± 0.09	12.16 ± 0.2	0.86 ± 0.04
Duck	72.19± 0.32	15.54± 3.73	4.49± 0.02	1.28± 0.13

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 8:-ChemicalComposition of eggwhite of five differentavianspecies.

Species	Moisture content (g/100g)	Protein content (g/100g)	Fat content (g/100g)	Ash content (g/100g)
Hen	88.5 ± 0.42	10.5± 0.54	0.09 ± 0.08	0.5± 0.02
Faisan	87.99 ± 0.52	10.20 ± 0.43	0.10 ± 0.03	0.83 ± 0.11
Partridge	87.85 ± 0.61	10.15 ± 0.44	0.12 ± 0.05	0.82 ± 0.07
Quail	87.82 ± 0.55	10.39 ± 0.50	0.09 ± 0.03	1.00 ± 0.11
Guineafowl	87.46 ± 0.84	10.61 ± 0.56	0.13 ± 0.04	0.79 ± 0.10

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

Table 9:-ChemicalComposition ofeggyolkofdifferentavianspecies.

Species	Moisture content (g/100g)	Protein content (g/100g)	Fat content (g/100g)	Ash content (g/100g)
Hen	47.5 ± 0.58	17.4 ± 0.8	33.0 ± 0.98	1.1 ± 0.18
Faisan	50.42 ± 1. 47	15.49 ± 0.68	31.71 ± 1.26	1.53 ± 0.21
Partridge	50.37 ± 1.03	15.12 ± 0.65	32.32 ± 0.95	1.57 ± 0.41
Quail	49.71 ± 0.55	15.99 ± 0.19	31.48 ± 0.76	1.79 ± 0.38
Guineafowl	49.80 ± 1.11	15.74 ± 0.55	31.91 ± 0.90	1.86 ± 0.35

Source : Adaptedfrom the findings of Tougan etal. (2021) ; Mopera et al. (2021) ; Bondoc et al., 2021 : Barik and Nayak (2020) ; Tougan etal. (2019) ; Lakehal, 2006 ; Ledvinkaet al. (2000) ; Leyendeckeret al. (2001) ; Song etal. (2010) ; Tůmováet al. (2007) ; Vits et al. (2005).

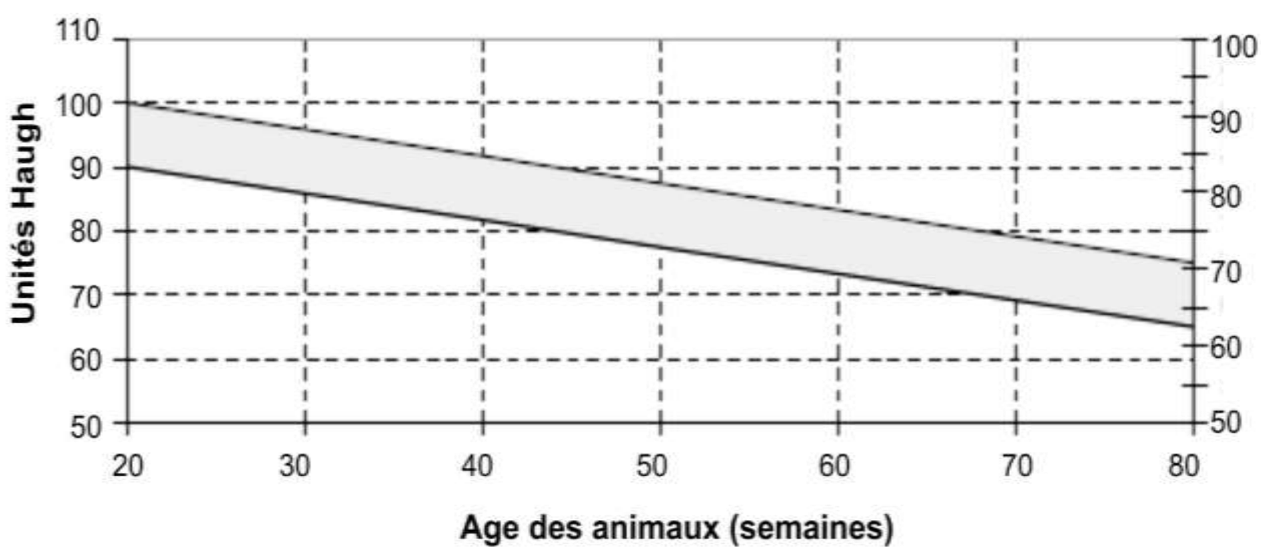

Figure 1:-Effect of chickenage on the Haughunits of egg (ADAS 1989).

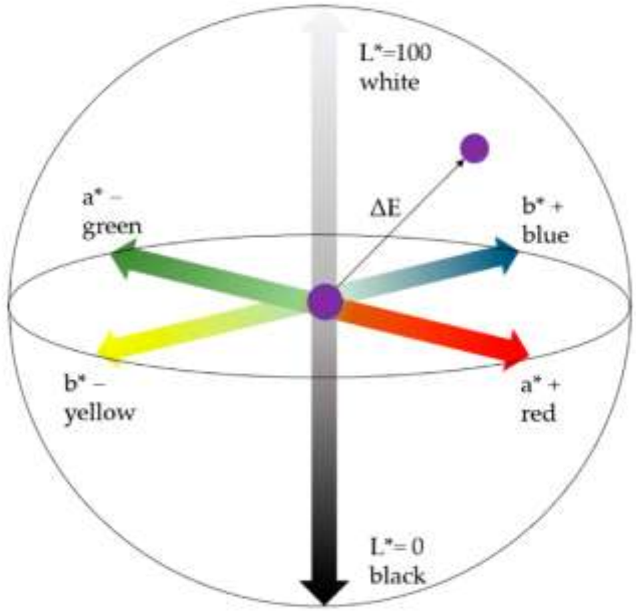

Figure 2:- Graphic diagram of the quantitative coordinatesused for color(CIE L* a* b*) determination.

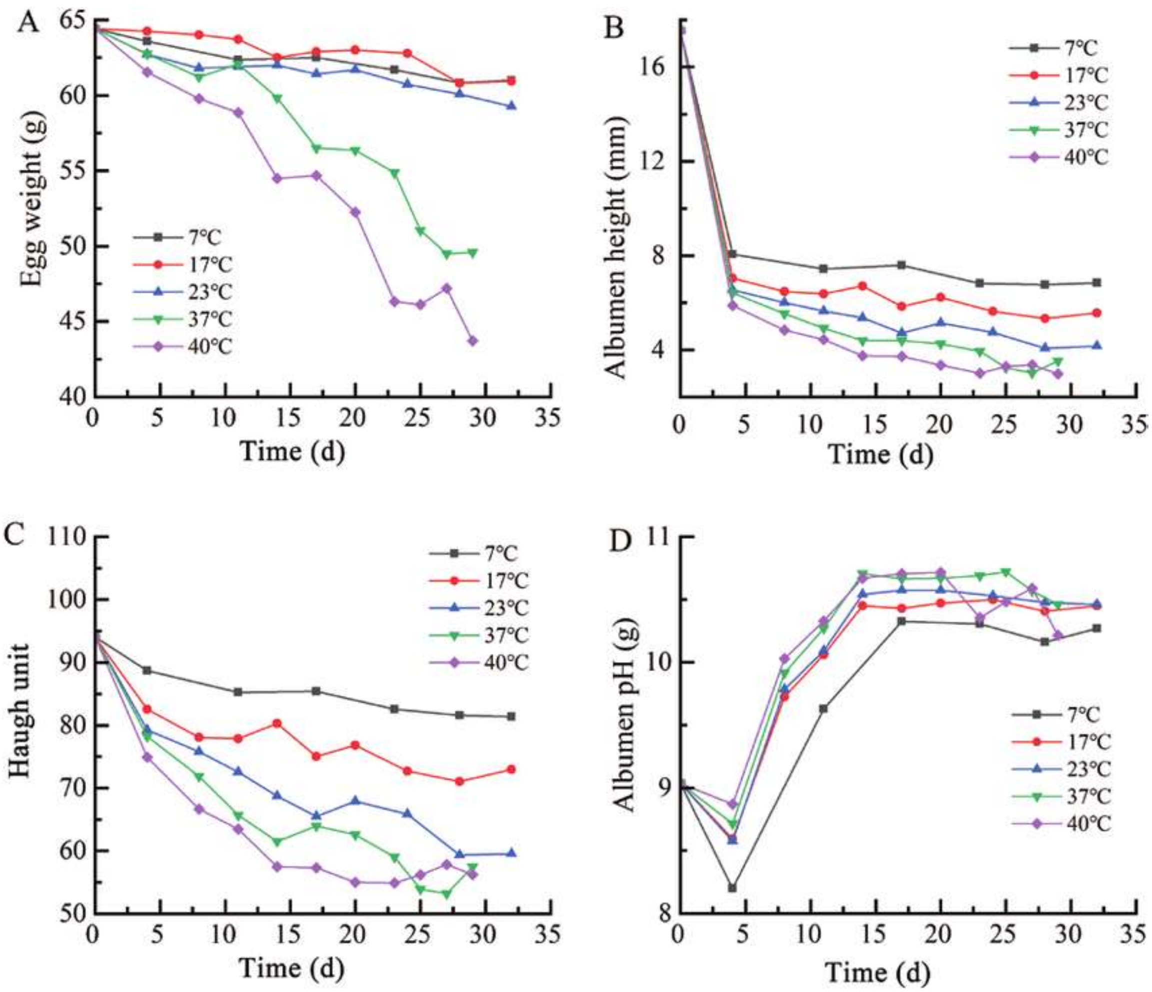

Figure 3:- Evolution of egg quality indicators over time, under different temperatures. A: egg weight; B: albumen height; C: Haugh unit; D: albumen pH. (Quan et al., 2021).

Conclusion:-

The egg quality can be affected by several factors of both intrinsic (species, strain, line, breed, age of the bird, stage of laying cycle) and extrinsic such as feeding; production and management system, environmental and micro-climate parameters, storage condition and transport. Egg producer and egg products industries have to apply good hygiene practices during egg production, handling and processing. Egg quality must be evaluated before processing. Water loss from the egg white through the pores of shell, the air cell expansion, the flattening of the egg yolk and the thinning of the egg white are signs of egg deterioration.

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Competing Interests

The authors declare that they have no conflict of interest.

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