SUMMARY

Eggs are a natural aliment with superior nutritional qualities, acknowledged as an important source of protein of the best quality. This poultry product can be used by itself or can be transformed into the so-called "egg derivates", such as egg powder (from mélange, egg white or egg yolk) and refrigerated or congealed liquid products (mélange or separate components).

As years passed, many efforts have been made with the aim of prolonging the shelf life of eggs, without depreciating their edible qualities.

Preserving eggs by refrigeration ensures the maintenance of their initial qualities for a long time, but provided that several physical stocking factors are respected.

Sometimes, this type of depositing is adopted at higher temperatures (for economic reasons) and without ensuring adequate humidity, which triggers the acceleration of the biochemical processes taking place inside the egg, associated with the decrease of the nutritional value and the increase of the risk of microbial contamination. What is worse is that sometimes, eggs are exposed for sale under completely inadequate conditions, with much more severe consequences on their salubriousness.

Although products derived from eggs (egg powder and refrigerated/congealed products) have a much longer shelf life compared to that of refrigerated eggs, their quality can decrease during storage, from various causes (low quality of the raw materials, ignoring the standards for the fabrication technology, inadequate packing, improper storage conditions etc).

On the aforementioned grounds, the Ph. D. thesis bearing the title ***„Research on the influence of preservation methods over the quality of hen eggs destined for consumption"*** was meant to study the way in which the preservation technique and storage conditions influenced the quality of hen eggs.

The general organization plan of the proposed research was conceived for four series of experiences, as following:

I-st series of experiences ***„Evolution of qualitative parameters in hen eggs (with brown shell) preserved by refrigeration"*** was organized for three batches of eggs (Lc-1, Lexp-1 and Lexp-2), distinguished one by another by the level of microclimate factors during the 91 days of storage:

- **Batch Lc-1**: eggs stored at the temperature of +4ºC and relative air humidity of 90%;

- **Batch Lexp-1**: eggs stored at the temperature of +6ºC and relative air humidity of 65%;
- **Batch Lexp – 2**: eggs stored at temperatures between +22 … +32ºC and relative air humidities between 50…70%.

II-nd series of experiences ***„Evolution of qualitative parameters in hen eggs (white shell) preserved by refrigeration"*** took into consideration the same experimental factors and number of eggs (200 pcs/batch), with the sole difference being that the three experience batches (Lc-2, Lexp-3 and Lexp-4) consisted of eggs with white shell (Lohmann White hybrid):

- **Batch Lc – 2** eggs stored at the temperature of +4ºC and relative air humidity of 90%;
- **Batch Lexp – 3:** eggs stored at the temperature of +6ºC and relative air humidity of 65%;
- **Batch Lexp – 4:** eggs stored at temperatures between +22 … +32ºC and relative air humidities between 50…70%.

The III-rd series of experiences: ***„Evolution of qualitative parameters in hen eggs preserved by congealing (integral mélange)"*** was organized for three experimental batches (Lc-3, Lexp-5, Lexp-6) distinguished one by another by the technique employed for obtaining the mélange and the temperature during the 12 months of storage:

- **Batch Lc-3**: pasteurized and rapidly congealed at -20°C melange; stored at -18°C;
- **Batch Lexp-5**: unpasteurized and rapidly congealed at -20°C melange; stored at -18°C;
- **Batch Lexp-6**: unpasteurized and rapidly congealed at -20°C melange; stored at -10°C.

IV-th series of experiences: ***„Evolution of qualitative parameters in hen eggs preserved by drying (egg powder)"*** was organized for three batches (Lc-4, Lexp-7, Lexp-8), distinguished one by another by the packaging method of the egg powder and storage conditions during the 12 months of storage:

- **Batch Lc-4**: whole egg powder, packed in polyethilene bags; stored in refrigeration conditions (t = +4°C and R.H. = 80%);
- **Batch Lexp-7**: whole egg powder, packed in polyethilene bags; stored at room temperature (t = +22 … +32°C and R.H. = 50 …. 70%);
- **Batch Lexp-8**: whole egg powder, packed in paper bags; stored at room temperature (t = +22 … +32°C and R.H. = 50 … 70%).

The materials studied in this Ph. D. thesis (eggs for consumption, whole mélange and egg powder) originated from production units (S.C. CONDOR S.A; S.C. AGRIMOND S.R.L and S.C. AGRICOLA INTERNATIONAL S.A Bacău), and specific qualitative analyses were performed in laboratories of institutions specialized in poultry research and food quality control (Faculty of Animal Breeding of Iasi; Unité de Recherches Avicoles, Tours - France; Sanitary Veterinary and Food Safety Direction of Galaţi).

The first series of experiences was performed on a total count of 200 eggs with brown shell obtained from the egg-laying hybrid Lohmann Brown. Eggs were taken directly from a production

unit, in the very day of laying, submitted to a very rigorous initial sorting (by weight, form and integrity of the mineral shell; only eggs with clean shells were taken), in order to avoid the influence of factors different from the experimental ones.

Obtained data regarding egg weight showed that this decreased during the 91 days of storage, the greatest weight losses (26,024 %) recorded in eggs stored at temperatures of +22 ... +32^{o}C and humidities of 50 …70% (batch Lexp-2), compared to only 11,674 % in eggs from the Lexp-1 batch (stored at the temperature of +6^{o}C and relative humidity of 65%) and especially 4,085 % in eggs stored at the temperature of +4^{o}C and relative humidity of 90% (batch Lc-1).

Predictably, in the same Lexp-2 batch were also found the lowest levels of specific weight, 18,6 % lower than in fresh eggs, but also the highest height of the egg chamber (19,43 mm after 91 storage days, compared to only 3,36 mm in fresh eggs).

Eggs stored in the ambient environment (batch Lexp-2) also recorded significant decreases of the egg white index (from 1,152 initially in fresh eggs, to only 0,0092 in those aged 91 days), egg yolk index (from 0,443, to only 0,215) and especially of the Haugh index (91,214 in fresh eggs and only 9,314 in those aged 91 days).

Weight losses in eggs occurred due to gradual evaporation of the contained water, but with different paces, depending on the storage conditions. Thus, in eggs stored in conditions of long time refrigeration (Lc-1), the water amount at the end of the experience was only 2,61 lower compared to that from fresh eggs, while in eggs from the Lexp-1 batch (short refrigeration time) water losses were up to 8,22 %, and in those stored in ambient conditions (batch Lexp-2), up to 20,22 %; the increase of dry substance in the egg white had the same amount.

The components of the dry matter from the egg white (proteins, fats, trace elements and macroelements) did not present any quantitative modifications under the action of the experimental factors.

In the case of egg yolk from eggs studied in these experiments a slight increase of the water amount was found (0,16% in batch Lc-1, 0,19% in batch Lexp-1 and 0,29% in batch Lexp-2), due to water diffusion from the egg white, under the influence of storage physical factors.

Although the dry matter amount decreased towards the end of the experiment (proportionally to the increase of water amount) lipids, fats and mineral substances maintained at a constant level during storage, confirming their character of highly stable chemical elements, placed outside the influence of exogenous factors.

The destructive effect of low temperatures over the multiplication rate of germs was obvious in eggs from the Lc-1 batch, where the TMAGC on the mineral shell increased by only 16,50 % during the 91 days of storage compared to 59,89% in batch Lexp-1 and especially 181,58 % in batch Lexp-2, with eggs stored in the ambient environment.

The microbian load in mélange of studied eggs also recorded increases under the influence of the experimental factors, being 6,9 ufc/g greater in batch Lc-1, 9,99 ufc/g greater in batch Lexp-1 and 16,96 ufc/g greater in Lexp-2.

None of the analyzed situations implied the presence of Salmonella bacteria.

The same egg count was used for the IInd series of experiments (200 buc.), harvested in the same conditions as the previous series of experiments, with the difference being that they originated from the Lohmann White egg laying hybrid, presenting white shell.

Though the studied eggs were stored in the same conditions as the previous series, the greater number of pores on the mineral shell generated a more severe depreciation of physical indicators of quality and higher loss of the contained water.

Weight losses in eggs were influenced by storage conditions, reaching only 5,467% in the Lc-2 batch (storage at temperature of +4°C and humidity of 90%), 12,21% in batch Lexp-3 (storage at the temperature of +6 and humidity of 65%) and 12,21% in batch Lexp-4 (storage at temperatures of +22 …+32°C and humidities of 50 …70%).

In comparison to fresh eggs, the air chamber height determined in the last day of the experiment (day 91) was 5,11 mm greater in batch Lc-2, 9,14 mm greater in batch Lexp-3 and 17,27 mm greater in eggs from batch Lexp-4.

Specific weight, egg white index and egg yolk index recorded gradual decreases during the experiment, but were more significant in the Lexp-3 batch and especially in batch Lexp-4, when stored at room temperature. As for the Haugh index, it presented the most radical decreases compared to fresh eggs, with 29,32 UH in batch Lc-2, 51,60 UH in batch Lexp-3 and 83,20 UH in batch Lexp-4.

In the case of egg white, the water amount decreased over the storage time, depending on the degree of adequacy of microclimate factors (2,58% in batch Lc-2, 8,6% in batch Lexp-3 and 20,41% in batch Lexp-4), which determined proportional increases of the dry substance content. Proteins, lipids and minerals were not highlighted to have suffered any significant modifications during storage.

Chemical analyses performed on egg yolk highlighted a slight decrease of the water content (0,09% in batch Lc-2, 0,11% in batch Lexp-3 and 0,19% in batch Lexp-4), correlated to the quantitative decrease of dry substance. The components of dry substance (proteins, lipids and minerals) stayed at constant levels during storage, without being influenced by experimental factors.

The determination of the total aerobic mesophilic germ count on egg shells presented increases during storage, by 180,77% in batch Lexp-4 (storage at temperatures of +22 …+32°C and relative humidities of 50 …70%), 60,55% in batch Lexp-3 (storage at the temperature of +6°C and humidity of 65%) and only 22,75% in batch Lc-2 (storage at the temperature of +4°C and humidity of 90%). The same was found when determining the TMAGC within the eggs, for

which levels greater by 46,12 – 102,06% were found in experimental batches (Lexp-3 and Lexp-4), in comparison to eggs stored in conditions of classic refrigeration (batch Lc-2).

Bacteria belonging to the Salmonella genus were not identified neither in eggs with white shell.

The III-rd series of experiences was performed on a natural proportion egg melange subjected to a fast congealing process at -20°C, in conformity to the technology applied in the Liquid product factory belonging to S.C. AGRIMOND S.R.L. Brăila. Samples forming the Lc-3 batch were subjected (before freezing) to pasteurization at temperatures between +64…+65°C, for five minutes.

The following conclusions were drawn following qualitative determinations on frozen egg melange:

Organoleptic indexes of quality wre influenced by experimental factors (storage temperature), but also by the treatment applied prior to freezing (pasteurization). Melange stored at temperatures of -18°C (Lc-3 and Lexp-5), both pasteurized and unpasteurized, did not suffer organoleptic modifications over the experience. The melange consisting of the Lexp-6 batch (unpasteurized and stored at -10°C) began to present external modifications starting with the 120th day, followed by modifications in consistence, color, taste and smell.

The pH values recorded statistically significant differences from the very first control, due to the pasteurization process applied to the egg melange which constituted batch Lc-3. Thus, in the first day, average values were 6,842±0,04 in batch Lc-3, 7,436±0,02 in batch Lexp-5 and 7,374±0,02 in batch Lexp-6, increasing to the end of the determinations by 0,32% in batch Lc-3, 0,27% in batch Lexp-5 and 35,88% in batch Lexp-6.

Analyzed main chemical indicators (water, dry substance, proteins, fats and mineral compounds) did not record any modifications during the 360 days of storage, whence it is deduced that storing the products in congealed state maintains initial product composition intact.

Determinations for the TMAGC in melange highlighted that, in products pasteurized before storing in freezing conditions (batch Lc-3), values were null in the fresh product, as well as the product stored for 360 days. In batches Lexp-5 and Lexp-6 (consisting of unpasteurized melange) colonies were identified only at the beginning of the experiments (day 0), because during storage, aerobic mesophilic germs were destroyed by the applied preserving process (freezing).

Regarding the identification of staphylococci and bacteria belonging to the Salmonella genus, it can be mentioned that none of these were present in any of the three realized dilutions.

The studied product in the IVth series of experiences was represented by whole egg powder (egg white and egg yolk in natural proportion), originating from the Egg powder factory belonging to AGRICOLA INTERNAȚIONAL S.A. Bacău.

From the 39 acquired kilos of the product, 26 kg were packed in polyethylene bags (1 kg/bag), and 13 kg in paper bags (1 kg/bag).

At the first control carried with the aim of determining organoleptic indexes (day 0), all three analyzed batches received maximum score, situation present until the 90th day of storage, when the product that formed the base of the Lexp-8 batch (egg powder packed in paper bags and stored at temperatures of +22 …+32°C and humidities of 50…70%) presented the first aspect and consistence modifications (unstable agglomerations), which became prominent (stable agglomerations), accompanied by color modifications and the presence of rancid taste and odor (from the 270th day of storage).

In batch Lexp-7, aspect and consistence modifications (unstable agglomerations followed by stable ones) were found only in the 210th day of storage, while batch Lc-4 presented the same type of depreciation only after 300 days of storage.

Compared to pH values recorded in the fresh products (day 0), the ones determined at the end of the 360 days of storage were greater by 5,54% in egg powder samples forming the Lc-4 batch (packed in polyethylene bags and stored by refrigeration), by 13,37% in batch Lexp-7 (packed in polyethylene bags and stored in the ambient environment) and by 14,59% in batch Lexp-8 (packed in paper bags and stored at room temperature).

Regarding whole egg powder solubility, values obtained at the end of storage highlighted less or more significant modifications under the action of experimental factors, with a decrease of 3,10% in batch Lc-4, 25,66% in batch Lexp-7 and 31,94% in batch Lexp-8, in comparison to levels determined in the fresh product.

Experimental factors (package type and storage conditions) affected only the water content of the product and, implicitly, the dry substance content, without inducing any modifications of the components (proteins, fats, mineral substances).

Thus, for example, the product water content at the end of the 360 days of storage was greater than the determined content at the beginning (day 0) by only 0,09% in batch Lc-4, compared to 0,57% in batch Lexp-7 and 1,76% in batch Lexp-8. Naturally, the dry substance content in the analyzed egg powder recorded decreased values, proportionally to the water content increase.

Regarding the total mesophilic aerobic germ count in the studied egg powder, it can be mentioned that the packing modality as well as microclimate factors granted during storage determined increases in values from a control stage to another. Thus, in batch Lc-4, in the first control day the number was that of 1,47±0,01 cfu/g, and at the final determination it was 1,62±0,01 cfu/g, meaning 10,20% higher. In batch Lexp-7, the initial load was 1,48±0,04 cfu/g, reaching a value 35, 81% higher than the initial one (2,01±0,03 cfu/g) at the final determination. Greatest increases were found in batch Lexp-8, meaning 88,51%, given the initial load of 1,48±0,03 cfu/g

and the final one of 2,79±0,06 cfu/g.

Neither staphylococci, nor bacteria of the Salmonella genus were found in the three dilutions prepared for identification.

Obtained results following the performed investigations allowed us to formulate a few recommendations regarding the preservation of eggs destined for public consumption:

- Storage of whole eggs only by refrigeration, at the temperature of +4°C and relative air humidity of 90%; in such conditions, qualitative parameters of eggs stay at levels similar to those encountered in the fresh product, and the multiplication rate of contamination microorganisms is considerably reduced;
- Mandatory pasteurization (at temperatures of +64…+65°C, for 5 minutes) of raw materials destined for obtaining frozen egg mélange and storage of the finite product at the temperature of -18°C;
- Adequate packing of the egg powder (polyethylene bags, hermetically sealed) and storage by refrigeration (at the temperature of +4°C and relative air humidity of 90%), especially in situations when the content of a package is not used completely.

The recommendations regard only the application of preserving techniques studied by us, because the consumer market is the one that imposes the form under which eggs shall be purchased (refrigerated, frozen or dehydrated).

Therefore, the profile industry will have to adopt the optimal egg preservation method that will satisfy the consumers' demands, but conditioned by respecting the food safety desiderate and maintaining the initial trophic-biologic qualities.