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The effect of production mode and market conditions on the quality of eggs in Yugoslavia

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I. – Introduction

There are a number of definitions which endeavour to more closely designate and explain the quality of goods, eggs inclusive. Amarine et al. (1965) claim quality to be a set of properties which may differ among units of a product, but have an established degree of acceptability of the unit by the consumer. Spackman (1987) quoted the Oxford English Dictionary definition of quality meaning that it represents a degree of excellence of a product.

Webb (1987) maintains that quality may be subject to individual perception based on the reception of stimuli by the five senses. Belyavin et al. (1987) asserted that the concept of egg quality should now take into account both internal and external egg characteristics. A strong shell of sound colour and structure is as important as a healthy coloured yolk and a strong firm albumen.

Since customers are the last and most important link in the chain of consumable egg production and are, to the greatest extent, a measure of successful production, it may be safely concluded that a good egg is one preferred by the customer.

Similar to any other article, consumable eggs are subject to the rule that faster development of science and technology provides for plentiful supply to meet the customer's demand. However, the customers demand for quality can never be met in its entirety. Therefore, all investigations of various factors affecting the quality of consumable eggs are relevant and justified as they may be significant for the production of consumable eggs aimed at improving the quality and supply of this foodstuff which occupies such an important place in human nutrition.

Each hen of any provenance which is laying consumable eggs, lays optimum quality eggs. This means that the egg is at its best immediately upon being laid, regardless of whether its quality is satisfactory or not (Stadelman and Cotteril, 1973 ; Skala and Swanson, 1962 ; Baker and Vadehra, 1970 ; Pavlovski, 1986).

The quality of consumable eggs available at the market is affected by a number of factors, such as race or hybrid, the mode of keeping and dieting, the age and health of the hen, the handling of eggs and the conditions of production, transportation and selling as well as the season of the year, etc... A permanent quality control of eggs is therefore imperative throughout the producer-consumer cycle to improve or at least maintain quality at an acceptable level. Quality control is an essential part of marketing any product and may be described as maintenance of certain properties of the article at a level accepted by consumers (Overfield, 1987).

External and internal egg characteristics that are essential to consumable quality have been investigated from various aspects, both in Yugoslavia (Žigić et al., 1967 ; 1970 ; Milovanović et al., 1976 ; Kralik, 1978;

Pavlovski et al., 1981, 1983, 1984 ; Mašić and Pavlovski, 1984 ; Pavlovski and Mašić, 1986) and abroad (Romanoff and Romanoff, 1949 ; Carter, 1968 ; Overfield, 1970 ; Wells, 1968).

The quality of eggs is affected by numerous factors, but due to limited space we shall only comment on those related to the mode of production, transportation and marketing conditions, based on results obtained from our investigations in Yugoslavia over the past two decades.

II. – Effects of the mode of production

In recent years intensive egg production (cage system) has become the principal source of supply to cities, industrial areas, touristic centres and the like. However, in countries with extensive (free range system) production, consumers are still exposed to the eternal dilemma : free range eggs have better quality ? Although the majority of consumers (70.6%) interviewed (Mašić and Pavlovski, 1984) claimed to accept a cage egg, a number of customers preferred eggs produced in free range systems.

Beginning in 1967, some researchers started investigating eggs produced in both cage and extensive free range systems. They explored external and internal properties relevant for the quality of eggs that originate from a typical cage production system and those from free range, being a system prevailing in Yugoslavia. Their results are presented in **Table 1.** Based on these results it may be safely concluded that free range eggs have less mass and lower shape index (except for the results obtained by Pavlovski *et al.*, 1981), while shell colour does not show any significant differences. However, other investigations have shown that free range eggs have greater albumen height (number of Haugh units, HU) and yolk index and remarkably pronounced colour of the yolk.

Incidence of AA quality (the quality considered superior by the USA standards) is more frequent in free range eggs. Shell thickness, as found by Pavlovski (1982), Pavlovski and Mašić (1986), was lower in these eggs, opposite to the findings of Zigić *et al.* (1974) and Pavlovski *et al.* (1981). The investigations included measurement of shell deformation (Zigić *et al.*, 1967, 1974 ; Pavlovski *et al.*, 1981) which is yet another indicator of shell thickness, thus leading to the conclusion that the free range egg had stronger shell.

The differences observed between the cited investigations may have resulted from rapid development in the field of poultry nutrition that directly affected the increasing thickness of shells and, probably, from the lack of limestone in the soil where the hens were kept, thus reducing their calcium supply.

The incidence of meat and blood spots was not markedly different in either system. Therefore, it is safe to assume that the spots occur incidentally and are not the result of the mode of keeping.

The results of research carried out for almost two decades lead to the conclusion that the mode of production (cage system, free range) considerably affects the quality of eggs and, specifically, the internal egg properties demonstrated by the height of albumen and HU number and the colour of yolk in particular. This means that eggs produced in the free range system have significantly better internal performance.

These data differ from the results of Hughes (1984, 1985), probably due to free range not being identical in Great Britain and Yugoslavia.

Apart from the system of keeping used, both external and internal egg properties are certainly subject to the actual use of production technology, this being further related to the person in charge.

Table 2 presents egg quality features in different production stages (Pavlovski and Mašić, unpublished).

The data shown are the results of a continuous evaluation of egg quality that was carried out throughout a production cycle (from 22 to 68-72 weeks of hen age). The control was performed at the end of each third week and covered 17 producers from the Valjevo region. The hens were of the same genetic origin, the feedstuffs originated from the same source, and the production buildings were typical, although at different locations. **Table 2** shows the average values of egg mass, yolk colour, Haugh units and shell thickness for only three phases of production (P : hens 25 weeks of age ; S : 42-45 weeks ; K : 68-72 weeks).

Based on these results a great variation of individual features may be observed among the producers. Particularly important are differences in number of Haugh units (from 80.48 to 80.50 HU). Naturally, a number of other factors may have been involved (water, food), but it is certain that each producer had his personal imprint on the production.

The literature recognizes that elder laying hens lay eggs of inferior quality whereas younger ones provide better grades, and that the age ranging from 30 to 52 weeks ensures that quality would be at the acceptable level (80 HU).

The data presented indicate that with the majority of producers hens lay eggs with a high number of Haugh units (good quality) at the end of the production cycle (68-72 weeks of age), while there are some producers who failed for reasons so far unexplained. However, it is certain that each individual mode of production affects the quality of eggs.

III. – Effects of market conditions

Our recent investigations (Pavlovski and Mašić, 1987) have unfortunately confirmed the results of past research which demonstrated that the Belgrade market offers generally poor and erratic quality of eggs (**Table 3**).

This table also presents, in general, the average values for external and internal egg quality features, as obtained from laying hen tests in 1984/1985 (Pavlovski, 1986). These results lead to the conclusion that initial quality was good but turned remarkably inferior on the way from producer to consumer.

A separate investigation has shown that consumable eggs having 85 HU initial quality, if kept at room temperature, tend to lose 5 HU per day on average during the first three days of storage and a further 2.5 HU daily for the next four days (3.57 HU/day on average for the first week). The loss continues by 1.28 HU/day in the second week, 0.86 HU/day in third, 0.57 HU per day in fourth, and 0.14 HU/day in the fifth week. Technically speaking, eggs lose 15 HU within the first three days, 10 HU in another four days, 9 HU in the second week, 6 HU in the third, 4 HU in the fourth, and only 1 HU in the fifth week. On the other hand, eggs kept refrigerated at 4°C lost their HU value at a considerably slower rate and still possessed 69 HU after five weeks storage, meaning that their internal quality corresponded to the quality of eggs kept at room temperature for three days and several hours. If the quoted parameters are taken as the basis for evaluation of data acquired from examination of the Belgrade market, it may be safely concluded that the average quality of marketed eggs corresponded to that of eggs aged for seven days or longer.

Figure 1 shows impoverished egg quality (expressed as HU) under different storage conditions (room temperature : 10-20°C ; refrigerator : 4°C). It becomes obvious from the chart that after seven days storage at room temperature eggs suffered losses of 55.5% of the total loss expected after five weeks, while refrigerated eggs maintained proper quality for a markedly longer period.

It is well known that during both storage and marketing eggs should be kept under controlled conditions (10-15°C temperature, 70 % relative humidity) (Berry, 1977 ; Kralik, 1978 ; Oesterle and Kepher, 1980). While investigating storage conditions at the Belgrade market, Pavlovski (1982) confirmed that during both cold and warm seasons the average temperature and relative humidity in various shops, in many cases, did not meet these optimal terms, i.e. that the eggs were kept under uncontrolled conditions.

During their investigations of the effect of storage conditions on egg quality in the market place, Čopić and Pavlovski (1985) confirmed a pronounced tendency towards a decrease in the number Haugh units (0-5°C, 64.10 HU ; over 20°C, 46.8 HU) with a rise of temperature.

Adverse effects of high temperature at the selling place on the quality of eggs concord with the generally recognized process developing in eggs under such conditions. Namely, the otherwise dense albumen deteriorates into a watery one, water from the albumen diffuses into the yolk and the yolk increases on account of the albumen. This further induces the decreases of the number of Haugh units, yolk index, albumen/yolk ratio and, consequently, the decreased percentage of superior (AA) quality eggs.

The effect of relative humidity at the selling place was not so pronounced as the effect of temperature.

Based on the above and having in mind inferior quality of eggs at the Belgrade market, but very good quality at the production phase, it is concluded that market conditions (temperature, air relative humidity) have adverse effects on both the external and internal egg features (consumable quality). This deterioration at the selling place, apart from the on-site conditions, was induced by a number of other agents among which transportation definitely assumes an important position.

As the Belgrade market, more often than not, offers eggs transported over hundreds of kilometers, the question arises as to the quality of transported eggs, as well as if such transportation may have been detrimental. Since Yugoslav literature provides no data on such effects and foreign references quote very little, Pavlovski *et al.* (1987) investigated the effect of transportation during the warm season on the quality of consumable eggs.

Gwin (1952) has shown that the diminishing quality of eggs is related to the duration of transport, mileage and the season of the year. Adams and Milam (1960) claimed that eggs transported from Lincoln (Nebraska, USA) to Rio de Janeiro (Brazil) lost 12.2 HU (from 84.6 down, to 72.4 HU) over 30 days of transportation.

As egg transportation in Yugoslavia is by unrefrigerated trucks, which is not the case in the United States, we present results of research on the influence of warm season transport on major internal quality features of eggs (**Table 4**).

This table also shows results of the air temperature effect on eggs after storage under thermostat at 27°C and 70% relative humidity. The investigation was aimed at accurate definition of the effects of transportation, regardless of its duration (hours).

Based on these results we conclude that transportation has adverse influence on the height of albumen, the number of HU and the central position of the yolk. The diminishing quality of eggs is most probably due to prolonged agitation that induces weakening of chalazae, shift of yolk towards the periphery, spilling of the dense portion of the albumen and reduced number of Haugh units. Walker *et al.* (1972) also confirmed that agitation adversely affects the quality of eggs, whereas Adams and Skinner (1962, 1963) produced opposite results. However, the difference is due to the different manner of transportation. These conclusions were confirmed by regression analysis performed for HU, as presented in **Figure 2**. It shows that the average loss of HU per 100 km distance amounts to 2.25 HU, i.e. after 600 km of transportation during the warm season the eggs had 13.5 HU less than their initial quality. On the other hand, eggs stored under thermostat for two hours lost 0.78 HU on average.

If we are aware that the eggs left at room temperature for one day may lose 5 HU (Pavlovski, 1986), it means that zero day old eggs transported over 200 km distance have quality similar to one day old untransported eggs.

This indicates that in the chain of egg marketing the proven adverse influence of transport on the quality of eggs must be taken into account, specifically during warm seasons.

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Table 1: External and internal characteristics of eggs from cages and free range

External characteristics average	Žigić *et al.* (1967)		Žigić *et al.* (1974)		Pavlovski *et al.* (1981)		Pavlovski (1982)		Pavlovski & Mašić (1986)	
	cages	**free range**	**cages**	**free range**	**cages**	**free range**	**cages**	**free range**	**cages**	**free range**
Egg mass, g	63.0	62.8	61.8	51.5	57.7	59.4	66.3	59.6	64.4	57.5
Shell deformation, 0,001 mm	24.2	23.0	25.4	22.3	25.7	23.3				
Shape index, %	75.1	74.1	74.6	73.1	73.6	74.6	75.4	74.1	75.8	73.2
Shell colour, points	2.51	2.94	3.78	2.35	3.69	3.58	3.30	3.00	3.16	3.02
Internal characteristics average										
Albumen height, 0,1 mm	51.3	59.9	51.4	55.9	49.9	56.2	47.3	56.4	72.6	77.6
Haugh units	66.6	73.9	66.0	75.0	66.7	71.6	60.6	70.2	82.6	88.1
AA Quality (USDA), %			63	83	39	62	3	39	38	57
Yolk colour, Roche	4.83	7.00 *	7.72	11.34	9.44	13.63	8.80	11.0	9.74	12.65
Yolk index, %	43.7	42.5	45.5	46.3	44.4	44.7	45.5	45.9	48.4	49.9
Yolk as % of egg mass			36.4	38.2	37.6	36.0	28.9	29.9	27.6	25.6
Albumen : yolk ratio							2.03	1.94	2.01	2.24
Shell thickness, 0,01 mm					31.9	34.6	36.0	34.3	35.1	32.7
Blood and meat spots, %	14	16	60	18	48	36	29	27	9	12

* Intensity of yolk colour, graded 1-12, was determined by comparison with the colour of varying concentrations of potassium bichromate solution (0,5-20 mg/ml water in tubes R 5 x 16 mm).

Table 2: Quality egg characteristics measured in different periods of production (P - Start ; S - Middle ; K - End) and average value for whole period. Examples recorded in different farms

Farmer	Eggs mass, g				Yolk colour, roche				Haugh units				Shell thickness, 0, 0lmm			
	P	S	K	X	P	S	K	X	P	S	K	X	P	S	K	X
1.	51	65	64	62	11.4	10.3	11.9	10.2	100	87	84	89	36.3	36.8	35.5	37.4
2.	54	64	72	64	10.3	10.2	10.1	10.1	102	83	83	84	36.4	37.3	36.3	37.8
3.	53	65	64	62	10.4	10.2	10.4	10.1	105	76	72	83	35.2	37.7	36.3	38.0
4.	57	63	68	63	11.6	10.1	10.0	10.1	99	84	83	85	27.8	38.4	34.6	37.4
5.	58	65	63	62	10.3	10.3	10.0	10.1	100	82	75	84	38.1	38.5	36.8	38.1
6.	59	64	66	63	10.6	10.3	9.9	10.1	101	79	84	86	37.3	36.9	35.6	36.7
7.	56	65	64	62	11.0	9.8	10.5	10.1	103	76	72	81	36.1	39.3	37.7	38.8
8.	54	61	66	62	10.5	9.9	10.2	10.0	94	81	81	83	37.5	29.8	35.7	37.4
9.	56	68	68	64	11.0	10.0	10.0	10.4	94	78	85	86	37.1	37.9	38.8	37.3
10.	57	59	65	62	10.2	10.1	10.2	10.2	98	81	72	80	36.2	40.3	38.8	38.1
11.	56	65	68	65	9.1	10.6	10.1	10.4	93	80	73	80	38.4	40.6	34.5	38.6
12.	57	65	68	65	9.7	10.6	10.2	10.2	95	90	84	86	37.8	38.6	35.2	37.9
13.	55	65	65	66	10.2	10.7	10.1	10.4	96	89	82	85	36.8	37.1	34.9	38.2
14.	54	61	65	63	9.4	10.5	9.7	10.3	97	92	83	82	41.5	37.6	35.7	37.0
15.	54	62	66	65	9.6	10.3	9.9	10.2	101	93	72	92	35.6	36.6	35.6	36.1
16.	53	64	69	66	9.2	10.1	10.0	10.3	92	86	72	93	34.7	36.7	38.8	38.5
17.	55	63	64	64	9.5	10.6	9.8	10.0	92	88	71	90	36.4	37.7	38.5	36.9

Table 3: External and internal quality of eggs in laying hens and Belgrade market

External characteristics average	Test for laying hens Pavlovski 86 1984/85	Belgrade market					
		Žigić *et al.* 1967	Pavlovski 1982	Pavlovski & Mašić 1985	Pavlovski 1986	Pavlovski & Mašić 1987	Pavlovski & Mašić 1987
Egg mass, g	63.5	49.55	63.90	60.60	62.60	64.50	61.50
Shell colour, points	3.07	1.58	3.30	3.30	3.60	3.40	3.60
Shell cleanliness, points	4.40	3.45	4.70	4.40	4.70	4.30	4.70
Internal characteristics average							
Albumen height 0,1 mm	76.6	25.24	41.20	46.80	47.70	31.10	29.40
Haugh units	86.3	44.21	55.80	63.80	62.10	38.80	39.30
USDA Quality, %							
AA	28.84		1.72	0,00	2.50	0.00	0.00
A	50.59		24.51	10.00	6.25	2.22	5.71
B	19.03		50.29	47.78	45.00	33.33	30.00
C	1.54		23.48	42.22	46.25	64.45	64.29
Yolk colour, points	9.57	8.03	9.60	10.20	10.80	10.70	10.60
Shell thickness, 0,01 mm	33.6		35.70	37.6	36.40	35.10	36.50

Table 4: Internal quality characteristics of eggs influenced by truck shipment (T) and storage (S) (during the warm season)

km	hour	Albumen height (0,1 mm)		Haugh Units		Yolk Colour		Centricity	
		T	S	T	S	T	S	T	S
0	0	65.30	67.13	79.03	79.36	9.50	9.83	3.63	3.20
100	2	62.17	68.77	77.10	80.53	10.40	10.03	3.37	2.83
200	4	54.80	71.73	71.73	83.23	10.70	9.57	3.30	3.37
300	6	51.17	65.60	68.73	78.83	10.17	9.67	3.00	3.23
400	8	56.27	67.43	72.90	80.73	10.70	9.33	3.13	3.20
500	10	45.53	64.47	63.63	78.67	11.47	10.06	3.17	3.17
600	12	49.93	59.06	66.59	74.17	10.13	10.13	3.14	3.47

Centricity of the yolk was assessed visually and marked 1-5, where 5 designated ideally centered yolk and 1 the poorest centricity.

Figure 1: Decline of egg quality (in Haugh units) under different conditions of storage

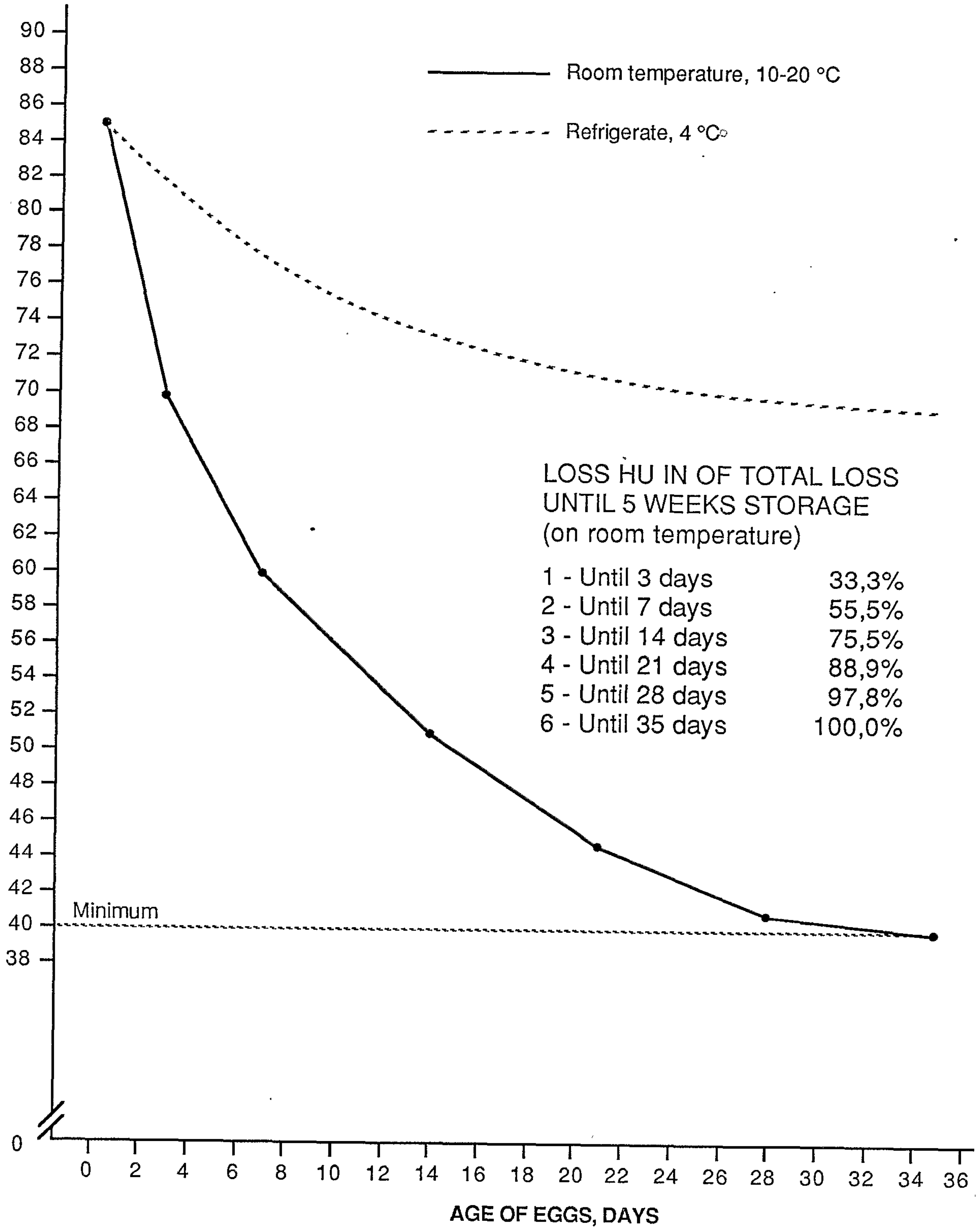

Figure 2: Regression of Haugh units