EGG SHELL QUALITY- THE PRESENT SITUATION

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SUMMARY

It is generally accepted that approximately 7 per cent of all eggs are downgraded, mostly because of poor shell quality. However , this figure is based on determined losses at packing stations and it has become evident from recent investigations that the true losses from poor shell quality are much greater. These additional losses occur as uncollectable eggs on the farm and damaged eggs at retail outlets. A more realistic estimate of shell damage from all sources approximates to 20 per cent of all eggs produced. The problem is greater with hens laying large eggs during the second half of the laying year. The only way to reduce the incidence of shell defects is to improve egg shell quality on the farm since initial shell quality will influence subsequent losses at all points in the processing chain.

INTRODUCTION

Egg shell quality has been a recurring problem for egg producers for many years, as is clearly evident from the extensive scientific and trade literature devoted to this problem. While many of the causes of poor shell quality have been identified, and remedies suggested, downgrading statistics have, in general, failed to respond in a positive manner.

Information produced by the Eggs Authority, UK (1978) showed that the incidence of downgrading rose from 4.7% in 1960/61 to nearly 7% in 1970/71. Overfield (1987) reported that the percentage downgrading from egg packing stations in the UK increased steadily from 1958 (4.1%) to 1978 (7.4%). Although a slight decline to 6.5% occurred in the early 1980s with the adoption of brown egg laying strains the percentage downgrading was still much higher than reported in the 1950s. Overfield indicated that surveys of individual farms and the results of laying trials show that the total incidence of downgrading is higher than national estimates because the latter do not include damaged and soiled eggs which many producers frequently remove prior to forwarding eggs for grading. Shell faults accounted for 87.4% of eggs downgraded by packing stations but this figure rose to 90.5% when eggs downgraded on farms were included. Information published by Hughes (1982) on the quality of eggs from retail stores in Adelaide indicated that egg shell quality was worsening at the retail level during the late 1970s (Table 1). Egg shell damage as high as 7.3% of retail eggs was reported by Hughes in this survey.

Table 1 Quality of eggs from retail stores in Adelaide (Hughes, 1982)

	Shell damage (%)	
	Summer	Winter
1976	4.7	4.0
1977	4.0	4.7
1978	4.9	6.0
1979	4.8	5.3
1980	6.5	7.3

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THE CURRENT SITUATION IN AUSTRALIA

The situation in Australia in mid-1988 was specifically discussed at an egg quality seminar organised by the Poultry Research Council in Sydney last July (Poultry Research Council, 1988). The following information was presented at that meeting.

The total second quality eggs received by the NSW Egg Corporation approximates to 10% of all eggs, with individual producers ranging up to 35%. In certain areas shell faults account for over 90% of second quality eggs, a value similar to that reported by Overfield (1987).

Information from Southern Queensland indicated that second quality eggs in that region had increased from approximately 6.7% in 1985/86 to 7.8% in 1987/88. Surveys showed that mean shell defects increase from approximately 5% at 35 weeks to 14% at 65 weeks of age.

Data from the other States confirmed that second quality eggs were of major economic significance. Approximately 9% of all eggs in South Australia are of second quality with little change having occurred over the past few years; end-of-lay hens are the main problem. In West Australia the incidence of second quality eggs is not considered to be a problem although it is recognised that cracked eggs account for up to 8% of eggs produced on farms. In Victoria approximately 7% of all eggs are considered to be second quality but the incidence of shell defects increases to 12% in hens nearing the end of lay. In some flocks shell defects are as high as 22% and uncollectable eggs account for up to 3% of production.

These data, which are based on determined losses at packing stations, give rise to some concern since they are minimum estimates and actual losses are much greater. This is because losses reported from the egg packing stations do not include the uncollectable eggs lost on the farm, second quality eggs disposed of in other ways and the losses which occur during the retail distribution of eggs. The latter problem, in particular, can have a marked effect on consumer confidence and food purchase preference. Recent studies from the USA (Roland, 1986), Australia (Balnave and Yoselewitz, 1988a) and the United Kingdom (Poultry International, 1988a) suggest that overall losses from shell defects may be as high as 20%.

SOURCES OF EGG SHELL DAMAGE

Egg shell damage occurs at a number of points in the production and processing chain. These can be classified into the following areas:

(i) On farm.
(ii) During transport to packing station.
(iii) At packing station.
(iv) In the retail chain.

(i) Egg shell damage on farm

The potential for egg shells to be damaged is greatest on the farm. Factors contributing to the problem can include the diet, the cage stocking density, drop-height of the egg whenbeing laid and the use of automatic egg collection systems. In addition, soft-shelled egg are normally not collected since they fall through the floors of the cages.

Pre-collection egg losses occur primarily with young flocks at the start of lay and with old hens approaching the end of lay. Workers in the USA (Poultry International, 1988b) have recently reported pre-collection egg losses as high as 8% in hens of 51-57 weeks of age (Table 2). Information supplied by Roland (1986) also showed that uncollectable eggs on the farm could account for up to 6% of total egg production.

Table 2 Pre-Collection egg loss (Poultry International, 1988b)

Age (weeks)	Birds/Cage	Egg Loss (%) A	Egg Loss (%) B
33-42	3	2.3	4.5
	4	1.9	1.3
51-57	3	4.1	5.0
	4	2.1	8.3

A number of factors related to mineral nutrition, especially dietary calcium and phosphorus, are known to influence soft-shelled egg production. However, we have recently identified the use of saline drinking water as a major contributor to this problem (Balnave and Yoselewitz, 1988b). when drinking water containing 2 g NaCl/l was supplied to laying hens soft-shelled egg production accounted for between 10 and 31% of all eggs laid. Although we have little definitive data for lower concentrations of salt visual observations have confirmed that soft-shelled egg production can be a problem with lower levels of salinity (Table 3).

(ii) Egg shell damage during transport

Investigations conducted by Sunny Queen Eggs in Southern Queensland have shown that, on average, transporting eggs from Toowoomba to Brisbane damages 1.4% of the eggs transported (Poultry Research Council, 1987). In general terms the extent of the damage occurring during transport depends on the length of the journey but obviously the shell quality of the eggs leaving the farm will have an important influence in that damage will increase as egg shell quality declines.

Shell quality is knowntodeteriorate when laying hens are provided with salinedrinking water (Balnave and Yoselewitz, 1987). We have used eggs from such a flock to examine the effect of transportation on shell damage. Visually-normal eggs with no shell defects were transported from the University of Sydney Farms, Camden to the NSW Egg Corporation at Lidcombe in commercial, refrigerated trucks.

In the first study 763 visually-normal eggs were transported from Camden to Lidcombe after which time 21 eggs were foundtobebroken (i.e. 2.8%) and a further 33 cracked eggs (4.3%) were identified after candling. Therefore, overall damage resulting from transport and candling amounted to 7.1%. In the second study 540 visually-normal eggs were transported in a similar way from Camden to Lidcombe. On arrival at Lidcombe 49 eggs were found to be broken (9.1%) and after candling a further 23 eggs were found to be damaged (4.3%). In this study 72 eggs from the original 540 transported (i.e. 13.3%) were found to be damaged after transport and candling, It should be stressed that these eggs were individually checked for shell damage at Camden prior to transport.

It is apparent that visually-normal eggs with poor shell quality, but with no shell defects when laid, can show high breakage rates during transport and candling. Therefore, total egg shell damage can often be much larger than expected from informal farm evaluation. Since eggs with poor shell quality show a high breakage rate during transport, variations in downgrading statistics from different egg grading floors may simply mirror the distances eggs are transported. Egg producers obtaining wide variations in downgrading statistics from different packing stations can assume that they probably have a poor egg shell quality problem.

(iii) Egg shell damage at packing station

Incorrectly adjusted equipment at the packing station can contribute to egg shell damage during candling and packing. However, as with transportation breakages, the extent of the damage will be related directly to the shell quality of the eggs received (see (ii) above).

(iv) Egg shell damage in the retail chain

As indicated previously, Hughes (1982) reported that more than 7% of eggs in retail stores showed egg shell damage in a survey conducted in Adelaide in 1980. Estimates given at the Poultry Research Council (1988) seminar indicate that egg shell damage in retail packs is as high as 8% in NSW, 7% in Victoria and 4.5% in Southern Queensland. These data indicate that in all States a relatively high percentage of eggs leaving the packing stations are of doubtful shell quality. It has been suggested (Poultry Research Council, 1988) that the loss in candling efficiency due to operator error increases substantially when egg shell defects account for more than 10% of the eggs being candled. Again the indication is that the initial shell quality of the eggs reaching the packing station has a major influence on the detection rate of damaged eggs. More importantly, these data, when combined with those for second quality eggs (see above) indicate that a minimum of between 12 and 18% of all eggs produced in these regions have doubtful shell quality.

Recent studies at Camden (Yoselewitz and Balnave, 1989) have identif iedthe main types of egg shell damage resulting from the use of normal and saline drinking water. These and more recent estimates are shown in Table 3. It is evident from these data that, with both sources of water, between 30 and 40% of damaged shells contained very thin cracks. These cracks areextremelydifficult to detect except by careful manual inspection of individual eggs. Since we were of the opinion that these eggs could contribute in a major way to the damaged eggs being observed at retail outlets we arranged for a consignment of 900 eggs containing 137 eggs with thin cracks to be candled at the NSW Egg Corporation. Only twenty two damaged eggs were detected during candling.

This low detection rate of 16% is not a reflection on the ability of the candling operators since they cannot be expected to detect these problem eggs with any degree of consistency. Some additional eggs may be detected by slowing the passage of eggs on the candling conveyor but it is unlikely that detection would be markedly improved. Since approximately one-third of all defective shells have this type of damage the problem will not be too noticeable when eggs with good shell quality are fowarded to packing stations. In these cases an average incidence of 6% egg shell defects will result in apprdximately 2% or less of eggs with defective shells passing through to the retail outlets. However, when egg shell

Table 3 Classification of egg shell damage in three studies (Yoselewitz and Balnave, 1989 and unpublished results)

	Study-1			Study-2			
NaCl(mg/l)	0	600	2000	0	500	1000	2000
Fine cracks	41	36	39	34	39	39	43
Holes	29	26	20	39	25	22	22
Star cracks	23	25	20	14	23	33	20
Deformation	1	2	5	13	7	-	1
Empty shells	5	10	13	-	6	3	4
Soft shells	1	1	3	-	-	3	10
Total % defects	6.2	11.8	19.6	7.3	15.0	19.7	29.4

	Study-3	
NaCl (mg/l)	0	600
Fine cracks	36	33
Holes	18	22
Star cracks	9	20
Deformation	9	4
Empty shells	18	6
Soft shells	-	16
Total % defects	4.9	20.6

damage is much greater at e.g. 20%, the numbers of these eggs reaching retail outlets will be much greater at 6% or more. Therefore, there is a much greater likelihood of damaged eggs reaching the consumer when eggs of poor shell quality are despatched from the farm-

REALISTIC ESTIMATE OF EGG SHELL DAMAGE IN COMMERCIAL FLOCKS

As indicated previously a mean overall loss of 6-7% of all eggs laid is recognised as being generally acceptable. However, when all the sources of egg shell damage are considered it is obvious that about 20% of all eggs produced have defective shells. This 20% is conservatively composed of 4% pre-collection egg loss on the farm, 8% loss at the packing station and 8% loss at the retail outlets. The pre-collection loss is normally not recognised and the losses at retail outlets cannot be assigned to individual producers. I would suggest that egg producers should double the incidence of egg shell defects detected at the packing station in order to obtain a more realistic estimate of egg shell defects from their flocks.

When we have given drinking water containing 2 g NaCl/l to hens in the second half of their laying year we have often obtained total egg shell defects of over 50% when soft-shelled egg production has been included. When soft-shelled eggs have been excluded shell defects of 21, 29 and 40% were obtained in three separate studies (Table 4). In addition, 2- and 3-fold increases in egg shell defects were obtained with concentrations of NaCl in drinking water approximating to 200 and 600 mg/l respectively. The problem takes longer to develop with pullets in early lay since these birds produce small eggs with better shell quality than older hens. Even so egg shell defects of 31% were obtained between 29 and 33 weeks of age from pullets which had received saline drinking water containing 2 g NaCl/l from pullets at 23 weeks of age. Few defective shells were obtained prior to 29 weeks of age although egg shell quality was poorer compared with eggs from pullets receiving town water without NaCl (Yoselewitz and Balnave, unpublished results).

Table 4 'Percentage on-farm egg shell defects resulting from supplementation of drinking water with sodium chloride (NaCl) (Balnave and Yoselewitz, 1988b)

Expt	NaCl (mg/l)	Control (%)	NaCl (%)
1	250	3.1	6.5
2	250	3.7	6.4
3	200	6.8	11.3
	400		15.0
	600		20.5
4	600	3.5	9.9
5	600	3.6	7.1
6	2000	3.1	52.0(31.3)*
7	2000	1.9	50.4(9.7)*
8	2000	7.3	46.0(17.3)*
9	600	6.2	11.8
10	2000	6.1	28.1

* Soft-shelled egg production

CONTRIBUTING FACTORS

Egg shell damage results from the interaction of shell strength with the number and strength of the insults to which the egg is exposed. The recently recorded large increases in the incidence of egg shell damage in NSW probably relate to a combination of factors contributing to one or other of these phenomena. Two important criteria have been the introduction of automatic egg collection on farms and more efficient candling equipment in egg packing stations. However, ultimately the problem relates directly to the quality of shell being deposited on the egg by the hen. This, in turn, reflects the nutritional and management expertise of the egg producer.

Many factors are known to influence egg shell quality (Hamilton et al., 1979). While the individual egg producer has little control over many of these it is apparent that in many instances existing knowledge is not being correctly implemented on the farm.

Egg producers may have no alternative but to use underground water containing high concentrations of mineral salts. Variations in biological factors within individual populations of birds such as 'drop-heights' and the shape of the egg are alsobeyond his control. However, other factors can be carefully assessed by knowledgeable producers. For example, modern procedures for optimising egg production include shortening the oviposition interval between eggs to 24 h or less. This involves selecting hens which retain the egg within the oviduct for a shorter time. This, in turn, influences the time available for egg shell calcification in the shell gland. Such a selection criterion may or may not be important in determining egg shell quality but it needs to be considered in any overall evaluation.

It is apparent from many reports that egg producers who mix their own feeds often are not able to meet dietary nutrient specifications because of inadequate equipment and/or knowledge of the nutrient composition of feed ingredients. In particular, variations in the calcium and phosphorus concentrations of diets can significantly affect egg shell quality. Calcium separation during transport in trucks or mechanical feeders can lead to wide discrepancies in the composition of mash feeds offered to laying hens; crumbling of the feed can prevent such separation. Other factors such as calcium availability from different sources and the particle size of calcium supplements (Balnave, 1988) as well as the supply of trace nutrients (Panic et al., 1978) can all influence egg shell quality.

FUTURE STRATEGIES

Egg shell quality will not improve unless egg producers accept that a serious problem exists. A conscious effort will be needed to improve the current situation. Egg producers must recognise that it is essential to supply hens with diets containing adequate and suitably-balanced nutrients, and to make necessary adjustments to meet changing environmental conditions. Greater attention needs to be paid to the inherent characteristics of individual strains. Perhaps the use of drinking water containing a low concentration of sodium chloride could be used as a suitable selection procedure to identify hens with limited ability to produce good shells. The effect of the age of the hen on egg shell quality characteristics is known and strong consideration should be given to shortening the egg production cycle and to replacing flocks at an earlier age than at present. In addition, continuing scientific research needs to be conducted to examine suggested remedies and to develop new strategies to improve the efficiency of egg shell calcification in the hen.

A C

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