Research Article

Received: 6 April 2010 Revised: 28 September 2010 Accepted: 25 November 2010 Published online in Wiley Online Library: 24 December 2010

(wileyonlinelibrary.com) DOI 10.1002/jsfa.4264

# Effects of housing system and age of laying hens on egg performance in fresh pasta production: pasta cooking behaviour

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## Abstract

**BACKGROUND: Very few studies concern the effects of layer housing systems and age on egg technological properties. Thus the aim of this work was to study the influence of these two factors on egg performance in fresh pasta production, focusing on pasta cooking behaviour. Samples of pasta subjected to analysis were prepared with eggs laid by Hy-Line Brown hens (from 27 to 68 weeks old) housed in cage, barn and organic systems.**

**RESULTS: Higher average values of weight increase and matter loss during pasta cooking were observed for samples prepared with eggs laid by older hens. Such cooking behaviour indicated the development of a weaker pasta protein network, resulting from a decrease in the quantity of albumen protein and an increase in fat content, which is due to the reduction in albumen/yolk ratio during hen aging. The housing system had a significant effect only on matter loss in cooking water, but differences between samples were so small as to be unlikely perceived by consumers.**

**CONCLUSION: Both hen age and housing system significantly affected pasta cooking behaviour, but the greatest effect was exerted by the hen age.**


**Keywords:** cooking behaviour; egg; fresh pasta; hen age; housing system

## INTRODUCTION

Consumers are becoming more and more aware of farmed animal welfare, considering it as a major factor affecting food quality and safety. Therefore, as regards commercial egg production, organic and other alternative housing systems for laying hens are gaining a market share to the detriment of the conventional cage system. In the egg product market too, a growing number of food producers are investing in products deriving from alternative systems, especially organic products.

Within the European Union (EU), Council Directive 1999/74/EC[1] sets minimum standards for the welfare protection of laying hens, and Council Regulation 1804/1999[2] outlines the organic production method. Besides the conventional cage system, three alternative farming methods are established in the EU, i.e. organic, free range and barn. According to Commission Regulation 2295/2003,[3] the designation of farming methods by specific codes on the egg package as well as on the egg shell is mandatory.

Several papers[4–11] deal with the effect of layer housing system on shell egg quality and hygiene, whereas very few studies[11] concern its influence on egg functional properties. In general, the literature indicates that layer diet and husbandry system can affect the sensory characteristics and chemical composition of eggs as well as some technological properties (e.g. foaming capacity).

When designing an experiment to compare the effects of different housing systems on egg characteristics and performance, important factors such as hen strain and age must be taken into account. In particular, layer age can dramatically affect many features such as egg weight and albumen/yolk ratio. Some albumen properties are also affected, such as consistency, Haugh units and foaming capacity.[8,12–15]

Among the technological properties of eggs, their performance in fresh pasta production is worth investigating, because the structural, nutritional and sensory features of fresh egg pasta are greatly influenced by the egg ingredient characteristics. In particular, egg proteins contribute to the formation of a more compact pasta protein network, yielding a harder and tougher product, both before and after cooking. Moreover, the tighter the protein network, the smaller are the penetration of water and the swelling of starch granules during cooking. A major role in the formation of a tight protein network is played by ovalbumin, the principal protein of albumen.[16] On the contrary, an increase in yolk content worsens the structural characteristics of pasta, increasing the adsorption of water during cooking.[17]

The aim of the present work was to study the influence of layer housing system and age on egg performance in fresh pasta production. This first paper focuses on the effects of these two egg production factors on pasta cooking behaviour and is part of a larger research project also investigating their effects on the mechanical and rheological properties of pasta.

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## MATERIALS AND METHODS

### Materials

Eggs laid by Hy-Line Brown hens were used in this study. At the age of 16 weeks the hens were housed in three different systems, i.e. cage, organic and barn, and eggs were sampled six times per system at different hen ages (27, 30, 35, 43, 53 and 68 weeks) during the layer production cycle, starting when egg production was steady at about 90%. The eggs were used for pasta production within 48 h of laying, preparing from each sample two pools of whole egg, for a total of 36 pools. Egg pool preparation was as follows: 30 eggs were manually shelled and mixed (six eggs at a time) at 3000 rpm for 50 s using a Sörvall Omni Mixer 17 106 (Dupont de Nemours & Co., Newtown, CT, USA).

Each whole egg pool was used for fresh egg pasta production, thus obtaining two technological replicates for each egg sample. The other pasta ingredients were durum wheat semolina, soft wheat flour and natural spring water. Semolina and flour were purchased as single lots from Molino Quaglia (Padova, Italy).

### Fresh egg pasta production

Pasta samples (1 kg each) were formulated with semolina and flour in a 1 : 1 (w/w) ratio, 201 g $kg^{-1}$ whole egg and natural spring water in order to achieve a constant dough moisture content (theoretical value 332 g $kg^{-1}$).

Fresh egg pasta was produced in sheets for lasagna (15 cm $\times$ 25 cm), using automatic equipment commonly employed by artisans (P. Nuova, La Monferrina, Asti, Italy). The ingredients were first mixed for approximately 15 min to obtain a crumbly dough. This was then fed through the pasta rolling device set at the minimum distance to smooth and firm it and subsequently fed a further four times between the rollers at the maximum setting to give the pasta a good shape and texture. Finally the pasta was rolled into sheets approximately 1 mm thick and immediately subjected to analyses, during which pasta samples were kept in airtight polystyrene containers to avoid moisture loss.

### Cooking behaviour

Each pasta sample was analysed for cooking behaviour by means of standard cooking tests carried out in triplicate as reported previously.[16] Briefly, four sheets of pasta (20 cm $\times$ 10 cm) were cooked for 180 s in 1.5 L of boiling natural spring water (pasta/water ratio *ca* 1 : 10 w/v) and then left to drain for 120 s. Salt was not added to the cooking water, because it improves the textural characteristics of cooked pasta[18,19] and could mask the egg effects on pasta structure. Pasta weight increase due to cooking (%) was evaluated by weighing the pasta sheets before and after cooking. Matter loss in the cooking water (g $kg^{-1}$ d.m. pasta) was evaluated gravimetrically by determining the dry matter content at 105 °C of the remaining cooking water, after restoring it to the initial volume by natural spring water addition.

### Egg contribution to pasta composition

The contribution of the egg constituents to pasta composition was calculated for the different samples on the basis of albumen/yolk ratio (w/w) and fat and protein contents of the separated albumen and yolk fractions of the eggs collected during the experiment (data not shown). The contents of egg fat, albumen proteins and yolk proteins were expressed as g $kg^{-1}$.

**Table 1.** *F* test values of MANOVA for pasta cooking behaviour

| | Weight increase | | Matter loss | |
|---|---|---|---|---|
| Source | *F* ratio | *P* value | *F* ratio | *P* value |
| Housing system | 1.24 | 0.2945 | 16.03 | 0.0000 |
| Hen age | 12.87 | 0.0000 | 28.51 | 0.0000 |
| Technological replicate | 2.79 | 0.0989 | 1.01 | 0.3174 |

### Statistical analysis

Values of the cooking behaviour variables of pasta samples, produced with the eggs obtained from the different housing systems during the entire layer production cycle, were jointly processed in a multifactor analysis of variance (MANOVA), considering the housing system, the hen age and the technological replicate as factors. Values of pasta composition (albumen and yolk proteins and fat) were also treated by MANOVA, considering as factors only the housing system and the hen age. To compare the average values, the least significant difference (LSD) multiple range test was applied ($P < 0.05$). A matrix of Pearson correlation coefficients for the observed variables was also calculated. All statistical analyses were performed using Statgraphics Plus 5.1 software (Statistical Graphics Corp., Warrenton, VA, USA).

## RESULTS AND DISCUSSION

The *F* test values of MANOVA for the pasta cooking behaviour are reported in Table 1. The first point to be observed is that the technological replicate was found to be a non- significant factor, indicating adequate standardisation of the pasta production process. On the contrary, the housing system and the age of hens having laid the eggs used for pasta production significantly affected the cooking behaviour of fresh egg pasta. In particular, both factors affected the matter loss in the cooking water, whereas the weight increase of pasta on cooking was significantly influenced only by the hen age. This latter, showing the highest *F* ratio values, is the egg production husbandry factor most significant in affecting fresh pasta performance during cooking.

Table 2 shows the average values of the cooking behaviour variables of the fresh egg pasta samples prepared with the two pools of each egg sample (two technological replicates). Pasta samples are identified by a code consisting of a letter and a number corresponding to the housing system (C = cage, O = organic, B = barn) and the age (weeks) of the laying hens respectively. For each housing system the total mean values of weight increase and matter loss are also reported, with different letters indicating significant differences according to MANOVA and the LSD test. As shown in Table 2 and already observed in Table 1, the housing system had no significant effect on the weight increase of pasta during cooking. On the contrary, the matter loss in the cooking water was found to be significantly different in pasta produced with the eggs of the different husbandry systems, with increasing values being observed in the order cage < organic < barn eggs. Therefore cage eggs seem to produce fresh pasta with improved cooking performance, which is generally associated with low values of matter loss in the cooking water. However, the observed differences are very small, so it is likely that the real effect on the structure of cooked pasta would not be sensorily perceived by consumers.



  

**Table 2.** Cooking behaviour of fresh egg pasta samples (average values and standard deviations of two technological replicates)

| | Cooking behaviour | |
|---|---|---|
| Sample | Weight increase (%) | Matter loss (g kg$^{-1}$ d.m.) |
| C-27 | 40.6 ± 0.7 | 22.2 ± 0.3 |
| C-30 | 44.9 ± 1.6 | 21.2 ± 0.2 |
| C-35 | 44.6 ± 0.2 | 25.3 ± 1.8 |
| C-43 | 49.7 ± 5.1 | 27.8 ± 1.3 |
| C-53 | 48.1 ± 4.8 | 25.5 ± 1.4 |
| C-68 | 48.8 ± 0.4 | 25.9 ± 2.6 |
| C (total mean) | 46.1a | 24.7a |
| O-27 | 39.0 ± 4.3 | 22.3 ± 0.8 |
| O-30 | 47.3 ± 0.6 | 24.0 ± 0.4 |
| O-35 | 45.2 ± 0.8 | 26.4 ± 0.1 |
| O-43 | 45.7 ± 0.6 | 27.0 ± 0.1 |
| O-53 | 48.6 ± 0.1 | 27.3 ± 0.5 |
| O-68 | 46.4 ± 1.1 | 26.4 ± 0.2 |
| O (total mean) | 45.4a | 25.6b |
| B-27 | 45.9 ± 0.9 | 22.3 ± 2.2 |
| B-30 | 46.5 ± 1.0 | 27.0 ± 1.7 |
| B-35 | 44.2 ± 0.8 | 28.8 ± 1.5 |
| B-43 | 46.6 ± 0.7 | 29.0 ± 1.9 |
| B-53 | 49.0 ± 2.2 | 26.9 ± 2.5 |
| B-68 | 47.7 ± 0.4 | 27.0 ± 1.6 |
| B (total mean) | 46.6a | 26.8c |

Within each column, total mean values with different letters are significantly different ($P < 0.05$).

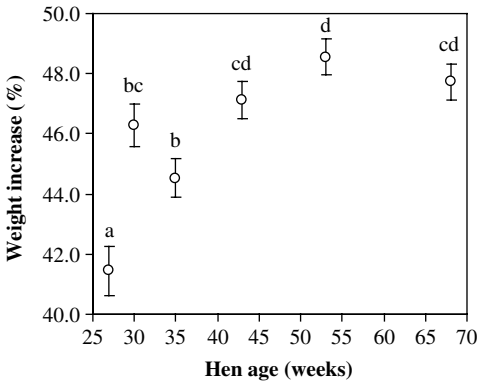


**Figure 1.** Fresh egg pasta weight increase during cooking as a function of laying hen age. Each point is the average value of the three housing systems. Error bars represent the standard error. Different letters indicate significant differences ($P < 0.05$).

The average effects of the hen age on fresh egg pasta cooking behaviour are illustrated in Figs 1 and 2. Both weight increase and matter loss in the cooking water showed a tendency to increase significantly when eggs laid by older hens were used in pasta production. This cooking behaviour is compatible with a less compact protein network, unable to limit the imbibition of the starch granules during cooking, thus favouring their solubilisation.[16] Such modifications in the protein network could be ascribed to the compositional change of eggs used for pasta production. In fact, with hen aging, a decrease in the albumen/yolk ratio was observed (data not shown), which moved

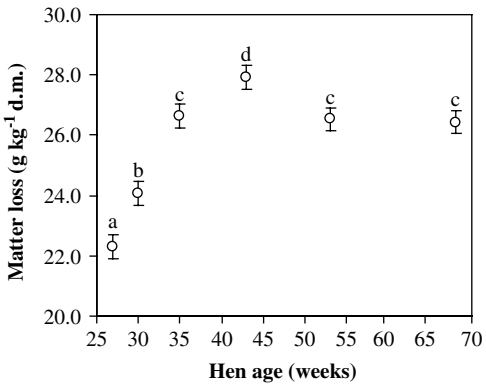


**Figure 2.** Fresh egg pasta matter loss during cooking as a function of laying hen age. Each point is the average value of the three housing systems. Error bars represent the standard error. Different letters indicate significant differences ($P < 0.05$).

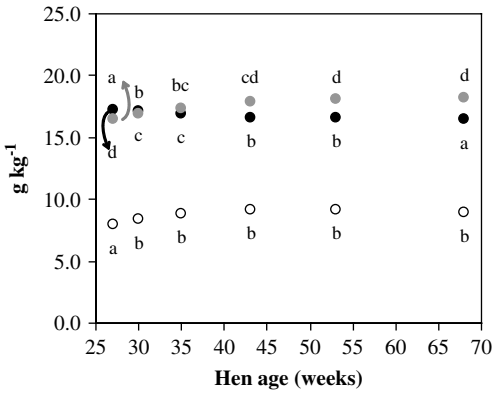


**Figure 3.** Yolk protein (○), albumen protein (●) and fat (●) contents in fresh egg pasta as a function of laying hen age. Each point is the average value of the three housing systems. Standard errors (g kg$^{-1}$): yolk protein, 0.165; albumen protein, 0.166; fat, 0.260.

the initial average value from 3.2 for 27-week-old hens to 2.6 for 68-week-old hens. The main effects of this modification were a significant increase in whole egg fat content, which changed from 81.9 (27 weeks) to 97.5 (68 weeks) g kg$^{-1}$, and a decrease in the quantity of albumen proteins in whole egg, which moved from 86.0 (27 weeks) to 71.9 (68 weeks) g kg$^{-1}$. The increase in egg yolk percentage with hen aging is a well-known phenomenon,[8,13,20] but its consequence on fresh egg pasta properties has not been studied so far. Such modifications in egg composition affected the protein and fat contents of fresh egg pasta. In particular, a significant increase in fat content and a significant decrease in albumen protein content of pasta were observed with aging of the hens (Fig. 3). The average yolk protein content in pasta is instead quite constant, with the exception of the samples produced with eggs of the youngest hens. As already observed in a previous study,[17] in which the albumen/yolk ratio was purposely modified from 0.18 to 5.82, the increase in yolk amount in the dough favours the formation of a less cohesive and continuous mass. In fact, yolk lipids inhibit the development of a gluten network during mixing, resulting in a worsening of structural characteristics and a higher weight increase of pasta during cooking. Similar structural changes were also caused by the small modification of the albumen/yolk ratio observed here as a natural consequence of hen aging. Actually, as shown in Fig. 4, significant



  

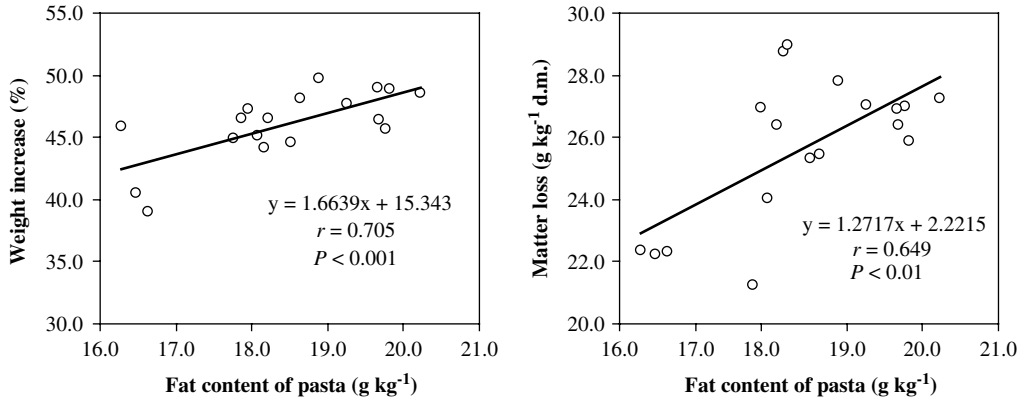


**Figure 4.** Correlations between cooking behaviour parameters and egg fat content in fresh pasta. Each point is the average value of the two pasta technological replicates obtained from each egg sample.

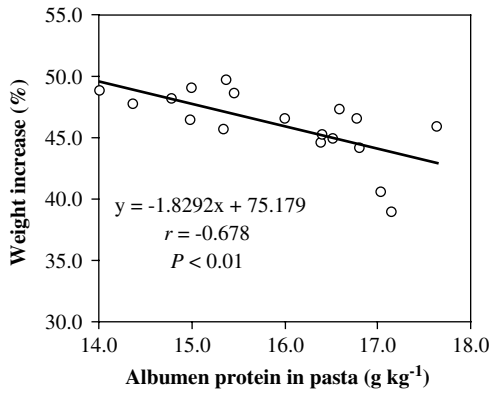


**Figure 5.** Correlation between albumen protein content in fresh egg pasta and weight increase during cooking. Each point is the average value of the two pasta technological replicates obtained from each egg sample.

direct correlations were found between pasta fat content and both weight increase ($P < 0.001$) and matter loss ($P < 0.01$), confirming that the presence of fat in the dough weakens the protein network, thus favouring the release of amylose by starch granules during cooking. The weakening of the protein network is also related to the reduction of albumen proteins in the dough, since, as mentioned in the introduction, ovalbumin plays an important role in the development of the pasta protein network in both the mixing phase and the cooking process.[16] This is confirmed by the significant inverse correlations found between albumen proteins in pasta and both weight increase ($P < 0.01$; Fig. 5) and matter loss in the cooking water ($P < 0.05$).

## CONCLUSIONS

The use of eggs deriving from different housing systems and laid by hens of different age influences the cooking behaviour of fresh egg pasta. In particular, the most significant effect is exerted by the hen age. In fact, with aging of the hens, both pasta weight increase and matter loss in cooking water grew, indicating a weakening of the protein network. Such modifications are mainly related to the decrease in albumen/yolk ratio due to hen aging, resulting in a lower content of albumen proteins in pasta and a higher content of fat brought by yolk. Instead, the housing system had a significant effect only on matter loss in cooking water, but in this case the differences observed cannot be ascribed to the albumen/yolk ratio, which was found to be similar for the eggs produced in the three housing systems (data not shown). However, these differences in matter loss are very small and it is likely that they would not be perceived by consumers.

## ACKNOWLEDGEMENT

The research reported in this paper was supported by a grant from Regione Lombardia, D.G. Agricoltura (project ECCEOVO).

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