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MICROBIOLOGICAL CONDITION OF "EGGSHELL FLOUR" IN THE FOOD INDUSTRY

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Abstract

There is an enormous need for calcium in both animal feed and human food - calcium in the proper quality, quantity and form. To meet this need, an egg producer could have an annex plant that produces "eggshell flour", a product whose basic component, egg shells, is a virtually boundless material that accumulates as waste. Thus produced, egg shell flour could be dispensed in various quantities to various food producers and feed producers.

The experiments were designed to determine the microbiological condition of egg shells. Following the customary handling, shells were broken into bits and heat treated (drying air temperature was 125 ^{0}C). Samples were diluted with cluster decimation and the total viable cell count and *Enterobacteriaceae* count was determined. Also, the samples were tested in 25 g amounts for the presence of *Salmonella* (Examination method: ISO 6579) as well as *Listeria monocytogenes* (Examination method: MSZ EN ISO 11290-1:1998).

According to the results, egg shell flour does not damage certain products' sensory characteristics and usability, and it poses no risks to food safety, either. After heat treatment, the samples displayed no signs of the pathogen *Enterobacteriaceae*, while the viable cell count remained under 10 CFU/g in every case.

This means egg shell flour may be used as a basic ingredient in both the food and feed industries, due in part to its low microbial risk. Naturally, further tests are required to determine shelf life as well as which packaging should be used for storage and merchandising.

Key words: *Egg shell, Calcium, Salmonella.*

1. Introduction

In both animal feeding and human nutrition, there is a great need for a source of calcium which is appropriate in quality, quantity, and price. To meet this need, it would make sense to establish an "eggshell flour" operation alongside an egg-processing facility. Its raw material would be the virtually endless supply of egg shells generated during production and which accumulate as waste, but contain organic calcium in significant quantities (Table 1) [1].

Nowadays, producers of foods containing eggs much prefer products such as liquid egg, which are ready for their technological requirements. Such products are easier to use and better from the food safety standpoint as well; moreover, that level of food safety is rising due to more and more technological advancements [1-14]. Facilities using liquid egg likewise need not trouble with shells.

The egg shell is often microbiologically contaminated (Table 2). The collection and treatment of shells could be done in a concentrated way [15] whereby treatment prior to breaking the eggs as well as separation after breaking could be carried out under better circumstances of inspection if done at the egg processor's location, which is much better than at a cake factory or place where buffet meals are served, for example. Moreover, the large accumulation of garbage could be converted to new products or ingredients for other products instead of becoming garbage.

One processing method for egg shells is powder, made by drying and pulverizing. The so-called egg shell flour which is thus produced may be used in various foods (pasta, noodles, egg powder, etc.), and feeds (dog and pig feed, etc.).

Table 1. Content of egg shell waste derived from broken eggs

Ingredient	Waste content of:		
	...egg protein adhering to the shell [%]	...eggshell after centrifuging [%]	...after soaking [%]
Moisture*	29.1	16.2	
Protein	7.6	5.3	5.2
Lipid	0.24	0.30	0.05
Ash	91.1	94.2	95.4
$CaCO_3$	90.9	91.8	93.1
Calcium	36.4	36.7	37-3
Iron	0.020	0.0022	0.0023
Potassium	0.097	0.072	0.060
Magnesium	0.398	0.400	0.407
Natrium	0.152	0.126	0.115
Sulphur	0.091	0.087	0.043
Phosphorus	0.116	0.104	0.117

*original moisture content

Table 2. Microbes which may occur in poultry eggshells

Microbe	Frequency
Streptococcus	±
Staphylococcus	+
Micrococcus	++
Sarcina	±
Arthrobacter	+
Bacillus	+
Pseudomonas	+
Acinetobacter	+
Alcaligenes	+
Flavobacterium	+
Cytophage	+
Escherichia	+
Aerobacter	+
Aeromonas	±
Proteus	±
Serratia	±

Legend:
± may occur from time to time;
+ occurs in small amounts in most cases;
++ always present in large amounts.

3. Materials and Methods

3.1 Basic material of the samples (egg shell)

The egg shell which served as basic material for the experiments was taken during normal factory operations from a storage container at the Capriovus Ltd Szigetcsép plant. The egg shells were transported by an auger, resulting in 0.5 to 5 cm pieces. This material had a moisture level of approximately 10%, and its temperature was 9 - 10 ^{0}C. The process is pictured in Figure 1.

3.2 Drying

Drying was done in a drying cabinet at 125 ^{0}C. Egg shells were placed in 5 cm thick layers on shelves whose holes were 1mm such that air easily circulated around the material. Drying lasted 4 hours, by which time moisture content was reduced to 1.5 - 3%.

3.3 Grinding and sifting

A hammer mill was used to reduce the grain size of the dried egg shells. When the material left the mill, it passed through a sieve whose openings measured 0.16 mm. Any material that did not fall through the sieve was returned to the mill and ground until it was considered fine enough.

3.4 Microbiological examination of egg shell flour

During the trials, measurements were taken after treatment (and in the case of *Enterobacteriaceae,* during the process as well) to determine the egg shell flour microbiological condition. The following parameters were tested: viable spore count, *Enterobacteriaceae* count, *Staphylococcus aureus* count, presence of *Salmonella enteritidis*, *Salmonella typhimurium*, and *Listeria monocytogenes* in 25 grams of material.

When determining spore count, a decimal diluent series was prepared with sterile water, followed by plate pouring with nutrient (for the *Enterobacteriaceae* count - VRBG agar, and for *Staphylococcus aureus* - Baird Parker agar).

Tests for presence of *Salmonella enteritidis* and *S. typhimurium*, as well as *Listeria monocytogenes* were done with Harlequin Salmonella ABC and PALCAM agar, following sufficient enrichment.

Figure 1. Preparation of egg shell samples

4. Results and Discussion

Eggshell moisture level decreased to an average of 2.1% over 4 hours of drying. Although the first 1.5 hours had negligible drying, afterwards a relatively stable hourly rate of 2.5 - 3% decrease occurred (Figure 2).

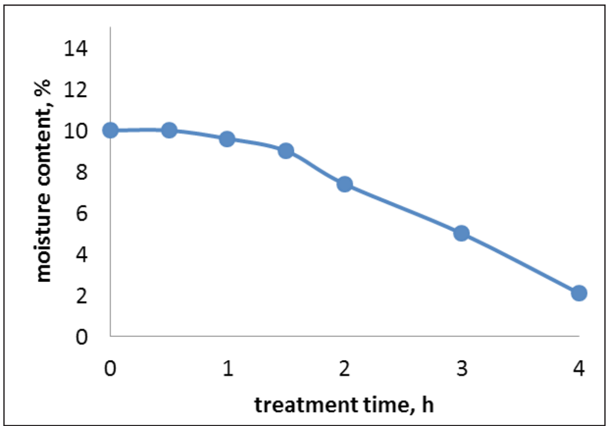

Figure 2. Eggshell moisture content change during drying

Behind this slow initial reduction in moisture content is the fact that the whole mass of eggshells heats up rather slowly at the start of the process. The 5 cm thick eggshell layer measured approximately 100 °C at its centre after 1.5 hours. Afterward the temperature of the eggshells increased, albeit at a slow rate, until at 4 hours of treatment it was 115 - 120 °C (Figure 3).

The temperature data show clearly that the drying at high temperature for an extended time is equivalent to heat treatment, which is definitely desirable in the case of raw material like eggshells.

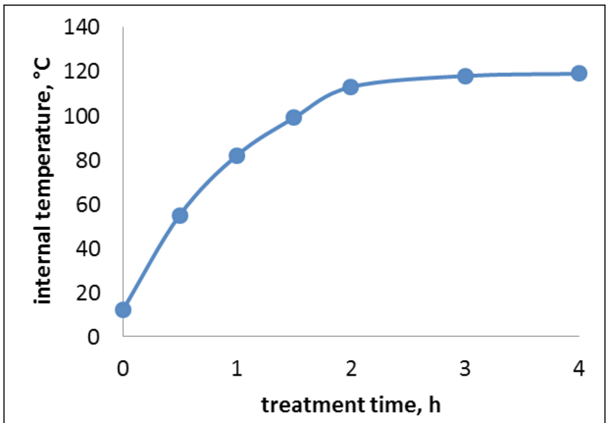

Figure 3. Internal temperature of eggshells, rate of increase during drying

Because of the intensive heat treatment, the microbiological state of the samples improved significantly. The eggshells which were heavily contaminated with fecal material and had a high *Enterobacteriaceae* count (prior to drying, nearly 10^5 CFU/g), decreased to under 10 CFU/g within just the first hour of drying (Figure 4).

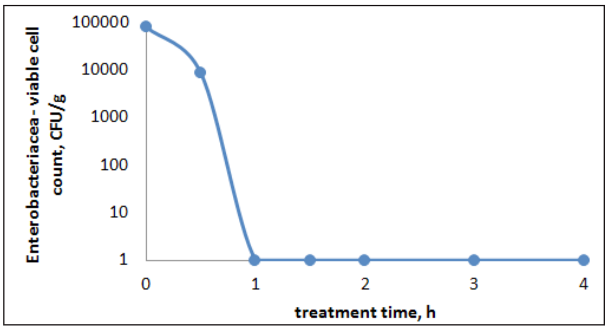

Figure 4. Changes in Enterobacteriaceae count during drying

Based on our results, it can be stated that eggshell flour neither damages the sensory nature of certain products, nor does it cause food safety risk. Heat treated samples showed no pathogens at all. The *Enterobacteriaceae* count in every case was under 10 CFU/g, while the mesophilic aerobic total spore count was under 10^2 CFU/g for all samples (Table 3).

Table 3. Microbes in eggshell "flour" after treatment

Microbe group	Result
Mesophilic aerobic total spore count (CFU/g)	below 10^2
Enterobacteriaceae count (CFU/g)	below 10
Salmonella enteritidis (present at 25 g)	negative
Salmonella typhimurium (present at 25 g)	negative
Listeria monocytogenes (present at 25 g)	negative

4. Conclusions

- Thus, eggshell flour is easily used, low-risk microbial, and good both for the food industry and in feed production as well. Naturally tests must be made to know how long it can be stored or preserved, and studies are needed to determine what kind of packaging would be suitable for storage and sale of this product.

- The egg shell can be converted into fine "flour" with easily automatable technological steps. It is easy to mix with other powders.

- Thank to our tests it is reasonable to make further investigation in order to create a usable product from this by-product.

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5. References

[1] Stadelman W. J., Cotterill O. (1995). *Egg science and technology*. Food Products Press, New York, USA.

[2] Bryson J. L., Chedid L., Michaels J. M., Rapp H., Cascione A. S. (1995). *Egg pasteurization*. Official Gazette of the United States Patent & Trademark Office Patents, 1179, (1), 326, 3.

[3] Cutler J., Hollander A. G. D., Ros A. J. (2000). *Method for treating a liquid egg product*. US 6149963.

[4] Davidson L. J. (2004). *Pasteurized eggs*. US 6692784.

[5] Liot M. (2000). *Process for obtaining long shelf life liquid egg products*. FR 2788406.

[6] Hincke M., Gautron J., Nys Y., Rodriguez-Navarro A. B., McKee M. D. (2011). *The eggshell: structure and protective function*. In: Nys, Bain és Van Immerseel (Ed.), Improving the safety and quality of eggs and egg products, Volume 1: Egg chemistry, production and consumption. Woodhead Publishing Ltd. Cambridge, UK.

[7] Németh Cs., Dalmadi I., Friedrich L., Pásztor-Huszár K., Suhajda Á., Ivanics J., Balla Cs. (2011). *Pasteurization of liquid egg by HHP treatment*. African Journal of Microbiology Research, 6, (3), pp. 660-664.

[8] Németh Cs., Dalmadi I., Mráz B., Friedrich L., Pásztor-Huszár K., Suhajda Á., Janzsó B., Balla Cs. (2011). *Study of Long Term Post-Treatment of Whole Egg Powder at 50-55 ^{0}C*. Polish Journal of Food and Nutrition Science, 61, (4), pp. 239-243.

[9] Németh Cs., Mráz B., Dalmadi I., Friedrich L., Zeke I., Juhász R., Suhajda Á. (2012). *Effect of high pressure treatment on liquid whole egg*. High Pressure Research, 32, (2), pp. 330-336.

[10] Németh Cs., Mráz B., Friedrich L., Suhajda Á., Janzsó B.,. Balla Cs. (2011). *Microbiological measurements for development of a new preservation procedure for liquid egg*. Czech Journal of Food Science, 29, (6), pp. 469-474.

[11] Swartzel K. R., Ball H. R., Hamid-Samimi M. H. (1991). *Method for the ultrapasteurization of liquid whole egg products*. US 5019408.

[12] Swartzel K. R., Ball H. R. (1991). *Method for pasteurizing liquid whole egg products*. US 5019407.

[13] Swartzel K. R., Palaniappan S. (1997). *Method for pasteurizing liquid whole egg products*. US 5670199.

[14] Wang C. Y., Hsu C. P., Huang H. W., Yang B. B. (2013). *The relationship between inactivation and morphological damage of Salmonella enterica treated by high hydrostatic pressure*. Food Research International, 54, (2), pp. 1482-1487.

[15] Moats W. A. (1980). *Classification of bacteria from commercial egg washers and washed and unwashed eggs*. Applied and Environmental Microbiology, 40, (4), pp. 710-714.