Microbial and enzymatic methods of glucose removal from egg white

Glucose removal from egg white

Identification

Key words  
egg white, albumen, fermentation, glucose removal, de-sugarization, enzymes, glucose oxidase, catalase

Latest version  
2011/06/29

Completed by  
FRIP

How does it work?

Primary objective  
Elimination of glucose from egg white enables to increase the temperature during subsequent dry heat pasteurization (hotrooming). Fresh egg white contains about 0.4% glucose. During the drying of egg white glucose causes unwanted browning. This color change is considered a sign of poor quality of dried egg white and reduces the possibility of sale.
Working principle

The removal of glucose from liquid white in industry uses two types of processes:

- the fermentation process with appropriate strains of bacteria or yeast [2, 4, 5]
- the enzyme system using glucose oxidase and catalase, or strains of microorganisms producing these enzymes.

Fermentation of egg white by naturally present microorganisms is the traditionally used method of removing glucose from liquid egg white. Experiments with addition of some bacterial strains were carried out since the forties, but the outcome could be affected by acidification of the egg mass during fermentation. The used strains must not contain organisms producing proteolytic enzymes, to avoid proteins being digested. The bacterial fermentation process has been preferred for many years because the finished egg powder has excellent whipping qualities, solubility, odor, and taste. Special bacteria single strain cultures or mixed cultures are used in this process [12, 14]. Yeast fermentation for which very specific kinds of yeast are used has not been too popular. The reason is that a yeasty flavor or odor is usually evident in the product. In the fermentation process glucose is converted into alcohol and carbon dioxide. These elements are volatile and will escape during the drying. Therefore, for industrial purposes of de-sugaring procedure, enzymes are chosen. Such process is faster and easier to control. The temperature ranges from 2°C to 15°C and in this low temperature range rapid bacterial development is avoided. Moreover, the hydrogen peroxide is an effective bacteriocide [7]. Glucose oxidase is a highly specific 'enzyme' from the fungi Aspergillus niger and Penicillium, which catalyses the oxidation of beta-glucose to glucono-1,5-lactone (which spontaneously hydrolyses non-enzymatically to gluconic acid) using molecular oxygen and releasing hydrogen peroxide. Because at higher concentrations of hydrogen peroxide, oxidation can degrade the protein molecules and inhibit further enzymatic oxidation of glucose, it is necessary to combine glucose oxidase with catalase. Catalase decomposes hydrogen peroxide into water and oxygen. Another function of catalase is providing of free oxygen to oxidize glucose to D-glucono-1,5-lactone [1].

\[
\text{Glucose oxidase}\quad \text{b-D-glucose} + \text{Enzyme-FAD} \rightarrow \text{Enzyme–FADH}_2 + \text{d-}\quad \text{-Gluconolactone} \\
\text{Enzyme-FADH}_2 + \text{O}_2 \rightarrow \text{Enzyme-FAD} + \text{H}_2\text{O}_2 \quad \text{Catalase} \quad 2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2
\]

FAD = flavin adenine dinucleotide, the cofactor of enzyme FADH2 = reduced form of the FAD.

The pH-value is reduced to 6.5-7.3 before the fermentation. Limited amounts of hydrogen peroxide are added continuously to the albumin under the fermentation process, which is completed within 10-16 hours. After the fermentation process the egg white is filtered, and pasteurized. The main disadvantages of de-sugaring by enzyme preparations are higher costs and risk of oxidation of proteins, especially at the level of the amino acids cysteine and methionine. The free glucose oxidase allows the glucose removal in egg white only with batch ordering and enzymes remain in substrate as contamination. Therefore, there were many attempts to link enzymes to a solid carrier, which allows the reuse of enzymes [3, 10, 11, 15].

Cost reduction in drying of egg albumen by conventional spray drying can be achieved by removing part of the water by preliminary reverse osmosis [13]. Egg white pH can be adjusted to pH 7 to obtain optimum results; about 60% of the water and 40-50% of glucose can be removed before the dehydration.

Images
Additional effects

- removal of glucose increases also resistance of powder against microorganisms (low content of direct substrate) and extends the shelf life of dried egg white. Therefore glucose is usually removed before drying of egg white.
- typical yeasty smell and taste of the albumen after de-sugaring by baker’s yeast or by special strains of yeast
- the bacterial fermentation process provides the finished egg powder with excellent whipping qualities, solubility, odor, and taste
- the bactericidal effect of the hydrogen peroxide
- risk of oxidation of proteins and amino acids cysteine and methionine during the enzymatic treatment
- bacterial strains used in fermentation or yeast have to be cultivated before the de-sugaring on a complex nutrient medium, which increases the cost of the process.
- the multiplication of contaminating microflora can occur in de-sugarized egg white
- egg white treated with glucose oxidase and catalase showed sometimes higher foaming ability than natural egg white, but foam stability decreased [16].

Important process parameters

- temperature, pH, enzyme/substrate ratio, microbial culture dosing, length of the cultivation or enzyme reaction, hydrogen peroxide level

Important product parameters

- final concentration of the residual glucose in egg albumen.

What can it be used for?

Products
The de-sugaring (fermentation, glucose elimination) is carried out as a separate pretreatment operation prior to drying of egg white.

Operations
After removal of glucose, egg white is pasteurized/ concentrated and dried in spray drier to powder or in pans to granules or flakes.

Solutions for short comings
The glucose removal from egg white resolves the problem of egg white solids damage during of the drying process. The microbial stability, color and the functional properties of dried egg white are improved due to this treatment. A similar process can be used for the egg yolk or whole egg mass de-sugaring.

What can it NOT be used for?

Products
- not applicable

Operations
- Not applicable

Other limitations
The industrial fermentation methods have some disadvantages. Bacterial strains used in fermentation or yeast have to be cultivated before the de-sugaring on a complex nutrient medium, which increases the cost of the process.

Risks or hazards
The multiplication of contaminating microflora can occur in de-sugarized egg white.

Implementation

Maturity
This technology is used on an industrial scale.

Modularity/Implementation
This technology is part of the production line. The choice between method using microbial fermentation or enzymatic process depends on the producer of dried egg white. The use of the reverse osmosis for concentration of egg white before drying is given mainly by economic reasons.

Consumer aspects
The de-sugaring technology of egg albumen does not cause problems in terms of public acceptability.
Legal aspects  This technology is used without legislative restrictions.
Environmental aspects  This technology will not cause environmental pollution.

Facilities that might be interesting for you

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<td>Video observation system for market research and product development tasks - Keki</td>
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Further Information

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References


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