Campden BRI
Station Road
Chipping Campden
Gloucestershire
GL55 6LD, UK

Tel: +44 (0)1386 842000
Fax: +44 (0)1386 842100
www.campdenbri.co.uk

Egg as a vital baking ingredient

The aroma of freshly made bread and other baked goods is irresistible to most people. The wide range of products that yield the delicious smells and tastes of freshly baked goods is the result of a complex interaction of various ingredients and physical processes.

Along with flour, egg is a crucial component of many baked goods due to its unique functional properties and the significant contribution it makes to structure, appearance, texture and taste. Exquisitely simple, yet enormously complex, the egg is one of Nature's marvels. It is a vital baking ingredient for a large number of products, such as cakes, pastries, meringues, macaroons, custard fillings, quiches and pancakes.

This paper discusses the structure and properties of egg used as a baking ingredient, and considers the resulting changes that arise within the product throughout the baking process.

For further information on this and other similar topics please contact:

Dr. Sarab Sahi
Rheology and Texture Specialist
sarab.sahi@campdenrbi.co.uk
+44(0)1386 842140

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Introduction

Eggs consist of a clear white substance called albumen, which is derived from *albus*, the Latin word for 'white'. Four alternating layers of thick and thin albumen contain approximately 40 different proteins, which are the main components of the egg white in addition to water[1].

The yolk contains less water and more protein than the albumen, some fat, and most of the vitamins and minerals of the egg. These include iron, vitamin A, vitamin D, phosphorus, calcium, thiamine, riboflavin and lecithin. Yolk colours range from just a hint of yellow to a magnificent deep orange, according to the feed and breed of the hen[1].

An examination of the functional properties of eggs is useful to understand how much they contribute to the baked goods we know and love today.

Binding

Whole eggs are used as a binder many baked goods, such as cakes, muffins, cookies, pancakes, waffles and doughs. Eggs are natural binders and help to hold all other baking ingredients together, while increasing the viscosity of batters and doughs. Egg white has the capability to gel and is frequently used as a binding agent in many different prepared foods. Using more whites in a cake mixture will help to create a fluffy, light baked product with a good volume and texture, while using more yolks will create a denser baked good with a deeper, richer flavour.

Aeration/Foaming

Aeration is a critical function in the formulation of baked goods. It refers to the process of introducing gas into a liquid or viscous solution. Beaten whole eggs and egg whites are highly effective leavening agents, incorporating air into the dough or batter. Processing the egg (e.g. through pasteurisation) can change its whipping properties (see Table 1). The air bubbles are trapped in the mixture and create a foam, which will expand in the oven. This causes the cakes to rise, increasing the volume and resulting in a lighter texture. Egg white aeration is also sensitive to storage conditions, with differences in whipping time and foam volume being observed with frozen and refrigerated materials.

Table 1. Effect of pasteurisation on whipping properties

Whipping Time (min)	Single pasteurisation (foam weight, g)	Double pasteurisation (foam weight, g)
2	139.01±0.00	139.00±0.00
3	89.44±0.21	85.05±0.60
4	78.19±0.43	74.93±0.42
6	66.26±0.20	62.83±0.40
8	57.41±0.13	54.66±0.49
10	53.48±0.35	51.78±0.32
12	51.37±0.31	49.68±0.10
14	50.10±0.05	48.61±0.63

Egg white's ability to make foods foam is due to complex interactions between the various proteins that make up egg white. The different protein components show a range of functionalities that affect both the tension between air-liquid interfaces as well as the viscosity of the liquid phase. The globulin fractions of proteins are highly surface active and they contribute to the formation of small bubbles when egg white is beaten, hence providing smooth texture to a cake or meringue. Another key protein is ovomucoid, which gives egg white its viscosity. This slows the draining of liquid between the foam cells, thus making the foam more stable. It's this unique combination of properties that results in egg being such an effective raw material. Egg whites can be whipped to produce foams that are six to eight times greater in volume.

Structure setting properties

Egg white proteins also contribute to the setting of the structure of batter systems. The key proteins in egg albumen fulfilling this role are ovalbumin and conalbumin (also known as ovotransferrin), which comprise 54 and 13% of egg white proteins respectively. Both are easily denatured by heat and help to set and stabilise the liquid foam to a more stable solid structure in the oven. It should be noted that the ovalbumin changes to a more heat-stable form known as S-ovalbumin during storage. In practice, this means that a higher temperature is needed in order to fully set the structure.

Emulsification

Egg yolk is rich in fat and lecithin (an emulsifier) and can therefore be used as a highly effective natural aid for emulsification. Emulsifiers provide superior palatability, mouth feel and texture, and a consistent, high quality appearance.

Emulsifiers are a crucial baking aid because they deliver process stability during the baking process, which results in increased volume and a good crumb structure. In general, emulsification stabilises the fat phase in batters, with one part of the emulsifier molecule attaching to fat and the other to water. By sitting at the fat-water interface, they hold the two phases together. This provides stability to the bubbles that form in the dough, helping to deliver an open, light, aerated texture. The effectiveness of egg in emulsification processes is enhanced by the fact that the yolk contains a complex mix of polar lipids and it is widely known that blends of emulsifiers are more effective emulsion formers and stabilizers in comparison with a single type emulsifier system.

With the help of emulsifiers, once mixed with other food ingredients, many of the fatty components of egg yolk are held in suspension, such as in batters. A non-baking example of this would be mayonnaise where yolk particles accumulate at oil-water interface and stabilize the emulsion by Pickering stabilisation.

Flavour and colour

In products such as enriched bread and pastries (as well as non-baked goods such as pasta and noodles), whole eggs are added for flavour and colour. The eggs can be added to the dough or roux either all at once or in batches. In these examples, the emulsification properties of egg provide extra value, since eggs are not the primary means of binding. Their main function is to provide good flavour and natural colour.

Whole eggs are often used as a glaze in numerous baked goods as they turn an attractive golden brown colour and shine when cooked. This is due to the Maillard reaction when the amino acids in the egg react with the reducing sugars. This reaction gives rise to the characteristic flavour and aroma of baked goods.

Eggs also add essential moisture to finished baked goods, reducing the risk of cakes and sponges which are too dry and crumbly, thus improving eating quality and overall mouth-feel.

No substitute?

Substituting eggs in baking can be a challenging task. It’s extremely hard to find one ingredient that can match all the beneficial properties of the egg and almost impossible to find an ingredient that will replicate the structural benefits of whipped egg whites.

While there are some good egg substitutes available on the market, there is no single egg alternative that can provide the functionality and natural capabilities of the egg itself. It’s normally necessary to add more functional ingredients when using egg substitutes.

For example, for binding purposes, ingredients such as ground flaxseed or potato starch may be used, but other ingredients would need to be added to provide structure building, such as soya bean or milk proteins. For emulsification, lethicin (a naturally occurring emulsifier in eggs) can be added. While this requires a label declaration, it's a generally permitted food additive in Europe (labelled as E322). Beta-carotene could be added to introduce more colour, but this adds to the list of ingredients on the packaging and can potentially deter consumers seeking a 'clean label' product.

It's important to remember that eggs are used in baking recipes for specific, functional purposes. If eggs are substituted, the resulting products will not have the same taste and texture as baked goods that incorporate eggs.

No two eggs are the same

Eggs are a naturally occurring product and one of the challenges of baking with eggs is that there is inevitably an element of variability when it comes to egg quality. The food industry needs consistency to meet consumer expectations for uniformity and stability. Free range eggs represent a challenge for the baking sector, despite being very positive for the food industry as a whole.

Egg characteristics will vary depending upon, for example, the hen's age and diet, production practices, genetics, and egg storage and distribution. Bakers must always be aware of the fact that no two eggs are the same. Different egg batches may also result in slightly different end products. The practice of blending eggs from different suppliers or suppliers from other countries which can differ in age and storage conditions adds to the complexity of the variability that can be experienced when different batches of eggs are used in the production of baked products.

Nature's marvel

Eggs are one of the most important, natural ingredients in baking. Egg-free baking recipes are few and far between, and for good reason. For many products, eggs are an indispensable ingredient. Eggs bind, aerate, leaven, emulsify, thicken and aid in setting. They are the base in many recipes and can be used as fillings, toppings, glazes and also for adding flavour and colour to baked goods. No other single ingredient in baking provides this level of functionality. Due to the humble egg's ability to do so many jobs at once, it really is Nature's very own miracle food and the reason why so many bakers all over the world have come to depend on it.

Want to know more?

Campden BRI provides help and support to the baking sector with ingredient suitability, product formulation and processing conditions to ensure that baked products meet the highest possible standards. For further information, please contact:

Dr. Sarab Sahi
Rheology and Texture Specialist
sarab.sahi@campdenrbi.co.uk
+44(0)1386 842140

For other general enquiries, please send an email to information@campdenbri.co.uk or call us on +44(0)1386 842000.

Reference

[1] https://www.exploratorium.edu/cooking/eggs/eggcomposition.html