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Effects of Emulsifier Type and Ingredient on the Foam Stability of Meringue

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ABSTRACT

Food foams provide texture and structure for many food products, such as meringues. Meringues, a fundamental of culinary arts, commonly consist of whipped egg white and sugar and have about most of the air phase. These types of composition allow for making different products with the same ingredients; thus, meringue design is essential to investigate foam stability and ability. This study aims to examine the foam stability of meringue using the different components such as protein as emulsifier (egg white and gelatin) and the composition of sugars (icing and granule) on the foam stability and formation of meringue. Using gelatin as an emulsifier showed the foam more stable than egg white (>24 h), and adding the icing sugar with gelatin made the foam texture smoother. On the other hand, foam formation was faster when using emulsifier egg white, but stability was less than gelatin. The more stable foam produced by the combination of emulsifier and sugar ingredients would provide a better texture of meringue after baking, a smooth surface, no hole, and a more crunchy sweet taste. It was concluded that the composition of the ingredients and type of emulsifier would affect the stability and ability of foam, resulting in the character of the meringue after baking.

Keywords: Foam, Foam stability, Emulsifier, Meringue, Foam agent

1. INTRODUCTION

Foams are dispersions of gases in liquids whereas emulsions are liquid in liquid dispersions [1], [2]. Foams can be generated simply by shaking a surfactant solution so that air bubbles become entrapped. The bubbles rise and liquid drains fairly rapidly from between them. Liquid foams are sometimes made relatively long-lasting by adding some substance, called a stabilizer, or emulsifier that prevents or retards the coalescence of the gas bubbles [3], [4]. Of the great variety of substances that act as foam stabilizers, the best known are soaps, detergents, and proteins. Proteins, because they are edible, find wide use as foaming agents in foodstuffs such as whipped cream, marshmallow (made from gelatin and sugar), and meringue (from egg white). In the upper part of the foam the bubbles become distorted giving a polyhedral structure (sometimes referred to as polyederschaum) in which the thin aqueous films are effectively planar and joined (at 120°) at Plateau borders (Figure 1)[5], [6].

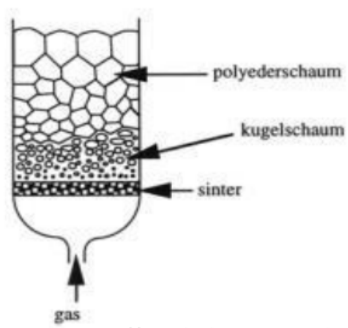

Figure 1. Formation of foam by blowing gas through a sinter into a surfactant solution. At the bottom of the column the foam is "wet" and consists of gas bubbles dispersed in the solution (kugelschaum). As the liquid drains from between the rising bubbles the foam becomes polyhedral, and consists of planar films joined at Plateau borders. This kind of foam is sometimes called polyederschaum [6].

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Table 1.Combination of protein and sugar in the foam formation

No	Code	Protein		Sugar	
		Egg white (ml)	Gelatin 10%(ml)	Icing (g)	Granule (g)
1	ENS	150	-	-	-
2	EIS	150	-	150	-
3	EGS	150	-	-	150
4	GNS	-	150	-	-
5	GIS	-	150	150	-
6	GGS	-	150	-	150

The Marangoni effect refers to the variation of surface tension of a liquid with temperature (thermocapillarity) or with the concentration of a surfactant (solutal Marangoni effect). The variation of surface tension in turn leads to convective motion of the fluid: Marangoni convection. This motion along the surface of the liquid layer then leads to flow in the bulk and may be used to transport fluids in microfluidic devices. Solutal Marangoni convection is caused by variations in the concentration of a surfactant at the interface between two liquids or a liquid and a gas. The surface tension being a function of the local surface concentration of surfactant, a variation in the latter will affect the value of surface tension locally and therefore give rise to stresses along the interface. The relation between the surface concentration of surfactant and the surface tension is a complex one which will be addressed first. Furthermore, three important dynamical phenomena need to be accounted for in order to compute the Marangoni flow for a moving interface: adsorption of surfactant molecules to the surface, transport of surfactant molecules in the bulk,and surface dilation or contraction[1], [6], [7]. The objective of this experiment is to measure the foam stability of different protein by using shake flask method and to study the effect of ingredienton the foam stability of a protein.

2. MATERIALS AND METHODS

2.1 MATERIALS

In this experimental study we use egg white, gelatine, icing sugar, granule sugar, graduated cylinder, beaker glass, household type mixer, and stopwatch.

2.2 Foam Formation

Foams were formed by whipping the protein (egg white and gelatin) and sugar (icing sugar and granule sugar) in a household type mixer at ambient temperature. The ratio of protein and sugar is 1:1 (150ml : 150g). Gelatin were prepared by dissolving 10% gelatin in water before mixing. Foams were formed by three different combination of each protein that shows in Table 1. The foam formation were recorded by using stopwatch.

2.3 Foam Ability

After mixing process, the mixer head was carefully lifted to minimize destruction of the foam structure. Samples of foam were genlty measure the volume of foam.

2.4 Foam Stability

The samples of foam that placed in the beaker glass were observed to determine the volume reducing. The time of volume reducing was recorded by using stopwatch.

2.5 Meringue Making

The samples of foam were shaped onto the lined tray by using the pastry bag. The meringues were baked by using the infrared oven at 80°C for 1 hour.

3. RESULTS AND DISCUSSION

3.1 Effect of composition and type of emulsion on the foam texture and stability

Table 2 showed the foam experiment results. We can see that the composition and type of emulsifier influenced the formation, stability and texture of foam. Foam is a substance that is formed by trapping many gaseous bubbles in a liquid or solid [3], [8]. In this experiment, we did meringue recipes to determine foam stability. The one keys of stability of foam is type of emulsifier [9]. In this experiment, we used two kinds of emulsifiers. There are egg white and gelatin. Egg albumen in egg white part has excellent food foaming properties. Such properties are determined by the ability to rapidly adsorb on the air-liquid interface during whipping or bubbling, and by its ability to form a cohesive viscoelastic film by way of intermolecular interactions. Protein molecules act as hydrophilic and hydrophobic groups. The hydrophilic groups are arranged towards the water phase and the hydrophobic groups towards the air phase. During the whipping process air comes into the solution to form bubbles, the hydrophobic regions facilitate the adsorption at the interface, process that is followed by partial unfolding (surface denaturation) Whereas the emulsifier properties of egg comes from phospholipids. Not only emulsifier properties from egg, but also it can be as stabilizer in emulsion and foam system [3], [10].

Gelatin is an amphoteric protein with isoionic point between 5 and 9 depending on raw material and method of manufacture. Like its parent protein, collagen, it is unique in that it contains 14% hydroxyproline, 16 % proline and 26 % glycine. Due to amphoteric properties of gelatin, it can be used as emulsifier [11], [12]. Figure 2 showed the effect of composition of foam in different of emulsions (egg white and gelatin) on the how long foam formation occurred. We can see that the formation of foam used gelatin as emulsifier was faster than egg. The usual emulsifier to make meringue uses egg white with sugar ratio 1:1. This results showed that gelatin had better make foam faster than egg white due to the molecular weight of gelatin is higher that emulsifier in egg white. The higher molecular weight of the emulsifier will absorb faster on the air - liquid interface during whipping [3], [13]. Thus, at the same amount of emulsifier and speed of whipping, the gelatin has lower time to make stable foam. When protein absorb air-liquid interafe, a process is followed by partial unfolding tha protein will denature. This change will loss solubility or precipitatian of some protein. The attendant of stabilized agent can reduce surface tension of the liquid - air interface. The association stabilized agent and emulsifier can fasilitate of the forming of new interfaces and the bubble. The present of sugar in this samples can fasilitate the new bubbles and more bubbles, thus the volume of foam increase due to associate the partial unfolding of protein and stabilizer [3], [14](Figure 3). The increasing of the formation of new bubble will make the longer time to make foam and following it will more stabile. This phenomena can be showed in Figure 1, the present of sugar, the time of formation of foam was longer than other samples [1], [10].

The influence of kind of sugar was also determined. The adding of granule sugar would be slower in foam formation compare than granule (Figure 1). The granule sugar has bigger particle size than icing sugar. The increasing of particle size of sugar will improve the rate of sugar powders to be wet with matrix of foam. The bigger powder tends to reduce the surface tension of air-liquid interface and then followed by the easier to dissolve into solution, that way the bigger particle size of powder has better wettability [15].

Table 2. The effect of composition ingredients and type of emulsifier on the ability and stability of foam.

Codes	Composition		Time of foam formation (mins)	Time of foam instable (mins)	Volume of foam (ml)	Texture
	Emulsifier	Sugar				
ENS	150 ml (egg white)	No sugar	2.83	5.42	750	Big foam, bigger droplets, the separation into coarse foam and is faster
EIS	150 ml (egg white)	150 g (icing)	21.43	28.80	650	Smooth ++, finer droplets
EGS	150 ml (egg white)	150 g (granule)	17.03	48.33	800	Smooth +, finer droplets
GNS	150 ml (10% gelatin)	No sugar	10	>24 hours	400	Big foam, coarse marsmello
GIS	150 ml (10% gelatin)	150 g (icing)	7	>24 hours	800	smooth, texture similar to marsemello
GGS	150 ml (10% gelatin)	150 g (granule)	5	>24 hours	800	smooth, texture similar to marsemello

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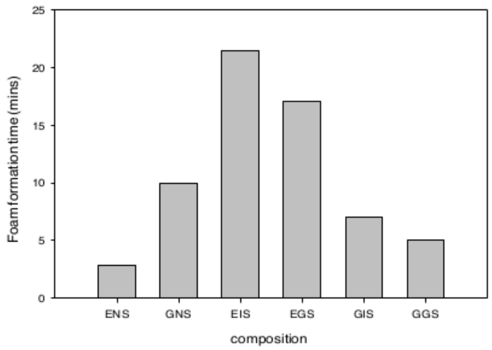

Figure 2. The effect of composition of foam ingredient on the foam formation time

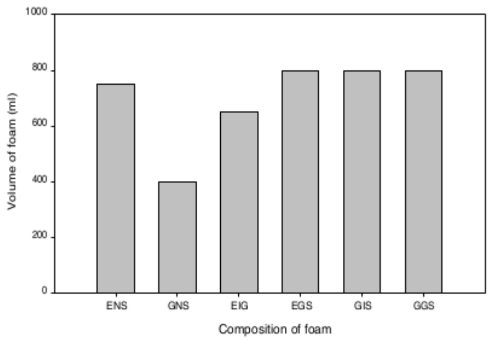

Figure 3. The effect of the composition of foam ingredient on the volume of foam formation

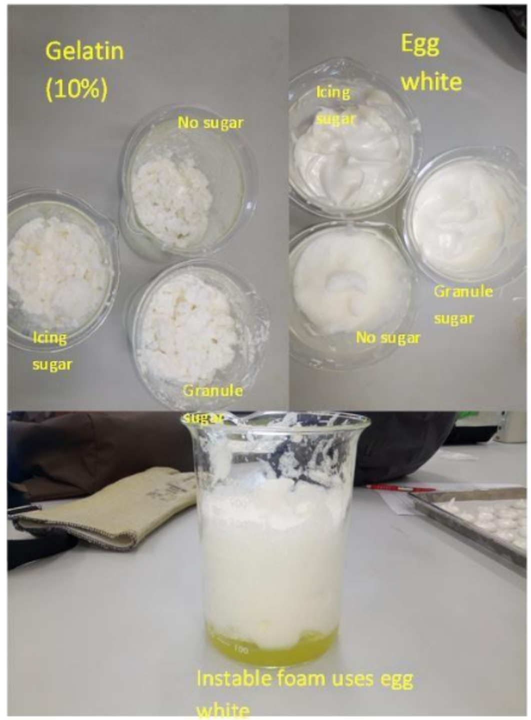

Figure 4. The photograph of foam formation from different emulsifier (upper), The instability of foam from egg white

The effect of composition of foam ingredient on the volume of foam formation was showed in figure 3. Without adding of sugar the formation of foam from gelatin was lower than egg white. Egg white contains of albumin that responsible to make more bubbles due to the highest properties to absorb the air – liquid interface rapidly. The adding of sugar in the composition will be no significant effect to volume of foam (650 – 800 ml). Not only egg white could absorb rapidly air liquid interface, but also it could produce good texture (Table 2). The texture of foam from egg white was relatively smooth and has finest droplet. On other hand, Gelatin as emulsifier had better stability of foam and texture showed finest like marsmallow (Figure 4). It could make foam stable over than 24 hours, whereas the egg white was just only less than one hour (table 1).

5.2 The Effect of the type of emulsifier of foam on the texture of meringue

The effect of type of emulsifier of foam on the texture of meringue after baking showed in Table 3 and Figure 5. We can see, gelatin could not maintain in sharp. It can be seen that all gelatin meringues were stick to baking paper. It showed that gelatin not heat resistant to maintain of foam formation during baking, thus, it may need another stabilizer.

Table 3. The effect of type of emulsifier on the texture of meringue

No	Emulsifier	Composition (emulsifier: sugar	Texture	Taste
1	Egg white	1:1	Good texture, in the sharp form, Not stick	Crunchy bake, sweet
2	10% gelatin	1:1	hard texture, Not in the sharp form, very stick with paper, it could not separate with the paper	Hard bake, sweet

Table 4. The texture of meringue from stabile an instable foam

No	Emulsion condition	Texture	Taste
1	Stable (Baking is directly after foam wipped)	Good meringue, smooth surface meringue, no hole	Crunchy+, sweet
2	Not stable (Baking is emulsion separated occurred	Still in the sharp form, not smooth surface, many holes/ pores in the meringue	Crunchy++, sweet

Figure 5. The effect different emulsifier on texture of meringue after baking at 80 °C

5.3 The Effect of stability of foam on the texture of meringue after baking

When the foam samples were storage in ambient temperature, it would be separated into two phases due to thermodynamically instable. Figure 6 showed the photograph of meringue from stabile and instable foam. Instable foam was determined after storage for 2 hours that foam showed liquid in the bottom of foam. The meringue condition after baking showed in Table 4. The different texture showed the holes or pores in meringue from instable foam resulting more crunchy taste. It may be due to the lack of albumin that absorb air-liquid interface that air droplets tend to coalesce to make bigger droplets, thus when baking leave the bigger holes[3].

Foam collapses by three principal mechanisms The first is the bubble disproportionation as a function of time, the bubbles reduce in size withtime due to air diffusion from the interior which is a region of higher pressure. The second is thelamellae rupture – bubbles coalesce quickly due to pushing and pulling forces causing holes formation between two bubbles. And the third is the drainage – water around the bubbles naturally drains down to the liquid layer removing proteins from the film around the bubble, which eventually becomes toothin to support the bubble [3], [10].

The figure 6 . The different texture of meringue from stabile and not stable foam

4. CONCLUSION

The formation of foam and retaining of the stability of foam are influenced by several factors. There are composition of ingredients and types of emulsifiers. Gelatin has better in stability of foam, but it has the worst in meringue baking. On other hands, egg white has less stability in foam, but it has better meringue texture. The molecular weight of emulsifier and presenting of another ingredient as stabilizer are also important factor of ability and stability of foam and meringue texture.

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