POTENTIAL APPLICATION OF UNCONSUMED LIQUID FROM COMMERCIAL CANNED FOOD PRODUCTS IN FABRICATION AND CHARACTERISATION OF NON-DAIRY EDIBLE FOAM

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ABSTRACT

Nowadays, the number of people restricted to consume egg and dairy products are increasing. Consequently, product formulation has to be tailored to suit with that dietary requirement. Therefore, this research is conducted to screen and characterise the properties of alternative sources for foam development from various canned pulses and vegetables. About 24 canned samples from many available pulses and vegetables canned food products were screened and compared to the egg white liquid as control. The overrun, air phase, foam density and drainage ratio were evaluated to identify potential foamation of non-dairy edible foam. The results showed that the overrun of Vegetable A and D, Pulses N, P, R and X were greater than 1000%, and comparable to egg white ($p<0.05$). This leads to increase the air phase with low density and high stability of non-dairy edible foam were formed ($p<0.05$). However, high drainage ratio was obtained in Vegetable A, C and D ($p<0.05$). In conclusion, there are 4 pulses and 2 vegetables canned samples showed capability to expand, producing light and stable foams comparable to egg white foam.

Key words: Non-dairy Edible Foam, Pulses, Vegetables, Canned Food Products.

1. INTRODUCTION

Foam is defined as a dispersal of air bubbles in a liquid (Obi, 2017). The proteins help to stabilise such system by building flexible, cohesive films around the surface of air bubbles in the liquid (Charter & Lagarde, 2014). Foam is an important contributor that makes product larger, insulating it, or changing its taste and feel without any increase in weight. Edible foams can be categorised as dairy edible foam and non-dairy edible foam. The whey protein in dairy foams is an excellent protein for water binding, emulsifying and gelling purposes (Tan *et al.*,2015). Due to the great functionality of the whey protein, dairy foams are often used in the production of many food foam products such as ice cream, and whipping cream. On the other hand, egg white is the common or only available protein source for foaming material that categorised as non-dairy edible foam. Egg white protein, the albumen, has the ability to quickly absorb on the air-liquid interface during whipping, and form a cohesive viscoelastic film by way of intermolecular interactions (Bovšková & Míková, 2011). Unfortunately, dairy and egg consumption are limited to some people. For example, vegan, who abstain from consuming meat, fish, eggs, dairy and other animal-derived products. There is also a demand for plant-based substitutes as a result of consumer health concerns regarding cholesterol, antibiotics and growth hormones often used in milk production (Janssen *et al.*, 2016). Besides, people who are in greater risk of cardiovascular diseases such as diabetes and hypertension are particular with their dietary cholesterol intake, specially egg intake (Kuang *et al.*, 2018). This study is able to provide alternative sources of edible foams especially to the community who are unable to consume eggs and dairy products.

Recently, great attention has been drawn through the internet where it is proposed that aquafaba, can be used as a replacement for egg and milk protein (Shim *et. al.*, 2018). Aquafaba is the term used for the unconsumed liquid resulted from boiling pulses. This unconsumed liquid is usually found in various commercial canned food products. During the canning process, some of the essential proteins lost in cooking may not totally debase, but rather be leached into the cooking liquid (Hill, 2017). A successful formulated eggless sponge cake by using aquafaba has been achieved in previous study, aquafaba, wastewater from chickpea canning, functions as an egg replacer in sponge cake (Mustafa *et al.*, 2018). Besides, there are more commercial canned food products available other than pulses, such as the vegetable canned products. Vegetables do not have nearly as much protein as legumes and nuts, but some do contain significant amount of proteins (Macmillan, 2017). However, as studies regarding pulses are still new as well as researches involving vegetables as the potential foaming agents have not been investigated, thus, the aim of this study is to screen and characterise the properties of various canned liquid of pulses and vegetables for development of non-dairy edible foam.

2. LITERATURE REVIEW

Foam can be defined as a two-phase colloidal system in which the air bubbles are widely distributed in the continuous liquid phase (Ho *et al.*, 2019). Foam formation only occur when there is protein in the liquid. The systems are stabilised by proteins by forming flexible, cohesive films around the surface of the air bubbles (Wittaya, 2012). Foam happens in two basic steps. Firstly, foam is able to produce mechanically through agitation such as beating the liquid causing air to be absorbed and eventually producing bubbles and lasty, foam. Second is by addition of surfactants between two liquids or a liquid and a solid. In food industry, foam can be categorised as dairy edible foam and non-dairy edible foam.

Dairy products are the foods derived from milk. The foamability of milk is determined by the swiftness commonly the whey proteins can move to the air-liquid interface, whereas foam stability is determined by the ability of the absorbed proteins to form a cohesive viscoelastic film via formation of intermolecular bonds (Kamath *et al.*, 2011). Dairy foams are highly likeable by consumers because of the sensory pleasure delivered that enhanced taste and texture of a food product. For example, the air in ice cream makes it sensorially more thrilling than only ice slush itself (Green *et. al.*, 2013). The second type of edible foam is the non-dairy edible foam and the only and common example of non-dairy products is the egg white. Eggs are sources of macronutrients, fats and proteins that play crucial functions in basic nutrition (Miranda *et al.*, 2015). Egg white protein, the albumen, has the potential to quickly absorb on the air-liquid interface during bubbling, and form a cohesive viscoelastic film by way of intermolecular interactions (Secci *et al.*, 2020). Although there are huge benefits of dairy products and egg in food foam products, there are also some undesirable effects of its consumptions in the society such as high saturated-fat content (Miranda *et al.*, 2015; Visioli *et al*, 2014).

Aquafaba is discovered from liquid obtained from commercial canned chickpeas or other pulses (Mustafa *et al.*, 2017). Other than pulses, there are some vegetables that consist high amount of proteins. For instance, mushrooms have excellent nutritional values as they are quite rich in protein (Valverde *et al.*, 2015). Vegetables can be boiled and are found in commercially canned food products same as the pulses. Proteins properties are important to form stable foams in the production of variety of foods (Wang *et al.*, 2014). Foaming properties of proteins are commonly assessed by aeration characterisation, foaming capacity and foaming stability (Nicorescu *et al.*, 2011). Foams quality and stability have been evaluated by measuring the foaming attributes such as index of whipping, index of foam durability, foam density, overrun and air phase (Bovšková & Míková, 2011). In addition, foam stability can be examined by measuring the foam drainage. A better foaming stability is indicated through the lower drainage value obtained (Tan *et al.*, 2015). Therefore, as pulses and vegetables liquids are still new in the food foam products, important analyses must be done in the foam produced by these foaming agents such as the foam aeration characteristics.

3. METHODOLOGY

3.1. MATERIAL AND PREPARATION OF CANNED LIQUID

Twenty pulses and four vegetables commercially canned food products are bought from supermarkets located in Kota Kinabalu and Papar, Sabah. The canned liquids were collected by separating it from its food products by using a stainless-steel strainer. 100ml of each canned liquid was whisked until it reached stiff peak by using a mixer (Kitchen Aid, America) for a maximum time of 15 minutes with speed of 10, at room temperature, 25°C (Tan *et al.*, 2015).

3.2. DETERMINATION OF FOAM AERATION CHARACTERISTICS

Foam characteristics such as overrun, air phase, foam density and drainage ratio were calculated by using the equation from Dabestani & Yeganehzad (2019). Potential formation of non-dairy edible foam is compared with egg white.

3.2.1 DETERMINATION OF FOAM OVERRUN

The percentage of overrun is used to determine the foaming capacity of the canned liquid. Before the canned liquid was mixed, the initial volume of the liquid was measured. The initial liquid volume for all the samples was the same which is 100ml. This is to ensure accuracy in result. Right after the canned liquid has reached stiff peak, the foam was transferred to a 2000ml measuring beaker. Triplicate result of the foam volume was taken. The volume of the foam was measured in ml.

$$\text{Overrun (OR) (\%)} = \frac{\text{Foam volume - Initial liquid volume}}{\text{Initial liquid volume}} \quad \text{X} \quad 100$$

3.2.2 DETERMINATION OF FOAM AIR PHASE

Next, percentage of air phase was calculated by using the result of each foam overrun percentage from previous experiment

$$\text{Air phase (\%)} = \frac{\text{OR}}{\text{OR + 100}}$$

3.2.3 DETERMINATION OF FOAM DENSITY

After the foam volume was measured, the beaker filled with the foam was immediately put to a weighing scale to measure its foam density in g. The original weight of the measuring beaker used was measured beforehand. 100ml foam mass is the result of the foam mass with beaker subtracts the beaker weight. Triplicate result of 100ml foam mass was taken. The density of 100ml water mass was referred from a trusted source to ensure accurate result.

$$\text{Foam density (g/cm}^3\text{)} = \frac{\text{100ml foam mass}}{\text{100ml water mass}}$$

3.2.4 DETERMINATION OF FOAM DRAINAGE RATIO

To calculate the drainage ratio, the successful foam was then transferred to a strainer with a beaker at the bottom to take the drops of the drained liquid. After 30 minutes, the weight of the beaker filled with the drained liquid was measured in g. The original weight of the beaker used was measured beforehand. The weight of the drained liquid after 30 min is the result of the weight of drained liquid with beaker subtracts the weight of the beaker used. Triplicate result of the drained liquid weight after 30 min was taken. The result of each sample 100ml foam mass was taken from previous experiment.

$$\text{Drainage ratio} = \frac{\text{weight drained liquid after 30 min}}{\text{100ml foam mass}}$$

3.3. EXPERIMANTAL DESIGN AND STATISTICAL ANALYSIS

Based on the foam characterisation, the best foaming liquids were selected by comparing it with egg white foam. The data is represented in mean ± standard deviation. The means of collected data were analysed by advance analysis in Statistical Package (SPSS Inc., version 26.0) application for Windows, ANOVA tests. The differences between the mean values were calculated using Tukey's multiple comparison tests at 95% confidence level ($p<0.05$).

4. RESULTS & DISCUSSION

4.1. OVERRUN

Overrun measured capacity of a liquid to incorporate air in foam formation. Table 1 shows that the canned samples had significant different in overrun as compared to control sample ($p<0.05$) except for aquafaba N and P were not significantly different with control ($p>0.05$). Overrun with 1000% or more is chosen as able to form a foam comparable to control. The selected samples are chosen based on the comparison made with the egg white as control similar to the previous study by Mustafa *et al.* (2018). Therefore, the six samples selected are Vegetable A (1000.00%), Pulses R (1066.67%), Vegetable D (1200.00%), Pulses X (1366.67%), and Pulses N and P, both with 1466.67%, same as control. Higher overrun implies greater incorporation of air bubbles and better foaming capacity of the protein (Tan *et al.*, 2015). Most of the selected pulses samples contained less than 1 g of sugar as per stated on its nutritional facts. Meanwhile, there are no sugar being added in vegetables canned samples. The selected sample Pulses R obtained higher percentage of overrun (1066.67%) despite its sugar content of more than 1g. This is most probably due to the lower foam density of the liquid as compared to other canned food products with sugar. Most of the canned liquids that are not selected have sugar content of more than 1g which might contribute to the lower foam overrun. Increase in foam density along with decrease in air phase and dramatic decrease in overrun are all evidences for reduction in sample foaming properties (Dabestani & Yeganehzad, 2019).

Table 1: Non-dairy edible foam characteristic of pulses and vegetables canned from different types of brands

Sample	Overrun (%)	Air Phase (%)	Foam Density (g/cm^3)	Drainage Ratio
Vegetable A	1000 ± 0.00^{j}	0.90 ± 0.00^{k}	0.14 ± 0.00^{bcd}	1.14 ± 0.00^{k}
Vegetable B	586.67 ± 11.55^{f}	0.83 ± 0.00^{h}	0.19 ± 0.01^{f}	0.98 ± 0.03^{j}
Vegetable C	983.33 ± 5.77^{ij}	0.90 ± 0.00^{k}	0.15 ± 0.00^{cde}	1.18 ± 0.00^{k}
Vegetable D	1200.00 ± 0.00^{l}	0.92 ± 0.00^{m}	0.12 ± 0.00^{b}	1.14 ± 0.00^{k}
Pulses E	486.67 ± 11.55^{e}	0.79 ± 0.00^{f}	0.21 ± 0.01^{fg}	0.12 ± 0.01^{c}
Pulses F	343.33 ± 5.77^{c}	0.71 ± 0.00^{d}	0.28 ± 0.01^{i}	0.29 ± 0.01^{e}
Pulses G	483.33 ± 5.77^{e}	0.79 ± 0.00^{f}	0.21 ± 0.01^{fg}	0.20 ± 0.01^{d}
Pulses H	200.00 ± 0.00^{a}	0.50 ± 0.00^{a}	0.40 ± 0.00^{k}	0.95 ± 0.00^{j}
Pulses I	933.33 ± 28.87^{i}	0.89 ± 0.01^{k}	0.13 ± 0.02^{bc}	0.00 ± 0.00^{a}
Pulses J	683.33 ± 5.77^{g}	0.85 ± 0.00^{i}	0.20 ± 0.01^{f}	0.05 ± 0.00^{ab}
Pulses K	583.33 ± 5.77^{f}	0.83 ± 0.00^{h}	0.23 ± 0.01^{g}	0.22 ± 0.01^{d}
Pulses L	583.33 ± 5.77^{f}	0.83 ± 0.00^{h}	0.23 ± 0.01^{g}	0.59 ± 0.03^{g}

Pulses M	493.33±5.77^{e}	0.80±0.00^{fg}	0.21±0.01^{fg}	0.62±0.03^{g}
Pulses N	1466.67±57.74^{n}	0.93±0.00^{n}	0.14±0.01^{bcd}	0.02±0.00^{a}
Pulses O	843.33±11.55^{h}	0.88±0.00^{j}	0.16±0.01^{de}	0.80±0.03^{i}
Pulses P	1466.67±57.74^{n}	0.93±0.00^{n}	0.06±0.01^{a}	0.61±0.12^{g}
Pulses Q	586.67±11.55^{f}	0.83±0.00^{h}	0.25±0.02^{h}	0.47±0.04^{f}
Pulses R	1066.67±57.74^{k}	0.91±0.01^{l}	0.14±0.04^{bcd}	0.09±0.03^{bc}
Pulses S	413.33±5.77^{d}	0.76±0.00^{e}	0.21±0.01^{fg}	0.32±0.02^{e}
Pulses T	253.33±5.77^{ab}	0.61±0.01^{b}	0.39±0.01^{k}	0.04±0.00^{ab}
Pulses U	693.33±11.55^{g}	0.86±0.00^{i}	0.20±0.01^{f}	0.64±0.02^{g}
Pulses V	296.67±5.77^{bc}	0.66±0.01^{c}	0.35±0.01^{j}	0.73±0.02^{h}
Pulses W	503.33±5.77^{e}	0.80±0.00^{g}	0.21±0.01^{fg}	0.94±0.05^{j}
Pulses X	1366.67±115.47^{m}	0.92±0.01^{m}	0.06±0.00^{a}	0.00±0.00^{a}
Control	1466.67±57.74^{n}	0.93±0.00^{n}	0.17±0.01^{e}	0.00±0.00^{a}

Different letter in the same column indicate significant differences (p<0.05), Mean±S.D. n=3

4.2. AIR PHASE

Based on the equation used in the methodology, the air phase results are highly affected by the percentage of overrun. The air phase values were ranged from 0.05 to 0.93% (Table 1). Pulses H with overrun of 200% had the lowest air phase as compared to all samples (p<0.05). The air phase of selected six samples are comparable to control with overrun values of equal or more than 0.90%. Higher air phase has resulted in the increase of number of bubbles and thus, extends path for liquid to flow out from the foam structure through bubbles lamella (Dabestani & Yeganehzad, 2019).

4.3. FOAM DENSITY

A good foam has a lower value of foam density. Pulses H and T with overrun of 200% and 253.33%, respectively showed high foam density compared to all samples (p<0.05). Meanwhile, the six selected samples are comparable to control in their foam density (p<0.05). Increase in foam density and increasing the viscosity leads to a decrease in the incorporation of air, which results in the reduction of the foam expansion (Mohammadian & Alavi, 2016). Foam expansion is crucial in making excellent aerated foods with desirable volume such as cakes. Longer capacity of gas retention and cake expansion in control due to swelling of starch and protein foam expansion may explain its high cake volume (Rodríguez-Garcíaet *et al.*,2014). The six selected samples showed not only a comparable high overrun, but also comparable low foam density to the egg white control which will assist in making excellent aerated foods.

4.4. DRAINAGE RATIO

Drainage ratio is an indicator of foam stability and the low values indicate the foam is highly stable (Tan *et al.*, 2015). Overall, the drainage ratio of the pulses foam is lower than foam from canned vegetables (p<0.05) except for Pulses H which had no significant different with Vegetable B (p>0.05) as shown in Table 1. The addition of salt in both pulses and vegetables canned samples might affect the foam stability. Additives such as salt and disodium EDTA might supress viscosity and foam stability as aquafaba from chickpea canned with these additives had lower viscosity and produced foams with lower foam stability (Shim *et al.*, 2018). Pulses foams in this study had sugar being added but not in the vegetables canned samples. This helps pulses liquid to form a more stable foam. The liquid drainage by gravity force can be significantly reduced by the addition of sugar (Altalhi, 2013). Good quality of pulses and vegetables canned liquids to act as a foaming agent is analysed through the liquid's foam properties including foamability and stability. Even though air is incorporated during foaming, aeration is only achieved by a stable network capable of retaining air bubbles in the foam systems (Tan *et al.*, 2015). Therefore, foam stability of each canned pulses and vegetables must achieve a low drainage ratio in order for it to become a potential foaming agent comparable to the egg white in food foam products. Although Vegetable A and Vegetable D have a high percentage of overrun, its drainage ratio of 1.14 is the highest among the six selected samples. These vegetable samples are not stable and foam produced may collapse in any time and thus, will affect the making of aerated foods such as biscuits.

The final aerated structure and volume of the biscuits depend on both the aerated structure of the batter and the expansion of bubbles during baking (Edoura-Gaena *et al.*, 2007). Loss of aeration results in a smaller product with a coarse texture (BIRT, 2010).

5. CONCLUSION

Six samples consist of 4 pulses cans and 2 vegetables cans showed potential in the formation of non-dairy edible foam. The pulses foams were comparably expanding, light and stable to egg white foam. Although vegetable foams have a very low stability, it is still chosen as its foam overrun exceeds 1000%. This study still in the screening stage therefore further analysis such as chemical composition and protein type of the liquid samples will be conducted on these six samples.

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