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# Physical and Chemical Properties of Mozzarella Cheese Analogue Microwavable

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**Abstract :** The purpose of this study was to improve physical and chemical properties of mozzarella cheese analogue microwavable using modified casein and inulin, there are 3 step researches. The method of stage 1 using combination of concentration of calcium chloride ($CaCl_2$) (0.025, 0,050 and 0.075% (w/v)) and pH (4.2, 4.6 and 5.0) treatments to determine the appropriate of modified casein. The method of stage 2 using five ratio of modified casein : inulin (50:50, 60:40, 70:30 and 60:40) treatments in mozzarella cheese analogue manufacturing. The method of stage 3 using five level of microwave power level (Low, Medium low, Medium, Medium high and High) treatments on manufacturing of mozzarella cheese analogue microwaveable.

The results showed that combination of $CaCl_2$ 0.025% (v/v) and pH 4.6 gave desired rheology properties. The ratio of modified casein: inulin gave similar effectiveness in terms of SEM profile and sensory properties of mozzarella cheese analogue. The higher level of microwave power decreased moisture content, increased protein content, fat content and volumetrix expansion of mozzarella cheese analogue, decreased cavity in the microstructure by SEM and sensory properties of both taste and aroma was similar however color score decreased and crispiness score increased.

It concluded that modification casein using $CaCl_2$ 0.025% and pH 4.6 produced more viscous than elastic and desired rheology properties of modified casein. Increasing inulin in modified casein:inulin ratio tend decreased sensory properties and cavity in the microstructure of mozzarella cheese analogue. Microwave power level affect the composition, volumetric expansion, sensory properties and microstructure of mozzarella cheese analogue microwaveable.

**Keywords :** Modified casein, Inulin, Mozzarella cheese analogue, Microwaveable, physical, chemical.

## Introduction

Milk is a complex component[1], have been recognized as important human nutrition[2]. Milk protein sensitive to the nature of the interacting materials[3], milk casein generates bioactive peptides with antihypertensive and antioxidative activities[4].

Casein is milk protein as casein micelles, ie monomer complex aggregate over the bridge of calcium phosphate[5]. Caseins are phosphorylated at clusters of serine residues. β-Casein contains 5 phosphoseryl residues, and αs1-CN contains 8 to 9 residues, and αs2-CN contains 10 to 13 residues[6]. The stability of casein micelles is due to hydrophobic interactions and Ca phosphate salt bridges[7]. The linkage between colloidal Ca phosphate and the casein structure is due to a series of phosphoserine residues[8]. Casein can be disrupted by changes in pH[5]. The nature of the casein will precipitate under acidic conditions (low pH), because its solubility is lower in acid conditions[9].

Casein determines the physico chemical properties of mozzarella cheese. Casein crosslinked with calcium becomes important on the functionality of the cheese. Electrostatic interactions between proteins take place in the cheese matrix is influenced by pH, through crosslinking by calcium[10].

Casein modifications necessary to improve such properties, one of them with a crosslinking method. pH adjustment and the use of crosslink agent have a strong effect on the protein matrix. Crosslink agent commonly using calcium chloride or transglutaminase[11]. Casein structures can be modified by variation of the physico-chemical environment through the release and deposition of calcium phosphate, it occurs at acidic pH. Milk turns into transparent in alkaline pH as well as the release of calcium phosphate and casein micelles destructuration original structure[12].

Inulin is a oligosaccharide that exerts beneficial effect on glucose intolerance, the metabolic syndrome and serum triglycerides[13]. Inulin can be used as a fat substitute up to 63% of the fat of mozzarella cheese analog. Addition of inulin affect to the texture and rheology of cheese analogue, but it has no effect on the melting power of mozzarella cheese analogues[14]. Inulin is a dietary fiber which is added to food products to increase fiber and calorie content. Inulin is known as dietary fiber are difficult to digest by digestive enzymes, but it can be fermented by bacteria in the digestive organs as a prebiotic. Inulin is a mixture of chain fructan that widely found in nature as a plant carbohydrate that can be classified as fructo-ligosaccharide (FOS)[15].

Today's some society has been selective in eating, diet and health issues become a major factor choosing a snacks. Some community avoid foods that contain higher fat to prevent various diseases such as cardiovascular, high blood pressure and obesity due to consumption foods that containing higher fat. The application of microwave technology in cheese is a new way to produce a crispy snack foods that beneficial for health[16]. Introduction mozzarella cheese analogue microwaveable is expected to be an innovation in healthy food.

Mozzarella cheese analog microwaveable containing inulin as a healthy food needs an observation on rheology properties, protein content, fat content, moisture content, volumetrix expansion, Scanning Electron Microscopy (SEM) and sensory both modified casein and mozzarella cheese analogue before and after heated with microwave.

## Experimental

### Materials

The materials in this research were bovine milk, NaCl, modified casein, mozzarella cheese analogue, calcium chloride ($CaCl_2$) (Merck), lactic acid (Merck), bovine casein, ethanol (Merck), citric acid (Merck), protease, sodium citric (Merck), sodium tripolyphosphate (STPP), carboxymethyl cellulose (CMC), guar gum and inulin (Orafti, GR).

### Casein isolation

1 L of bovine milk centrifuged at 3000 rpm for 10 minutes, milk cream was separated from skim, 500 ml of skim milk was heated at 40°C in waterbath, add 10 drops of 10% glacial acetic acid slowly, stirred until no more cloth formed, taken precipitate, omitted milk fat by adding 25 ml of 96% ethanol, repeated two times, left it for a while, then the precipitate was taken, dried and crushed to fine precipitates[17].

**Casein modification**

Soaking bovine casein in $CaCl_2$ solution with different pH according to the treatments (CaCl2 0.025; 0.05; 0.075 g/ml and a pH of 4.2; 4.6; 5.0), the colloid was cooled at 4°C for 30 minutes, remove modified casein and left at room temperature for 10 minutes, casein stored at 4°C[11].

**Manufacturing of mozzarella cheese analogue**

Pasteurized milk was warmed at 35°C, add citric acid (0.05%) and protease (0.025%) and wait for 15 minutes, cut the curd to remove the whey as much as 3 times and wait for 15 minutes each cutting times, remove curd and blend together with salt (1%), 1% sodium citrate (1%), citric acid (0.1%), STPP (0.25%), CMC (0.25%) and modified casein according to the treatments (50%, 60%, 70% and 80%), heated and stretched the mixture of mozzarella cheese component that has been blended, when the temperature reach 50°C add inulin according to the treatments (50%, 60%, 70% and 80%) and stretch at 75-80°C and then removed[16].

**Manufacture of Mozzarella cheese analogue microwaveable**

Mozzarella cheese analogoue sliced put in aluminum foil, heated at different power level of microwave (Low, Medium low, Medium, Medium high and High) for 2 minutes on each treatment[16].

**Rheological measurement**

Samples were taken with a 20 mm diameter and covered with aluminum foil. Samples were stored at 4°C for 24 hours. Samples to be tested was placed on the surface of the plate. TA Instrument rheometer prepared and arranged according to the measurement, ie the sweep frequency was set at a temperature of 20°C and the strain amplitude at 0.5% with a variation of 0.01-10 Hz frequency. Set the temperature constant at a frequency of 1 Hz and strain amplitude constant at 0.5% with a temperature of 20-90°C at a temperature of 3°C / min using a Peltier heating element. Specified storage modulus (G') and loss modulus (G")[18].

**Microstructure**

Very thin sample was placed evenly on the aluminum plate that has two sides. Samples coated with a layer of metal powder coating containing gold for 30 seconds. Observed the microstructure using Scanning Electron microscopy (SEM) with a voltage of 15 kV and a magnification of up to 5000x[19,20].

**Protein content**

1 gram sample placed in Kjeldahl flask, add a third kjeldahl tablet and 15 ml $H_2SO_4$, destructed on the hood with a temperature of 200-250°C for 2-3 hours (until the clear green color formed). 50 ml of distilled water was added to the results of destruction then transferred to erlenmeyer and add 15 ml 40% NaOH. Distilled with a distillate accommodated in erlenmeyer which contain 50 ml of 3% boric acid and added 2-3 drops of methyl orange and indicators PP. Distillate obtained by distillation terminated after 50 ml. Titrated distillate obtained using 0.2 N $H_2SO_4$ until the color changes to pink. The protein content was calculated as follows[21,22].

% N = (N HCl x titration mL x 14.008) / (weight of sample (g) x 1000) x 100%

The percentage of N protein content of the sample could be calculated by multiplying the conversion factor N of milk x % N.

% protein content = % N x FK N
Description:
Milk correction factor N = 6,38
N HCl = 0.12872

**Fat content**

Extraction thimbles were dried to constant weight at 105°C, dried sample ground into small particles and 3 g (X) homogenate sample filled to extraction thimble. The thimbles plus sample were extracted in a

Soxhlet apparatus for 5 h using petroleum ether. Samples aerated briefly to evaporate petroleum ether, furthermore dried in oven for 24 hours at 105°C. Dried sample was inserted in a desiccator for 15 minutes. Weights the dried extracted samples were determined. Fat content determined using a calculated as[21]:

% Fat content = (initial weight-final weight) / (initial weight) x 100%

**Moisture content**

The cup dried in oven at 100-105°C for 30 minutes, weight until constant. The sample ground into small particles and 3 g (X) homogenate sample filled to the cup, weight wet sample immediately using analytical balance and record as "wet weight of sample". Dried it in oven at 105°C for 24 hours, placed in a desiccator for 15 minutes and weighed to constant weight (Y). Moistute content was calculated as[23]:

% Moisture content = (initial weight-final weight) / (initial weight) x 100%

**Volumetrix expansion**

Sample prepared with a thickness of 2 mm and a diameter of 2 cm. Samples were wrapped in aluminum foil and stored at 4°C for 24 hours. The samples placed on the surface of the pan. The samples were tested in accordance with the desired temperature of the microwave for 2 minutes. The observation was repeated 2 times and volumetric expansion calculated as[16]:

% Volumetrix expansion = (initial weight-final weight) / (initial weight) x 100%

**Sensory evaluation**

Samples were prepared according to the number of panelists. Each sample was given identity /code with as many as three-digit numbers randomly. Questioner for the panelists were prepared in the scale interval of low intensity to high intensity (as needed). Panelists were explained about the test objectives and procedures for awarding scores to assess a sample[24].

**Statistical analysis**

Data were analyzed by analysis of variance (ANOVA) followed by Honestly Significant Difference Test (HSD)[25].

## Results and Discussion

**Effect of pH and CaCl2 content on rheologycal properties of modified casein**

Based on the rheology analysis at Fig 1 was known that all treatment of pH, level of $CaCl_2$ and a combination of pH and levels of $CaCl_2$ showed that storage modulus (G') higher than loss modulus (G") as the range of the temperature changing from 0°C to 40°C, which indicated that modified casein had more viscous than elastic, the G'and G" were parallel. Increasing temperature from 0°C to 40°C for all treatments showed decreasing of storage modulus (G') and loss modulus (G"), this may have been caused by weakening of protein-protein interactions within the casein network[9]. However, the combination of pH 4.6 and 5.0 with $CaCl_2$ showed that storage modulus (G') and loss modulus (G") increased when heated at 40°C or higher.

Casein has an isoelectric point (pI) at pH 4.6, at pH 5.0 or higher than pI the protein has a net negative charge, however at pH 4.2 or or below than pI the protein has a net positive charge. At pH higher than pI, $Ca^{2+}$ ion has important role in electrostatic attractive between micelle casein which has negative charge especially if casein heated at 40°C or higher. The addition of $CaCl_2$ at 0.025, 0,050 and 0.075%-resulted in the formation of intra- and intermolecular crosslink, if casein micelles has negative charge. However, at pH 4.2 or below pI, micelle casein has positive charge, formed electrostatic repulsive, $Ca^{2+}$ ion has no capability to create an interaction between micelle casein. Combination pH and $CaCl_2$ induced more intensive interaction intra- and intermolecular micellar casein, resulting in the attraction between the casein micelles are more powerful if pH higher then pI,

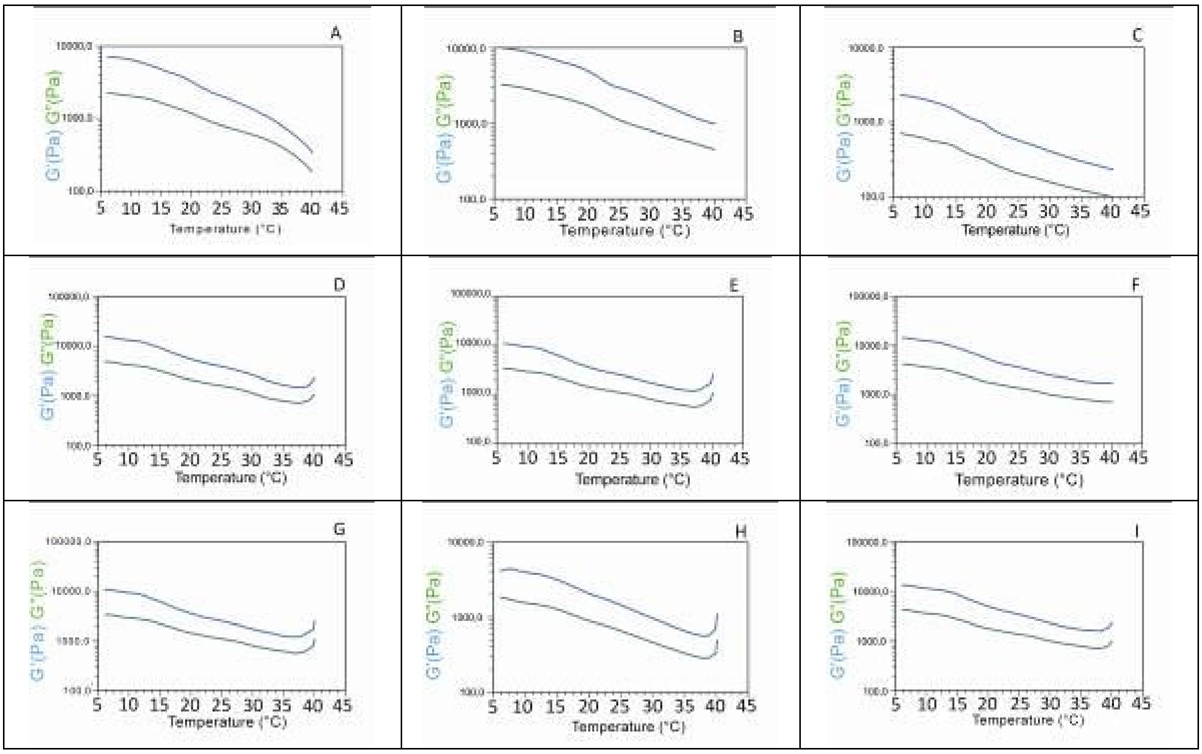


**Figure 1. Rheology properties of modified casein**

A. $CaCl_2$ 0.025%, pH 4.2
B. $CaCl_2$ 0.050%, pH 4.2
C. $CaCl_2$ 0.075%, pH 4.2
D. $CaCl_2$ 0.025%, pH 4.6
E. $CaCl_2$ 0.050%, pH 4.6
F. $CaCl_2$ 0.075%, pH 4.6
G. $CaCl_2$ 0.025%, pH 5.0
H. $CaCl_2$ 0.050%, pH 5.0
I. $CaCl_2$ 0.075%, pH 5.0

A decrease in storage modulus and loss modulus may be due to the influence of the plasticity of casein that increased hydration of casein to water. When the storage modulus and loss modulus declined may be due increasing plasticity of protein matrix which more hydrated due to increasing of moisture content[26].

Casein hydration was also affected by low calcium in the casein matrix. The decrease in calcium levels result in increased hydration casein. The addition of calcium ions in the casein have a important role in the chemically modification of casein, thus forming intermolecular interactions between the casein molecules that are required in the formation of the protein network[20]. Decreasing storage modulus and loss modulus after reaching a temperature of 40°C may be due to low calcium content.

Interactions between calcium and casein in the matrix of casein molecules occur as positively charged calcium ions associate with negatively charged regions of casein. This could lead to the neutralization of the charge repulsion between the casein. Divalent calcium-calcium could contribute to bridge between proteins become stronger, because crosslinking process in casein matrix[28]. pH affect on the structure and functional properties of cheese, in this section there was a relationship between calcium, casein and pH. Casein associated with calcium serves as a crosslinking agent in casein matrix[29,30].

Chemically modification of casein which could formed casein more resistant to heating. Chemical method was one method of modification of the structure of casein which aimed to improve the functional properties of casein. Casein was very important in the formation of the physico chemical properties of the cheese. Chemical methods using formaldehyde produced a permanent changes in casein. The structural of modified casein produced a heat-stable polymer[31].

Casein was expected to improve the functional properties of mozzarella cheese analogue. pH affects the interaction between calcium and casein that play a role in shaping the functional properties of cheese[10].

**Effect of modified casein and inulin ratio on mozzarella cheese analogue**

**Microstructure**

The microstructure of mozzarella cheese analogue with the addition of modified casein and inulin at several ratio observed using Scanning Electron Microscopy (SEM) shown at Fig 2. Mozzarella cheese microstructural images showed the increasing proportion of inulin in modified casein:inulin ratio produced more uniform of cheese matrix. It could be seen from fewer cavities in mozzarella cheese analogue, the cavities where due to fat globula or an indicator of water evaporation within the cheese[14,16]. In the image at Fig 2A showed visible cavities large enough. Fig 2B and 2C were also showed visible cavities - are somewhat smaller cavity. Fig 2D showed the cavities were smaller than others. Higher inulin ratio gave smaller cavity, this result may be indicated that inulin produced more effective fat emulsification. Higher cavities in mozzarella cheese analogue at Fig 1A may be due to higher modified casein content and starch free cheese expanded strongly[16].

During the process of cheese-making wheat starch evenly dispersed because of heating and mixing. Starch dispersion evenly affected the equitable distribution of the cheese composition also included fat globules and starch which improved the structure of the cheese protein matrix[32].

All the mozzarella cheese analogue protein matrix containing inulin except control showed more smooth and uniform without honeycomb. This structure showed that the addition of inulin bind more free water. Serum or free water formed in the matrix casein of cheese due to hydration capacity casein was exceeded. Free water in the matrix-bound protein prevents the formation of honeycomb structure either without or with the addition of inulin[14].

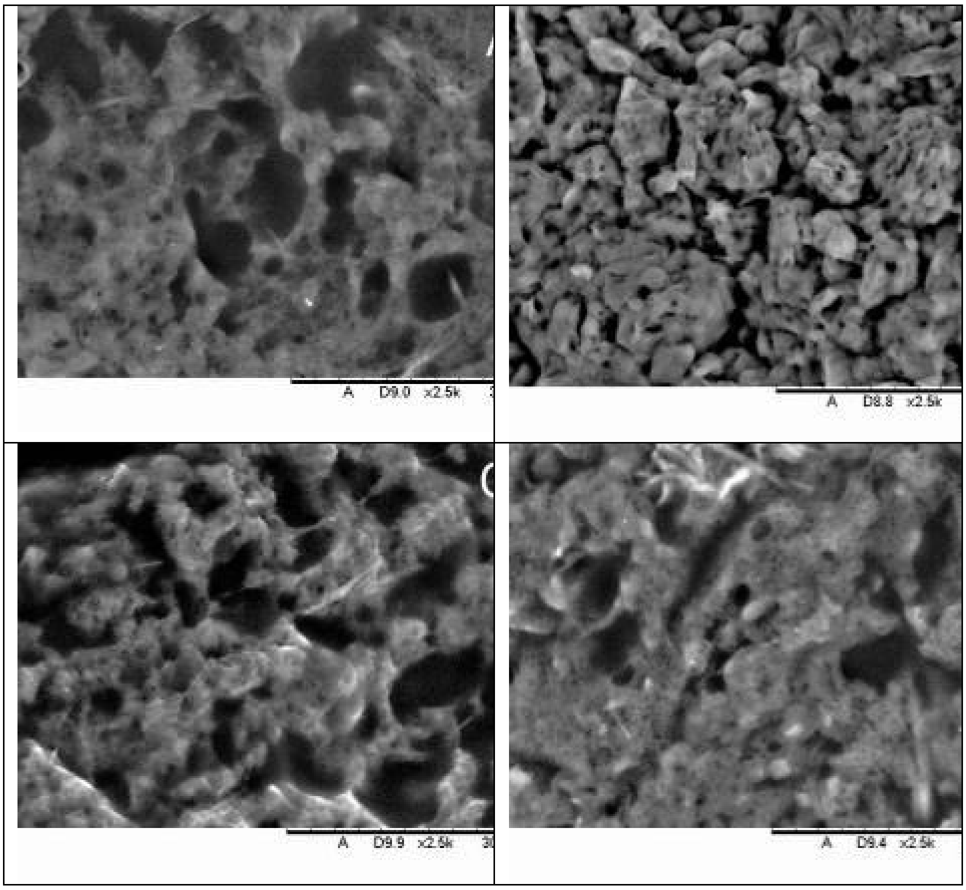


**Figure 2. The scanning electron microscopy image of mozzarella cheese analogue (Modified casein: inulin ratio: A. 80:20; B. 70:30; C. 60:40; D. 50:50)**

**Sensory evaluation**

Effect of modified casein ratio and inulin on the sensory of mozzarella cheese analogue shown in Table 1. The addition of modified casein: inulin at several ratio did not gave significant effect ($P > 0.05$) on color, aroma, texture and taste of mozzarella cheese analogue, however, if inulin ratio increased there are decreasing trend of sensory score for color, aroma, texture and flavor.

**Table 1. Sensory evaluation of mozzarella cheese analogue**

| Modified casein: inulin ratio | Color | Aroma | Texture | Flavour |
|---|---|---|---|---|
| control | 4,53 ± 0,83 | 4,53 ± 0,52 | 3,73 ± 0,80 | 3,13 ± 1,13 |
| 80:20 | 3,80 ± 1,08 | 4,47 ± 0,52 | 3,40 ± 0,83 | 3,07 ± 1,16 |
| 70:30 | 4,27 ± 0,88 | 4,20 ± 0,94 | 3,00 ± 0,85 | 3,27 ± 0,96 |
| 60:40 | 4,20 ± 1,01 | 4,00 ± 1,13 | 3,20 ± 0,86 | 3,20 ± 1,08 |
| 50:50 | 4,20 ± 0,94 | 4,47 ± 1,06 | 3,27 ± 1,28 | 3,00 ± 1,25 |

This result showed that the addition of of modified casein: inulin at several ratio had the same effectiveness with control (without modified casein and inulin). The quality of the cheese was determined by the color, aroma, texture and flavor[5]. Color score of mozzarella cheese analogue from control, modified casein:inulin ratio 80:20, 70:30, 60:40, and 50:50 are 4.53, 3.80, 4.27, 4.20 and 4.20 respectively. Color score indicated white to yellowish white. Aroma score of mozzarella cheese analogue from control, modified casein:inulin ratio 80:20, 70:30, 60:40, and 50:50 are 4.53, 4.47, 4.20, 4.00 and 4.47 respectively. Aroma score indicated a slight aroma of milk to milk aroma. Perception of aroma depends on the nature and concentration of volatile compounds and the availability that can be modulated by physicochemical interaction with other food components[33].

Texture score of mozzarella cheese analogue from control, modified casein:inulin ratio 80:20, 70:30, 60:40, and 50:50 are 3.73 , 3.40, 3.00, 3.20 and 3.27 respectively. Texture score indicated soft enough to soft. Taste score of mozzarella cheese analogue from control, modified casein:inulin ratio 80:20, 70:30, 60:40, and 50:50 are 3.13, 3.07, 3.27, 3.20 and 1.25 respectively. Taste score indicated a good taste.

**Effect of microwave power level on mozzarella cheese analogue microwaveable**

**Composition of mozzarella cheese**

The protein, moisture and fat content of five mozzarella cheese analogue is presented in Table 2. The results shown that power level of microwave gave significant effect ($P<0.05$) on protein content and moisture content of mozzarella cheese analogue microwaveable, however, did not gave significant effect ($P > 0.05$) on the fat content of mozzarella cheese analogue microwaveable.

**Table 2. Composition and volumetric expansion of mozzarella cheese analogue microwaveable**

| Microwave power level | Protein content (%) | Fat content (%) | Moisture content (%) | Volumetric expansion (%) |
|---|---|---|---|---|
| Low | $26.73 \pm 0.63^a$ | $32.21 \pm 3.06^a$ | $43.70 \pm 1.38^d$ | $14.00 \pm 1.85^a$ |
| Medium Low | $38.72 \pm 0.34^c$ | $31.35 \pm 2.35^a$ | $35.60 \pm 1.95^c$ | $69.53 \pm 53.9^a$ |
| Medium | $33.92 \pm 0.88^b$ | $35.01 \pm 6.20^a$ | $14.79 \pm 3.63^b$ | $142.57 \pm 20.4^c$ |
| Medium High | $39.73 \pm 0.73^d$ | $43.20 \pm 10.10^b$ | $4.03 \pm 1.12^a$ | $90.73 \pm 30.6^b$ |
| High | $41.55 \pm 0.25^e$ | $33.91 \pm 3.99^a$ | $5.62 \pm 4.95^a$ | $50.43 \pm 25.8^a$ |

Higher power levels of microwave gave higher protein content and fat content, this results due to increasing power level of microwave generated higher moisture evaporation caused decreasing moisture content and increasing the dry matter content of cheese.

Microwave power level decreased moisture content of mozzarella cheese analogue microwavable from Low (43.70%) Med low (35.60%), Medium (14.79%), Medium high (4.03%) and High (5.62%). Microwave power level increased protein content of mozzarella cheese analogue from Low (26.73%) Med low (35.60%), Medium (14.79%), Medium high (4.03%) and High (5.62%) and tend increased fat content of mozzarella cheese analogue from Low (32.21%) Med low (31.35%), Medium (35.01%), Medium high (43.20%) and High (43.20%). Lower moisture content of the material, the higher organic content[34].

The higher protein content associated with decreased water content due to evaporation of mozzarella cheese analogue microwavable by increasing frequency and temperature microwave power level used. The warming phase snack rice flour from low to high indicates that the moisture content decreased[35].

Based on the results of analysis of variance (Table 2) it was known that microwave power level did not gave significant effect ($P > 0.05$) on fat content, but Honestly Significant Difference Test showed a different notation on levels fat content of mozzarella cheese analogue microwaveable. Medium high power levels on the microwave generating the highest fat content while at Low power level generating lower fat content. Differences in fat content of mozzarella cheese after heating in microwave caused by differences in the components of dry material, the higher the microwave power level, the higher dry matter content of mozzarella cheese analogue microwaveable. Fats and oils are one of the most important food constituents because it has an important role in improving the palatability of foods[36].

**Volumetric Expansion**

Based on the analysis of variance (Table 2) it was known that microwave power level gave significant effect ($P < 0.05$) on volumetric expansion of mozzarella cheese. The volumetrix expansion of mozzarella cheese increased with increasing microwave powel level from Low until Medium power level, however, the volumetrix expansion decreased at higher power level i.e. at Medium high and High power level. The volumetrix expansion of mozzarella cheese increased sharply from Low power level (14,00%), Medium Low power level (69,53%) until Medium power level (142,57%), however, the volumetrix expansion gradually decreased at Medium High (90,73%) and High power level (50,43%). At higher power level of microwave, microwave gave higher temperature on mozzarella cheese, caused water within the cheese will boils and begin to evaporate if the temperature reaches 100°C, the evaporated water increased internal pressure of cheese and acts as blowing agent that induces expansion[27]. However, at Medium high and High power level, the volumetrix expansion decreased. This is may be due to starch granule from inulin in mozzarella cheese are scattering disruption the continuous protein matrix caused the protein matrix in cheese less able to stretch[37,38]. Based on the result at Table 2 showed that Medium High and High power level gave higher protein, lower water and higher lipid content, decreasing moisture content reduced plasticity of cheese and increasing lipid content reduced antifoam and plasticity of cheese protein matrix[38].

**Microstucture**

Modified casein microstructure was observed by Scanning Electron Microscopy (SEM). The microstructure of mozzarella cheese analogue microwavable is presented in Fig 3. The microstructe of mozzarella cheese analogue showed the cavity - airspaces. All microstructure in Fig 3 provide a visible effect microwave power level on microstructure. Power level of microwave at Low and Medium low at Fig 3A and 3B showed higher cavity than Medium, Medium high and High at Fig 3C, 3D and 3E. The microstructure at Fig 3D showed that cavity size decreased and decreased sharply at Fig 3E. Higher power level of microwave increased heating cause the hydrated casein form more expanded structure. Microstructure at Fig 3D showed most compact than others, this result may be due to inulin disrupts the continuous casein matrix. The presence of starch disrupts the continuous protein matrix, creating weak points in the matrix and limiting its ability to stretch[16].

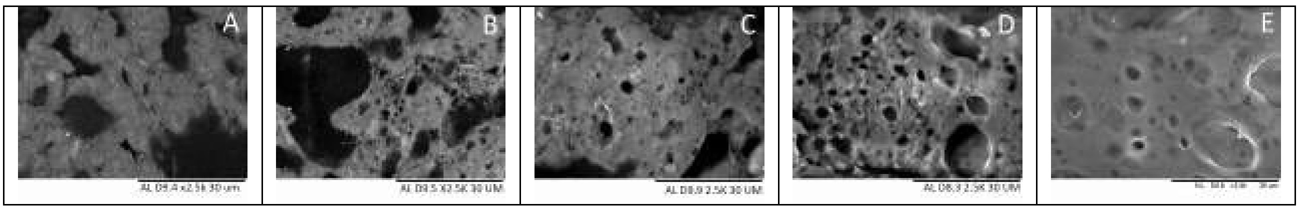


**Figure 3. Microstructure of mozzarella cheese analogue microwaveable**
**A:Low, B: Medium Low, C: Medium, D: Medium High, E: High**

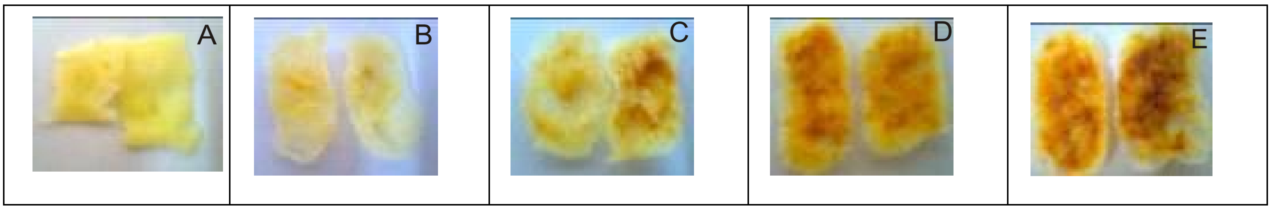


**Figure 4. Photograph of mozzarella cheese analogue microwaveable**
**A:Low, B:Medium low, C:Medium, D:Medium high, E:High**

Larger protein aggregate in protein matrix showed at Fig 3A and 3B than at Fig 3C, 3D and 3E, this structure may be due to power level of microwave at Medium, Medium high and High form superheated steam and increasing internal pressure inside cheese to induce expansion during microwave heating, however, at Low and Medium low did not enough produce superheated steam to induce cheese expansion.

Microwave power level from Low, Medium low, Medium, Medium high and High produced different frequencies and temperature. Higher power levels of microwave, higher frequency and temperature resulted. Higher temperature produced more alteration of mozzarella cheese microstructure.

Photograph of mozzarella cheese analogue microwaveable, microwave power level gave different appearance of mozzarella cheese analogue microwaveable. Fig 4 showed that increased the microwave power level showed the trend color of milky white to brownish. Temperature changes affect interaction between the component in mozzarella cheese[39], induced microstructure changes and discoloration of cheese become brownish as shown at Fig 4.

**Sensory evaluation**

Microwave power level affected the sensory properties of mozzarella cheese analogue microwaveable as shown in Table 6. Based on the data in Table 6, it was known that the microwave power level showed significant effect ($P < 0.05$) on color and crispiness of mozzarella cheese analogue microwaveable, however did not showed significant effect ($P > 0.05$) on the aroma and taste of mozzarella cheese analogue microwaveable.

**Table 3. Sensory evaluation of mozzarella cheese analogue microwaveable**

| Microwave power level | Color | Aroma | Cryspiness | Taste |
|---|---|---|---|---|
| Low | 3.93 ± 0.96$^{a}$ | 4.60 ± 0.51 | 1.20 ± 0.41$^{a}$ | 3.07 ± 0.80 |
| Medium Low | 4.13 ± 1.06$^{b}$ | 4.33 ± 0.62 | 1.60 ± 0.74$^{a}$ | 3.13 ± 0.74 |
| Medium | 4.40 ± 0.83$^{c}$ | 4.07 ± 1.16 | 2.20 ± 0.78$^{a}$ | 3.33 ± 0.72 |
| Medium High | 3.13 ± 1.46$^{a}$ | 4.33 ± 0.98 | 2.87 ± 0.83$^{b}$ | 3.27 ± 0.70 |
| High | 2.47 ± 1.19$^{a}$ | 4.13 ± 1.19 | 3.60 ± 0.99$^{c}$ | 3.60 ± 0.74 |

The treatment of microwave power level from Low to High power, low, medium low, medium, medium high and high showed significant changes to the color and crispiness of mozzarella cheese analogue microwaveable. The higher the power level resulted in a decrease panelist preference to the color of mozzarella cheese analogue microwaveable and increased crispiness preferences of mozzarella cheese analogue microwaveable.

Microwave power level from Low, Medium low, Medium, Medium high and High, panelists gave color score 3.93, 4.13, 4.40, 3.13 and 2.47 respectively, mozzarella cheese analogue have milky white color to brownish, while the High power level gives the brown color on mozzarella cheese analogue microwaveable. Panelist gave aroma score 4.60, 4.33, 4.07, 4.33 and 4.13 respectively. This result indicated that treatment microwave power level to produce the aroma was almost close to raw material and the aroma that did not dominated by the aroma that produced by heating. Panelist gave crispiness score 1.20, 1.60, 2.20, 2.87 and 3.60 respectively. Increasing crispiness due to increasing water evaporation and interaction among mozzarella cheese component which heated by microwave, evaporated water produce cavity in cheese structure[27]. Panelist gave flavor score 3.07, 3.13, 3.33, 3.27 and 3.60. This indicated that microwave at several power level produce accepted flavor.

## Conclusion

Based on the research results, it concluded that: Modification casein using $CaCl_2$ 0.025% and pH 4.6 induced protein-protein interaction and produced modified casein had more viscous than elastic and desired rheology properties. Increasing inulin in modified casein:inulin ratio tend decreased sensory properties and cavity in the microstructure of mozzarella cheese analogue. Higher microwave power level decreased moisture content, however increased fat and protein content of mozzarella cheese analogue microwaveable. Volumetric expansion increased from Low until Medium, however decreased at Medium high and High power level of microwave. Increasing power level of microwave decreased microstructure cavity of mozzarella cheese analogue microwaveable. The higher the power level decreased panelist color score and increased panelist crispiness score of mozzarella cheese analogue microwaveable.

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