Effect superheated steam on physical and lipid stability of reconstituted whole milk powder

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***Abstract*-** Milk powders are considered as food ingredients and its intervention in the manufacture of many foods and all this exposed to high temperatures when it cooked. Many of changes accrue in physical and chemical properties of milk. In this study the changes in physical properties color, viscosity, density, P^H and lipid stability peroxide oxidation value (POV) and total free fatty acids (TFFA) was measured to reconstituted (WMP) whole milk powder in relation thermal treatment using superheated steam with different temperature and period time. The temperature ranged from 150-210 °C for 5-25 min. The result for color showed in three different system (L, a, b). The superheated steam show lower different to color at the high temperature 210 °C and long time 25 min compare with control**.** At the viscosity, density and P^H the result of superheated steam showed clear differences at temperature 150 and 210 °C at long time 25 min. About the lipid stability (POV peroxide oxidation value and total free fatty acids) the result of POV to superheated steam do not showed any significantly differences between sample heat treatment compare with control at 150-180 °C and that indicates no any oxidation reaction occur between the fatty acids and molecule oxygen in superheated steam. The result of total free fatty acids content showed lower changer at the high temperature 210 °C and long time 25 min but other sample no any significantly different show compare with control. All the result in this study showed stability of milk fat to reconstitute whole milk powder and that will be lead to maintain of nutrition value to milk fat during cooking.

***Index Terms*-** physical analysis, superheated steam, milk powder, lipid oxidation.

I. INTRODUCTION

Milk is one from the important products and can entered to manufacture many food because it has many properties to improve test and flavor with high nutritional value and it use in many food industry such as cake, biscuits, chocolate, caramel candy, famous Indian milk balls known as rasgulla and popular Indian sweet etc [1]. Milk has many compounds affected by temperature which can led to change sensorial quality to consumers which view of the color, viscosity and flavor [2, 3]. Whole milk powder use to manufacture many food because it has large impact to suitability for confectionary [4]. The manufacture of milk chocolate it is usually preferred the powder milk product by roller drying. Effect heat treatment on the physical and chemical properties in whole milk powder was study from many researchers. Marie showed in his study that was many damage in physical properties when stored the milk at long time and also showed damage in the color that was cause by Millard reaction which occurred during the storage [4]. From other study the effect ultrasound with the temperature on the physical properties in sheep milk and the result were recorded changes in the viscosity, P^H and density by different heat treatment with different time [5]. Increase of heat treatment on the milk cause increase of Millard reaction whereby Millard reaction was became very active with increase temperature [6]. Effect heat treatment and the storage on changes color in whole milk powder and the causes increase in color changes at high temperature and long storage that can causes damage in physical properties of product [7, 8]. Many thermal methods use to process food and get good result with the least possible impact on the components of food like air oven, microwave and superheated steam oven. The superheated steam is steam that has temperature above the boiling point, that mean up the boiling point the steam will be formation than the steam convert to unsaturated steam than to superheated steam [9]. Superheated steam oven its new thermal method public now to cook and drying foods and it has many good advantage such as, high heat transfer capability, produces condensation heat on coming into contact with the food, provides no oxygen environment and can be obtained under normal pressure.

Superheated was discover before 100 years ago but not development until 30 years ago specially in energy efficient [10, 11]. Superheated steam uses to dry many products continent high fat that was to exhibit the lipid oxidation by use high temperature because has less oxygen and that it prevents formation hydroperoxide [10]. The objective of this study to studies effect of superheated steam on the physical changes and lipid oxidation in reconstitute whole milk powder by use different heat treatment and different time.

II. MATERIAL AND METHOD

Whole milk powder- The whole milk powder was supplied from Nestle company was choose (Nespray) type which purchase from the Tesco market in Penang city in Malaysia. The amounts of contents were following the standard milk powder which contented fat (28.2 g per 100 g) protein (23.6 g per 100 g) carbohydrate (39.9 g per 100 g).

Reconstitute the whole milk powder- The reconstitute whole milk powder was followed instructions to the consumer listed on the package. The whole milk powder (WMP) was reconstitute by use (33) g from the powder milk and added (225) ml water after that shaking on the magnetic stirrer for (10) min,

all amount of milk was prepared before applied in superheated steam.

Superheated Steam Drying Oven- Superheated steam drying was carried out by placing the tray containing reconstitute whole milk samples in the processing chamber of superheated steam processing system and exposed to different temperatures (150,180 and 210) $^{\circ}$C for (5,10,15, and 20) min respectively. superheated steam equipment was used Sharp AX-1500 with a steam generation capacity of 16 cm^3/min, oven capacity of 31 L, and team engine heater of 900 W.

Color measurement- The color was measured by use the colorimeter (Minolta CM-3500d) made in japan. Where they were taken 10 ml from the sample and filled in the standard glass cell to colorimeter. For each sample where measurement triplicate to L (brightness), a (- green to +red component) and b (- blue + yellow) for each color values was taken on the temperature 25 $^{\circ}$C [12].

Viscosity and density measurement- The viscosity was measured by use viscometer model (SV-10) made in Japan. Where was take 45ml from the sample and laid in the vial of the viscometer and taken the number of viscosity. All each values were taken at temperature 25 $^{\circ}$C and also the values were taken triplicate. After correction the temperature of sample the density was calculated on the temperature 25 $^{\circ}$C.

PH measurement- The P^H was measured by use P^H meter model (Mettler Toledo S20-K) made in Germany. The sample was taken at triplicate at temperature 25 $^{\circ}$C .before start use the P^H meter do the calibration by different puffer solution than where take 20 ml of the milk to measurement P^H.

Acid value- After expose heating to each of sample 10 g was weight from milk sample in a conical flask. Two drops of phenolphthalein indicator were added and with 0.1 N potassium hydroxide solution (KOH) until the advent of color pink the end point. Acid value was calculated (Eq. 2) [14] .

$$AV = \frac{56.1 \times V \times C}{m} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where: AV acid value, (56.1) is equivalent weight of KOH, (V) is the volume in ml of standard volumetric KOH solution used, (C) is the exact concentration in KOH solution used (0.1 N) and (m) is the mass in grams of the test portion (10 g).

Milk fat extraction and analysis- Milk fat extraction was performed using the method of Oveisi, Sadeghi, Hajimahmoodi, Jannat, and Sobhani (2006) with some modification. Fat was extracted from 500 ml of reconstituted milk by adding 20 ml of 65% nitric acid into the sample. The sample was shaked and transferred to a centrifuge type Kubota 4000 (N41548-M000, Japan) at 3500 rpm for 20 min to separate the solid phase that contains fat and proteins. After the extraction, we added 20 ml of 99% ethyl alcohol and heated the mixture until boiling point. The mixture was then placed in a water bath for 10 min to denature the protein. Subsequently, 100 ml of petroleum ether was added. The mixture was mixed well and centrifuged again at 3500 rpm at 20 min to separate the organic phase. The petroleum ether evaporated without heating. The fat was stored in 5 ml brown glass vials [15] until needed for analysis.

Peroxide oxidation Value (POV)- Peroxide value was determined according to AOCS official methods descripted by [14]. Wight 1 ± 0.05 g of milk fats into 250 mL of conical flask with 30 mL of acitic acid – chloroform (3-2) solution swirl the flask until the sample dissolve in the solution and add 0.5 ml saturated potassium iodide (KI) solution and swirl for one minute and added 30 mL of distilled water than titrate with 0.01 N sodium thiosulfate ($Na_2S_2O_3$) until the color change to light yellow than added 0.5 ml 0f 1% soluble starch indicator to get blue color and continued titrating until the blue color disappears. Calculate the peroxide value as meq of peroxide/kg of oil (Eq. 1)

$$PV = \frac{(S-B) \times N \text{ thiosufate} \times 1000}{\text{Weight of sample}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 2$$

Statistical Analysis- The experimental data was subjected to one-way analysis of variance (ANOVA). Significant differences between mean values were determined using Duncan's Multiple Range test ($P \leq 0.05$) following ANOVA statistical analysis, which were performed using SPSS version 20- 2013 (SPSS Inc., Chicago, USA).

III. RESULT AND DUSSCATION

Color in reconstitute whole milk powder- Effect superheated steam treatment by use different temperature and different time on the reconstitute whole milk powder (WMP) on the color. The color measured by colorimeter (Minolta CM-3500d) and the results show in table (1), reconstitute whole milk powder (WMP) recorded lower (L) and (b) values ($P \leq 0.05$) under high heat treatment and long time that was between (180 and 210) $^{\circ}$C at long time (20-25) min compared with the control (Raw sample without heat treatment) lightness (L) describes the light-reflecting or transmitting capacity of an object. When the values of (L) take decrease that's mean the color will be take dark color. The reason because some reaction happens between the sugar and protein it's specially amino acids called Millard reaction and it's responsible on the brown color in the food [4, 16]. At 5 min the color not recorded significant any high changes in the three systems (L, a and b) at all temperature which can explained did not effect on temperature color on with short time [10]. At the time 10-15 min the result showed some significantly changes specially on the temperature 210 $^{\circ}$C that was by increase the temperature accompanied increase in Millard reaction [17, 18].

Table 1: Effect superheated steam on color value (L, a and b) to reconstituted whole milk powder.

Superheated steam temperature °C	(Values of L) Time of treatment (min)					
	Control*	5	10	15	20	25
150	14.32^{a} ±0.02	13.99^{b} ± 0.01	13.88^{b} ± 0.04	13.85^{b} ±0.03	13.63^{c}± 0.02	13.44^{d}±0.10
180	14.32^{a} 0.02	13.93^{b} ± 0.01	13.75^{c} ± 0.02	13.60^{d} ±0.02	13.44^{e} ±0.02	13.20^{f} ±0.01
210	14.32^{a} 0.02	14.23^{b} ± 0.02	14.30^{ab}± 0.01	13.72^{c} ±0.01	12.63^{d} ±0.02	12.11^{e} ±0.01
(Values of a) Time of treatment (min)						
150	5.66^{a} ±0.01	5.67^{a} ±0.01	5.68^{a} ±0.01	5.69^{a} ±0.01	5.80^{b} ±0.01	5.89^{c} ±0.01
180	5.66^{a} ±0.01	5.67^{a} ±0.04	5.72^{a} ±0.01	6.25^{b} ±0.01	6.93^{c} ±0.03	7.06^{d} ±0.03
210	5.66^{a} ±0.01	5.60^{a} ±0.07	5.83^{b} ±0.01	5.89^{b} ±0.01	6.69^{c} ±0.01	7.20^{d} ±0.07
(Values of b) Time of treatment (min)						
150	24.20^{a} ±0.03	23.64^{b} ±0.01	23.46^{c} ±0.08	23.42^{c} ±0.05	23.05^{d} ±0.03	22.88^{d} ±0.07
180	24.20^{a} ±0.03	23.55^{b} ±0.03	22.72^{c} ±0.04	22.47^{d} ±0.03	19.73^{e} ±0.02	11.83^{f} ±0.02
210	24.20^{a} ±0.03	24.04^{a} ±0.08	24.16^{a} ±0.01	23.42^{b} ±0.24	21.38^{c} ±0.01	20.50^{d} ±0.03

$^{a–c}$ Symbols bearing different letters in the same row are significantly different ($P < 0.05$).
* control (raw sample).

Peroxide oxidation value- Lipid peroxidation is a free radical chain reaction in lipid oxidation that explains in the three terms of initiation, propagation, and termination processes. Available oxygen species which considered key factor of deterioration of polyunsaturated fatty through three different avenues: oxygen, hydrogen abstraction and free radical attack [19]. In this study the peroxide value in all samples ranged between (2.23- 4.21 meq O2/kg), were below 25 (meq of active O2/kg), That is considered an acceptable level of food. Peroxide value is measure lipid oxidation that's why associated the oxygen with alkeyl radical to produce hydroperoxide The result of effect superheated steam time on the peroxide value show in table 2 that was no significantly different between period of time 5-15 min at temperature 150,180, 210 °C compare with control but show significantly different at long time 20 - 25 min compare with control. Peroxide value can use it as indicator to rancidity of fat by measurement the primary oxidation product (hydroperoxides). Superheated steam is recorded minimum of peroxide value 2.28 (meq O2\kg) and maximum 4.21 (meq O2\kg) that led to conclude superheated steam is mountain milk fat from formation the hydroperoxides that's why less of molecule oxygen[20].

Table 2: Effect superheated steam on POV value (meq.peroxide/kg)value to reconstituted whole milk powder

Superheated steam temperature °C	Time of treatment (min)					
	Control*	5	10	15	20	25
150	2.23^{a} ± 0.55	2.29^{a} ± 0.59	2.69^{ab} ±0.25	3.98^{b} ± 1.72	3.49^{ab} ± 0.56	2.94^{ab} ±0.50
180	2.23^{a} ± 0.55	2.28^{a} ± 0.55	2.52^{a} ± 0.49	2.81^{a} ± 0.93	3.01^{ab}±0.57	3.54^{b} ± 0.59
210	2.23^{a} ± 0.55	2.95^{a} ± 0.02	2.85^{a} ± 0.08	3.14^{ab} ±0.51	3.35^{ab}±0.60	4.21^{b} ± 0.56

$^{a–c}$ Symbols bearing different letters in the same row are significantly different ($P < 0.05$).
* control (raw sample).

Acid value- The result of effect superheated steam on acid value show in table 3 that was no higher level for acid value between each of sample compare with control. The result show no significantly different between time 5-15 min at 150 and 180 °C compare with control. At the time temperature 150 °C the period time 25 min recorded significantly different with control but did not show any significantly different compare with each of treatment sample. At the high temperature 180 °C the period time show no significantly different between 5 and 25 min compare with control. At the 210 °C the result of acid value showed compare with control and also sow significantly different between 5, 10 min compare with 15, 20 and 25 min. The level of acid value explain level of free fatty acid because the fatty acid it's found in fat or oil as unit associated with triglyceride so any higher in acid value that mean higher in free fatty acid which translates into decreased oil quality[14]. Period of time 5-15 min at all temperature in superheated steam did not recorded higher level of acid value compare with control but higher temperature with long time effect on increase acid value that mean superheated steam at below temperature 150 and 180 °C

maintains the milk fat from formation free fatty acids because superheated steam is use dry steam and hydrolysis of triglyceride by heating require wet steam to broken the ester bounds between the triglyceride and fatty acids [21].

Table 3: Effect superheated steam on Acid value (mg KOH\g)to reconstituted whole milk powder.

Superheated steam temperature °C	Time of treatment (min)					
	Control*	5	10	15	20	25
150	$2.31^{ab} \pm 0.58$	$1.84^{a} \pm 0.27$	$2.14^{ab} \pm 0.36$	$2.27^{a} \pm 0.08$	$2.44^{ab} \pm 0.03$	$2.62^{b} \pm .012$
180	$2.31^{a} \pm 0.58$	$2.00^{a} \pm 0.05$	$1.92^{a} \pm 0.59$	$2.13^{a} \pm 0.54$	$2.31^{a} \pm 0.62$	$2.84^{a} \pm 0.08$
210	$2.31^{ab} \pm 0.58$	$2.07^{a} \pm 0.11$	$2.41^{ab} \pm 0.23$	$2.75^{bcd} \pm 0.05$	$2.86^{cd} \pm 0.08$	$3.14^{c} \pm 0.03$

[a–c] Symbols bearing different letters in the same row are significantly different ($P < 0.05$).
* control (raw sample).

Physical properties- The values of the viscosity show in fig 1. The result did not recorded significantly increase at the temperature (150) °C at all the time when compared with control and also with the180 °C at time (5-20) min but at time 25 min the result of 180 °C show significantly different compare with control. At high temperature 210 °C the viscosity recorded significant increase ($p<0.05$) at time (10, 15, 20, 25) min respectively as shown in Fig 1. Aguilar and Ziegler(1995) shown increase to viscosity when used different heat treatment and long time on the milk chocolate and descript that is the denaturation of why protein on the high temperature laid to increase the viscosity [5, 6].

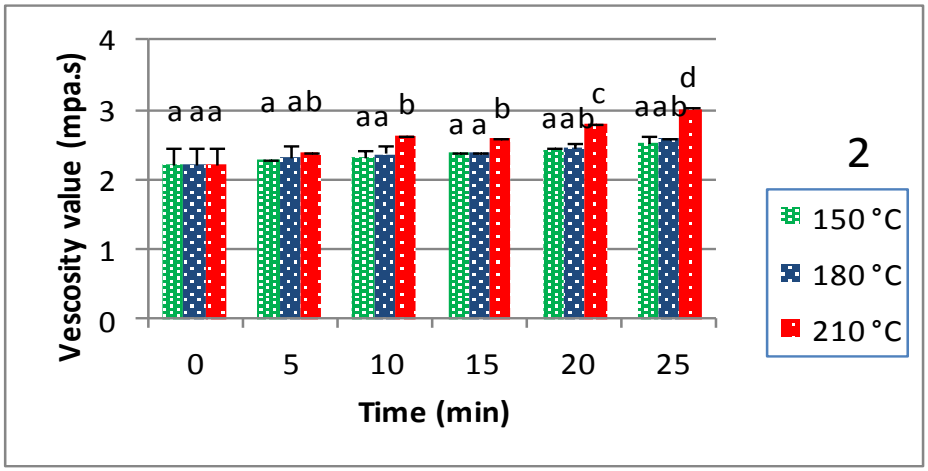

Fig.1. Effect superheated steam on viscosity value to reconstitute whole milk powder

The values of the density show in fig 2. The result did not recorded significantly decrease at the temperature (150) °C at time (5-20) min when compared with control but at temperature180 and 210 °C the density recorded significant decrease ($p<0.05$) at time (5, 10, 15, 20, 25) min respectively as shown in Fig 1. Also increase the heat treatment with increase time effect on properties density as shown in this result decrease the density by use different treatment and different time.

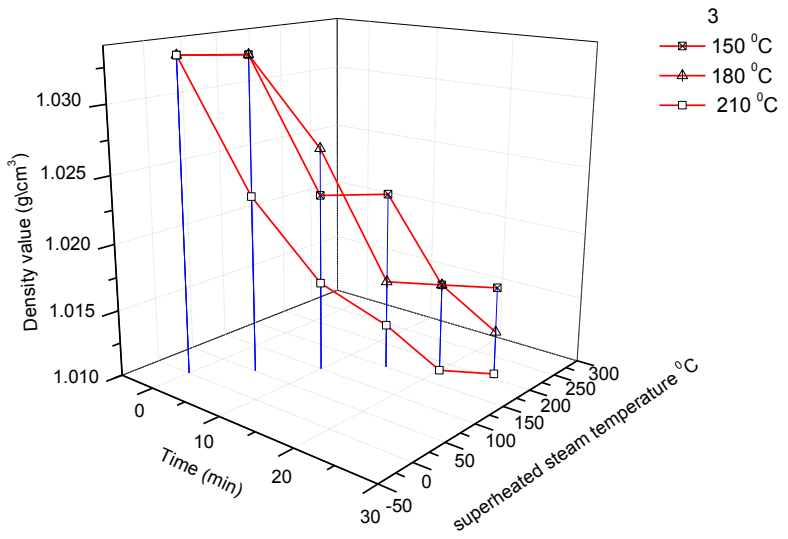

Fig 2. Effect superheated steam on density value to reconstitute whole milk powder

The value of the P^H show on fig 3. The result did not recorded significantly change at the all temperature at time (5) min that mean the superheated stem do not effect on the PH at short time but at the (10, 15, 20 and 25) min at all temperature recorded significant decrease in the PH when compare those values with the control and that mean the high temperature and long time lead to decrease the PH values as shown in Fig 1. Increase temperature effect on content of water in the liquid and that can be cause increase of PH [22].

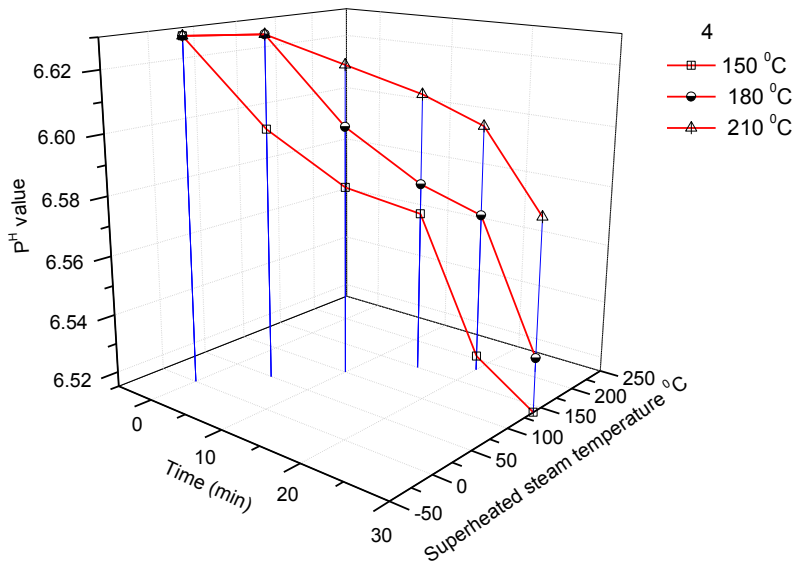

Fig 3. Effect superheated steam on P^H value to reconstitute whole milk powder

IV. CONCLUSION

The present study assessed the key role of initial study of superheated steam oven on the physical changes occurring in reconstitute whole milk powder during different heat treatment and different time. The superheated steam not show significant impacts on the color (L, a, b) at 150-180 ˚C for 5-15 min with slightly changes on time 20-25 min. however 210 ˚C recorded effect on color value for time 10-25 min. P^H, viscosity also do not recorded obvious changes at 150-180℃ for 5-15 min. however 210℃ time show effect for period time 10-25 min. superheated steam show effect on density value at 180-210 ˚C for 10-25 min. superheated steam did not show any oxidation

activity for milk fat that was showed by result of peroxide oxidation value and acids value at 150-180℃ for 5-25 min.

ACKNOWLEDGMENT

Financial support for this study was provided by the School of Industrial Technology, Department of Food Technology, Malaysia.

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