SIMPLE VIBRATING TABLE FOR CHOCOLATE MOULDING

Meja Getar Sederhana Untuk Pencetakan Cokelat

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Abstract. *This work deals with design of a simple vibrating table prototype for chocolate moulding. Designed for small scale and home made chocolate industry, the main components of the equipment are a 50 x 40 cm vibration table, a 1 HP vibration electric motor, four 7 inch dia. rubber vibration supports, a vibration control system with frequencies from 0 to 50 Hz, and a frame. The table height is 60 cm. Experiments for chocolate moulding using the equipment were conducted to form 2 x 15 pieces of chocolate bars (weighted 22 gram) from dark and milk chocolates, respectively. Vibration frequencies were set from 20 to 50 Hz and durations from 2 to 10 minutes of vibration. Sensory evaluation indicated the high integrity and fine shape levels of the moulded chocolate were given at minimum 40 Hz and 2 minutes and at 35 Hz and minimum 5 minutes of vibration using dark chocolate (107.68 ps in viscosity), and at minimum 40 Hz and 5 minutes and at 45 Hz and minimum 4 minutes of vibration using milk chocolate-1 (115.23 ps in viscosity)*

Key words**:** *simple vibrating table, moulding, chocolate*

Abstrak. Penelitian ini merupakan desain sebuah prototipe meja getar sederhana untuk mencetak cokelat. Didesain untuk industri cokelat skala kecil dan skala rumah tangga komponen utama alat ini terdiri dari sebuah meja getar datar 50 x 40 cm, sebuah motor getar 1 HP, 4 buah bantalan getar dari karet diameter 7 inchi sistim kontrol getaran dengan frekuensi dari 0 sampai 50 Hz, dan rangka. Tinggi alat 60 cm. Eksperimen pencetakan dengan menggunakan meja getar dilakukan untuk mencetak 2 × 15 buah cokelat batangan (berat 22 gram) masing-masing dari *dark* dan *milk chocolates.* Frekuensi getar diset dari 20 sampai 50 Hz dan waktu getar dari 2 sampai 10 menit. Evaluasi sensori mengindikasikan bahwa level kepadatan dan keutuhan yang tinggi dari cokelat batangan hasil cetakan diperoleh pada frekuensi getar minimum 40 Hz dan waktu getar 2 menit dan frekuensi 35 Hz dan waktu getar minimum 5 menit untuk *dark chocolate* (viskositas 107,68 ps) dan pada frekuensi minimum 45 Hz dan waktu getar 4 menit dan frekuensi 40 Hz dan waktu getar minimum 5 menit untuk *milk chocolate-1* (viskositas 115,23 ps).

Kata kunci: meja getar sederhana, pencetakan, cokelat

INTRODUCTION

Chocolate moulding deals with a way of forming the final shape of chocolate using moulds into which tempered chocolate is poured (Gray, 2017). According to Minifie (1999), moulded chocolate products are conventionally produced by depositing tempered chocolate having liquid fat phase into the moulds, allowing the chocolate to cool, and harden into solid pieces before demoulding the chocolates. By shaking the moulds allows to remove the air entrapped in the chocolate that would form undesired bubbles in the finished product. It also allows forming a fine shell by forcing in all the cavities of intricate moulds (Beckett, 2000). In general, the first one refers to integrity to or compactness level, while the second one refers fine shape level of the finished product. The chocolate may be formed in various shapes such as candy, button, bar and block (Sri Mulato *et al.,* 2005) depending on mould shapes and sizes.

A very simple method of forming the shape of chocolate is by hitting the mould or the moulding plate containing the chocolate on the table edge gently and repeteadly. This method has been practiced by many small scale and home made chocolate industry, due to it is relatively cheap and simple in operation. Nevertheless, the method is quite low in productivity, and no guarantee that the air bubble is fully removed and the chocolate fully fills the intricate moulds In the large scale chocolate industry, the fill is designed

to operate automatically and relatively fast to maintain chocolate temperature around 32 ^{o}C. A typical chocolate machine may be divided into several sections, such as tempering, filling or depositing, moulding, cooling tunnel, and demoulding in an assembly line (Minifie, 1999 and Gray, 2017).

In patent WO 2012139175 A1, the filling head which fill the mould cavities in a row of the chocolate machine advances the mould assemblies and vibrates the assemblies to release any air trapped in the mould cavities. Optical or proximity sensors, selectively control the advance of the shape moulds (Taylor, 2012).

This work deals with design of a simple vibrating table prototype for chocolate moulding. Equipped with a vibration control system, the vibrating table is designed for small scale and home made chocolate industry in order to increase productivity and to mantain quality of the finished or moulded product in terms of integrity and fine shape. As a simple vibrating table, the fill is still done by manual means.

This simple vibrating table has been registered for patent at *Direktorat Jenderal Kekayaan Intelektual, Kementerian Hukum dan HAM, Republik Indonesia,* with the registration number of P 00 201508170 dated, 9 December 2015.

METHODOLOGY

This work consisted of design and construction of a simple vibrating table for chocolate moulding. Sensory evaluation can determine the value and acceptability of a food sample (Thamke and Durrcsmid, 2009 and Xin Gao *et al.,* 2015). In this case, they were levels of the integrity and fine shape of the moulded chocolates. The integrity level was determined by the absence of air trapped in the sample, while the fine shape was determined by the cavities of intricate moulds.

For moulding experiments using this vibrating table, the tempered chocolate was poured manually into two acrylic moulding plates, each consisting of 15 moulds to form 22 gram chocolate bars. During moulding, chocolate is deposited at a temperature of approximately 30 °C and is cooled down to temperature below 20 °C for solidification (Keijbets *et al.,* 2010).

Vibration frequencies were varied at 20, 25, 30, 35 until 50 Hz, while vibration durations were varied at 2, 3, 4 until 10 minutes. Frequency, by definition, is the number of vibration per second.

From each plate, we took the finished moulded samples, four from each edge of the plate and one sample from the middle. Sensory analysis was done by two semi-skilled persons. Both levels of the integrity and fine shape were indicated by +++ (high); ++ (medium) and + (low).

The chocolates used in the moulding experiments were dark chocolate, milk chocolate-1, and milk chocolate-2. Compositions of those chocolates are given in Table 1, in which their preparation referred to the method stated in Minifie (1999) and Sri Mulato *et al.* (2005).

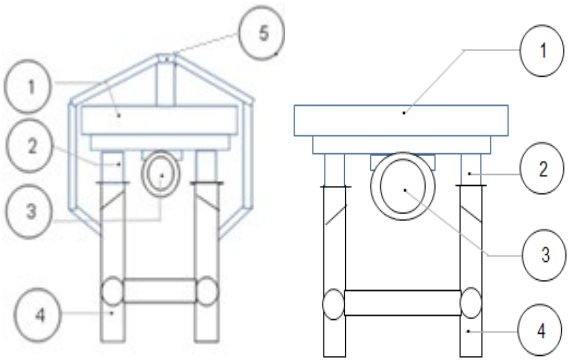
Table 1. Compositions of Dark Chocolate and Milk Chocolates

No	Ingredient	Composition (%, w/w)		
		Dark chocolate	Milk chocolate-1	Milk chocolate-2
1.	Cocoa mass	70	30	20
2.	Cocoa butter	10	13	15
3.	Full cream milk powder	9	25	44
4.	Sucrosa	10	31	20
5.	Lecithin	0.3	0.3	0.3
6.	Vanilla	0.4	0.4	0.4
7.	Salt	0.3	0.3	0.3

RESULTS AND DISCUSSION

Main components

The simple vibrating table prototype consists of five main components i.e. a 50 x 40 cm vibration table where moulding plates are placed on, a 1 HP vibration electric motor, four 7 in dia. rubber vibration supports, a vibration control system from 0 to 50 Hz in frequencies, and a frame. The table height is 60 cm. The vibration motor is operably connected to the table and operable to vibrate the table primarily in horizontal direction (thus to the moulds placed on) during moulding process.



Side view Front view

Legend :
1. Vibration table
2. Rubber vibration support
3. Vibration motor
4. Frame
5. Table cup

Figure 1. Simple Vibrating Table for Chocolate Moulding

The vibration table and the frame are constructed from stainless steel material, while its table cup is constructed from acrylic. Figure 1 shows the technical drawing of the vibrating table, while Figures 2 and 3 show the photos of the vibrating table and its vibration control system.

Sensory Evaluation

The results of the sensory evaluation of the moulded chocolate is shown in Table 2 for dark chocolate. For milk chocolate-1 and milk chocolate-2 are shown in Tables 3 and 4, respectively. The integrity and fine shape levels shown in the tables are the average values. Table 5 presents viscosity analysis of the dark and milk chocolates.

Data in Tables 2, 3, and 4 show clearly that the frequency and duration of vibration affected the integrity and fine shape levels of the moulded chocolates. In general, the higher frequency and the longer duration set for vibration, the more integrity and fine shape levels of the moulded chocolates were, and vise versa.

As stated before that vibration allows to remove the air entrapped within the chocolate mass and to form a fine shell by forcing in all cavities of intricate moulds (Beckett, 2000). As stated by Chevalley (1975), Servais *et al.* (2003) and Bergemann (2015), the flow properties of chocolate during moulding operation are influenced by vibration. Therefore, the effects of vibration is very useful for the spreading of chocolate in moulds. Determinant factor is the result of frequency and amplitude.

Figure 2. Simple Moulding Vibrating Table for Chocolate Moulding

Figure 3. Vibration Control System

The high level of the integrity and fine shape (of three levels i.e. high, medium, and low) were given at minimum 40 Hz and 5 minutes of vibration and at 45 Hz and minimum 4 minutes of vibration, if using dark chocolate (Table 2), and at minimum 40 Hz and 5 minutes, and at 45 Hz and minimum 4 minutes of vibration, if using milk chocolate-1 (Table 3).

Phenomena of the bubble removing was visually seen in the moulding experiments. As the frequency was increased and the vibration duration was set longer, the bubles trapped within the chocolate mass would release more intensively and quickly.

Another finding, as can be seen in Tables 2, 3 and 4, was that vibration affects more on the fine shape level rather than on the integrity level. Tables 2, 3, and 4 also show that viscosity (along with frequency and duration of vibration) influences the integrity and fine shape levels.

For instance, to form chocolate from dark chocolate (10.768 ps) at 30 Hz and 5 minutes resulted in medium integrity and high fine shape levels. But if using milk chocolate-1 (11.523 ps) with the same frequency and duration resulted in low integrity and high fine shape levels.

In the case of milk chocolate-2 (16.257 ps), the chocolate could not result in high integrity levels at any frequency available, eventhough it could have high fine shape levels. Therefore, the milk chocolate-2 composition was not recommended for chocolate moulding. The main cause was most probably due to the relatively high portion of 44% milk powder in the chocolate composition (Table 1). This is indicated by the relatively high viscosity of the milk chocolate-2 i.e. 16.257 ps (Table 5). Chocolates with high viscosity have a pasty feel (Beckett, 2000). As a rheological property of the chocolate flow, viscosity relates to composition, processing strategy, and particle size distribution of the chocolate (Rao, 2014).

Table 2. Integrity and Fine Shape Levels of the Chocolate (Dark Chocolate)

Frequency(Hz) \ Duration (minute)	2	3	4	5	6	7	8	9	10
20	U + K ++	U + K +++	U + K +++	U + K +++	U + K +++	U + K+++	U + K +++	U + K +++	U + K +++
25	U + K +++	+ K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
30	U + K +++	U + K +++	U + K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++
35	U ++ K +++	U ++ K ++	U ++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U ++ K +++
40	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++
45	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++
50	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K+++	U +++ K +++	U +++ K +++

Notes:

+++ = high, ++ = medium, + = low

U = integrity, K= fine shape

Table 3. Integrity and Fine Shape Levels of the Chocolate (Milk Chocolate-I)

Frequency(Hz) \ Duration (minute)	2	3	4	5	6	7	8	9	10
20	U + K ++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
25	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
30	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
35	U + K +++	U + K +++	U + K +++	U + K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++
40	U ++ K +++	U ++ K +++	U ++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++
45	U ++ K +++	U ++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++

Table 3. Integrity and Fine Shape Levels of the Chocolate (Milk Chocolate-I) (Continue)

50	U ++ K +++	U ++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++	U +++ K +++

Notes:

+++ = high, ++ = medium, + = low

U = integrity, K= fine shape

Table 4. Integrity and Fine Shape Levels of the Chocolates (Milk Chocolate-2)

Duration (minute) / Frequency(Hz))	2	3	4	5	6	7	8	9	10
20	U + K ++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
25	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
30	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
35	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
40	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++	U + K +++
45	U + K +++	U + K +++	U + K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++
50	U + K +++	U + K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++	U ++ K +++

Notes:

+++ = high, ++ = medium, + = low

U = integrity, K=fine shape.

Table 5. Viscosity of the Dark Chocolate and Milk Chocolate

No.	Sample code	Spindel code	Rpm	Duration (second)	Temperature (°C)	Viscosity (centipoise)	Average
1	2	3	4	5	6	7	8
1	Milk Choco 2	LV 64	5	300	50	16.436 16.077	16.257
2	Dark Choco	LV 64	5	300	50	10.750 10.786	10.768

Table 5. Viscosity of the Dark Chocolate and Milk Chocolate (Cintinue)

3	Milk Choco 1	LV 64	5	300	50	11.242 11.805	11.523

CONCLUSION

Experiments for chocolate moulding using this simple vibrating table prototype to form 2 x 15 pieces chocolate bars (each weighted 22 gram) from dark and milk chocolates respectively, indicated high integrity and fine shape levels (of the three category levels i.e. high, medium, and low) of the moulded chocolates. Those high levels were given at minimum 40 Hz and 2 minutes and at 35 Hz and minimum 5 minutes of vibration, if using milk chocolate and at minimum 45 Hz and 4 minutes and at 40 Hz and minimum 5 minutes of vibration, if using milk chocolate-1.

Another finding was that vibration affected more on the fine shape level of the chocolate rather than on the integrity level. Overall, vibration frequency, vibration duration, and viscosity of the chocolate influenced significantly the integrity and fine shape levels.

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