SENSORY CHARACTERISTIC OF DARK CHOCOLATE FROM ROASTED COCOA BEANS USING DIFFERENT BRANDS OF HOME OVEN

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ABSTRACT - *Recently interest in home-based chocolate production has been rising due to market demands for single-origin chocolate. However, information on alternative equipment for small-scale chocolate production in Malaysia is limited. Therefore, a preliminary study on the suitability usage of different brands of home ovens to roast cocoa beans for chocolate production was conducted. The cocoa beans were roasted at a temperature range between 80°C to 150°C for 20 minutes. Dark chocolate was prepared for all samples and subjected to a sensory acceptance test with 20 consumers. Six trained panelists were further assessed on three of the most accepted dark chocolate for flavour characteristics based on quantitative descriptive analysis. The results showed that three of the dark chocolate; sample-8 (Butterfly oven at 130°C), -5 (Millux oven at 120°C) and -6 (Millux oven at 150°C) respectively, were the most preferred by consumers and received the highest score in overall liking attribute. While, analysis by the trained panelists showed that the highest overall acceptability was sample-8, followed by sample-6 and -5. Dark chocolate sample-8 has a medium cocoa intensity with low bitterness, astringent and sourness. Nevertheless, the chocolate needs further optimization on the duration and temperature for each oven as the GLM ANOVA shows significant differences between brands used, temperatures, and interaction.*

Key words: Chocolate, home-based roasting, alternative processing, wet grinder and sensory

INTRODUCTION

Cocoa is the fourth agricultural commodity being traded in Malaysia after palm oils, rubber and timber (Anon, 2020a). In 2020, the industry has contributed about RM6.2 billion of the total value of Malaysia's export earnings (Malaysian Cocoa Board, 2020). This has benefited more than 31,000 people including estate workers, smallholders, cocoa processors, manufacturers as well as chocolate entrepreneurs (Abdel Hameed and Arshad, 2014). Although the cocoa export earnings have increased about 1.4% compared to 2014, the smallholders are still the lowest beneficiaries. Whereby, some of them have only received an average income of RM96 per month (Anon, 2020b).

Cocoa is planted in a region range between 20° north and 20° south of the equator and can be intercropped with other plants such as coconut and durian (Nurfadzilah and Rozita, 2018; Nurfadzilah and Rozita, 2016). Unlike the others, the cocoa seeds must be processed through fermentation, followed by drying and subsequently by roasting before a unique chocolate flavour are fully developed. The fermentation and drying of cocoa beans are usually carried out at the farm, while roasting is performed by cocoa grinders at their facilities. Roasting is a process involving high temperatures, which is reported to vary from 80°C to 160°C (Rocha et al., 2017). During roasting, a specific brown colour and the desirable chocolate flavour are developed as a result of reactions between flavour precursors such as peptides, amino acids, reducing sugars and organic acids that are formed during fermentation through Maillard reaction and Strecker degradation (Kumari et al., 2018; Brillouet and Hue, 2017; De Taeye et al., 2016). The roasting condition mainly depends on the temperature applied and time during the process which determines the flavour and colour quality of the final products (Rocha et al., 2017). Normally, the roasted cocoa beans will be further processed by cocoa grinders to nibs and subsequently to commercial semi-finished products which are liquor, butter and powder (Beckett, 2015).

Typically, chocolate manufacturer uses conventional equipment to produce a variety of chocolate by blending, refining and conching the commercially available semi-finished products

(Caligiani et al., 2016). This conventional equipment is industrial-scale manufacturing that handles huge quantities of raw materials and requiring a hefty cost, highly skilled personnel as well as large operational space (Hinneh et al., 2019). Due to these factors, the chocolate production is categorized as expensive and less suitable for small-scale production. In line with the current increasing demand for specialty chocolate such as the single-origin, fine flavour and organic (Myers, 2021), which are marketed as luxurious products (Vanderschueren et al., 2019), an alternative chocolate processing method especially home-based is desperately needed. Notably, the alternative processing should cater requirement for the small-scale industries where the chocolate is produced using a limited quantity of cocoa beans solely harvested from a specific farm or region. To overcome these issues, several attempts have been carried out to scale down chocolate production by a small-scale processing approach such as using the combination of Stephan mixer and ball mill (Saputro et al., 2016), by using conical and cylindrical roller stone melangers (Tan and Balasubramanian, 2017), by the combination of a ball mill and a liquefier device (Saputro et al., 2019) and also usage of the melanger and Stephan mixer for chocolate refining and conching (Hinneh et al., 2019). However, the study on the usage of home ovens as alternative roasting equipment for small-scale chocolate production is limited. Therefore, this work aims to evaluate the suitability of different brands of home ovens to roast cocoa beans for chocolate production.

MATERIALS AND METHODS

Cocoa Fermentation and Drying

Ripe cocoa pods of mixed clones were harvested from the farm of Kg Khantan, Cemor, Perak. A cocoa fermentation was carried out for four days using the shallow box measuring 30 x 30 x 30 cm^3. The pods were split open by machete after four days harvested. A total of 25 kg of healthy cocoa seeds was placed in each boxes and covered with a clean gunny sack. The cocoa beans were mixed once after 48 hours by transferring the fermented beans mass from one box to another. The samples were sun-dried after 96 hours by spreading out uniformly over a platform with a dimension of 120 x 60 x 3 cm^3. The platform was placed under transparent roof to protect the cocoa beans from the rain. Mixing of the cocoa beans was performed every three hours to ensure the beans were dried uniformly. At night, the platforms were covered with gunny to avoid dewdrops. The drying was continued until the moisture content was reduced to about 7.5% measured by using a Protimeter (Grainmaster, USA).

Sampling

Upon drying, the resulted samples were sub-sampled as described detailed in Malaysian Standard MS230:2007 (Anon, 2007) by using quartering tools. Each of the respective samples was divided into four parts and two parts of the quarter were put aside. The remaining parts of the samples were combined before being divided into four again. The procedure was repeated until each of the quarters was reduced to about 250 g. Each of the quarters was labeled according to analysis and stored in a vacuum container.

Roasting

A total of 200g the dried cocoa beans were roasted in each brand of the home oven as listed in Table 1.0. Before roasting, the cocoa beans are washed and dried with a paper towel. The cocoa beans were conditioned to 50°C for 10 minutes before roasting was carried out. The roasting process for each sample was carried out for 20 minutes according to temperature also listed in Table 1.0. After that, the roasted beans were deshelled by manually removing the shell from the nibs. The roasted cocoa nibs were then stored in a vacuum thermos before proceeding to chocolate preparation.

Table 1.0: Oven brand and roasting temperature.

Sample	Oven Brand	Temperature (°C)
1	Faber FBR-FORNO10	80
2	Faber FBR-FORNO10	110
3	Faber FBR-FORNO10	140
4	Milux MOT-25	90
5	Milux MOT-25	120
6	Milux MOT-25	150
7	Butterfly BEO5229	100
8	Butterfly BEO5229	130
9	Butterfly BEO5229	160
10	Hanabishi HE0-23R	100
11	Hanabishi HE0-23R	130
12	Hanabishi HE0-23R	160

Chocolate preparation

The dark chocolate samples were prepared according to Rocha et al., (2017) using the following recipes: cocoa liqueur (63.00%), cocoa butter (7.00%), sugar

(29.60%) and lecithin (0.40%). Initially, cocoa nibs were mixed with sugar and ground into a powder using a Philips dry blender. Afterward, the mixed powder was milled in a Lakshmi 2 L Table Top Wet Grinder for two hours. Cocoa butter was added before the mixtures were milled further for another two hours. Finally, lecithin was added in the last 30 minutes of milling and the resulting chocolate paste was tempered, moulded and packaged.

Sensory evaluation

a) Consumer acceptability test

The consumer acceptability test is to evaluate products using untrained panels (Sharif et al., 2017). The consumers were served with a 1.0 g sample of each treatment, randomly coded with three-digit numbers. The evaluation was carried out in an open space during the daytime and the consumers as the untrained panels were provided with plain drinking water to cleanse their palates between samples tasting. The consumers were required to visualize and taste the chocolate samples. They evaluated the appearance, aroma/flavour, texture, and overall liking attributes according to a 5-point hedonic scale (1 = Unpleasant, 2 = Disappointing, 3 = Recommended, 4 = Highly recommended, 5 = Outstanding).

b) Quantitative Descriptive analysis

Three of the dark chocolates which obtained the highest score were further assessed for quantitative descriptive analysis (QDA) sensory profiling. The analysis was carried out at Cocoa Innovative and Technology Centre (CITC), Nilai, by MCB trained panelists. The analysis was carried out during daytime in individual stations with a well-lighted and ventilated environment. Prior to the analysis, the chocolate samples were placed in individual zip-lock plastic, codified with a three-digit-cod and conditioned to room temperature. The panelists were required to evaluate the following attributes: appearance/glossiness, taste/aroma cocoa, sweet, creamy/milky taste, salty, bitter, astringent, sourness, nutty taste/aroma, roasted taste/aroma, rancid taste/aroma, texture (hardness) as well as overall acceptability. A scale of "0" to "10" was used, where “0” indicated the intensity of the attribute is absent or minimum while “10” indicated the maximum. The panelists were provided with plain biscuits and water to cleanse their palates in between the samples testing.

Statistical analysis

Analysis of variance (ANOVA) using Minitab 18 was carried out and followed by the Tukey test ($p \leq 0.05$) for the data obtained from the consumer acceptability test and quantitative descriptive analysis.

RESULTS AND DISCUSSIONS

A total of 20 consumers aged between 20 to 45 years from four different locations which were Pasir Putih, Ketereh, Tanjung Malim and Bagan Datuk have participated on a voluntary basis. The consumers have chocolate consumption habits of dark chocolate at least three times per week. The results obtained for the acceptability test of the chocolate samples are shown in Figure 1.0. Ten out of the 20 consumers expressed that the appearance of the chocolate sample-8 was 'Recommended' (Figure 1.0a). Whereas, the appearance of the remaining samples was either expressed as 'Disappointing' or 'Unpleasant'. In terms of the aroma/flavour of the chocolate, sample-8 was chosen as 'highly recommended' by the majority of the consumers (Figure 1.0b). Another four samples which were sample-5, -7, -9 and -10 were rated as 'Recommended'. This study revealed that almost all the consumers felt 'Disappointing' by the texture of chocolate produced (Figure 1.0c). Regarding to overall liking attribute (Figure 1.0d), sample-8 was voted as the most 'Outstanding' by the majority of the consumers, while scale of 'highly recommended' for sample-5 as well as sample-6. The General Linear Model (GLM) ANOVA results were shown that interaction of the oven brand and roasting temperature have a significant ($p \leq 0.05$) effect on the appearance, aroma/flavour and overall liking attributes of chocolate samples. However, a non-significant ($p > 0.05$) interaction was found for the texture attribute in the study (Table 2).

Based on the GLM ANOVA results of the overall liking attribute (Table 2.0), three of the dark chocolates which were sample-8, sample-6 and sample-5, respectively were selected for quantitative descriptive analysis (QDA) sensory profiling. Six trained panelists have participated and the sensory characteristics are shown in Table 3.0. In line with the acceptability test, sample-8 has the highest score for the overall acceptability of the three selected dark chocolate. However, the panelists have selected sample-6 as the second rank compared to sample-5. The panelists have characterized the sample-8 as dark chocolate with medium intensity of cocoa flavour (3.7 ± 1.5), low intensity of bitter (2.6 ± 1.4), astringent (2.3 ± 1.3) and sour (1.9 ± 1.2). The sample also has a slightly creamy/milky (2.5 ± 1.3) and nutty (1.7 ± 1.5) taste. However, the quality of all the samples seems deteriorated as the panelists have detected the taste of rancid and off-flavour. In terms of roasting, all the samples have a lower scale of roasted taste with 1.3 ± 1.2, 2.0 ± 1.7 and 2.4 ± 1.6 for sample-5, -6 and -8 respectively. While, sample-5 has the hardest texture (3.7 ± 1.3), followed by sample-8 (2.8 ± 1.5) and sample-6 (0.8 ± 0.8), respectively.

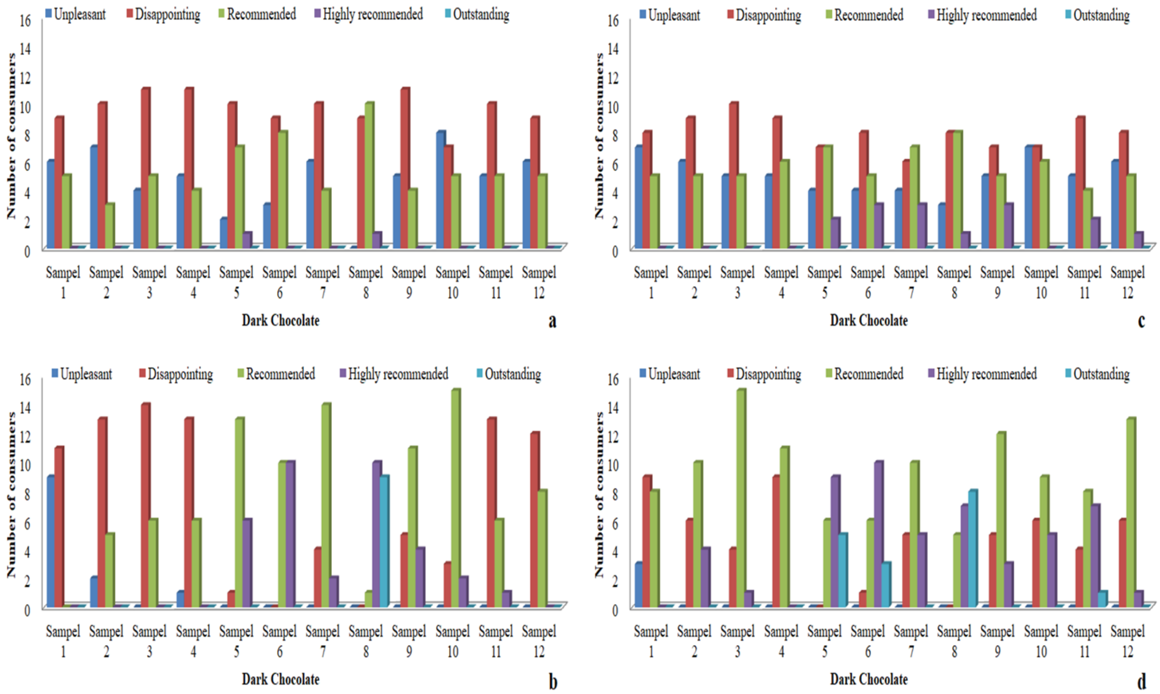

Figure 1.0: The acceptability test on the (a) appearance, (b) aroma/flavour, (c) texture and (d) overall liking of the chocolate samples.

Table 2.0: Average appearance, aroma/flavour, texture and overall liking attributes scores of acceptability test for dark chocolate prepared from roasted cocoa beans using different brands of home oven.

Sample	Appearance	Aroma/flavour	Texture	Overall liking
1	2.0 ± 0.8^{ab}	1.6 ± 0.5^{f}	1.9 ± 0.8^{a}	2.3 ± 0.7^{d}
2	1.8 ± 0.7^{b}	2.2 ± 0.6^{e}	2.0 ± 0.8^{a}	2.9 ± 0.7^{cd}
3	2.1 ± 0.7^{ab}	2.3 ± 0.5^{e}	2.0 ± 0.7^{a}	2.9 ± 0.5^{cd}
4	2.0 ± 0.7^{ab}	2.3 ± 0.6^{e}	2.1 ± 0.8^{a}	2.6 ± 0.5^{cd}
5	2.4 ± 0.8^{ab}	3.3 ± 0.6^{bc}	2.2 ± 0.8^{a}	4.0 ± 0.8^{ab}
6	2.3 ± 0.7^{ab}	3.5 ± 0.5^{b}	2.2 ± 0.8^{a}	3.8 ± 0.8^{ab}
7	1.9 ± 0.7^{ab}	2.9 ± 0.6^{cd}	1.9 ± 0.7^{a}	3.0 ± 0.7^{c}
8	2.6 ± 0.6^{a}	4.4 ± 0.6^{a}	2.4 ± 0.8^{a}	4.2 ± 0.8^{a}
9	2.0 ± 0.7^{ab}	3.0 ± 0.7^{bcd}	2.0 ± 0.7^{a}	2.9 ± 0.6^{cd}
10	1.9 ± 0.8^{b}	3.0 ± 0.5^{bcd}	2.0 ± 0.8^{a}	3.0 ± 0.7^{cd}
11	2.0 ± 0.7^{ab}	2.4 ± 0.6^{de}	2.2 ± 0.9^{a}	3.3 ± 0.8^{bc}
12	2.0 ± 0.7^{ab}	2.4 ± 0.5^{de}	2.1 ± 0.9^{a}	2.8 ± 0.6^{cd}

Analysis of Variance ($\alpha = 0.05$, n=20)

Factor	F-ratio	P-value	F-ratio	P-value	F-ratio	P-value	F-ratio	P-value
B	2.32	0.076	0.82	0.482	1.71	0.165	3.13	0.027*
T	2.12	0.020*	36.18	0.000*	0.58	0.843	13.23	0.000*
B X T	13.65	0.000*	7.6	0.000*	1.96	0.052	4.04	0.000*

B: Brand of oven; T: Temperature use (the F-ratio and P-Value for the 4 attributes)

Table 3.0. Average quantitative descriptive analysis score (n=6) of dark chocolate prepared from roasted cocoa beans using different brands of home oven.

Attributes	**Sample**		
	Sample 5	**Sample 6**	**Sample 8**
Appearance /glossiness	0.0 ± 0.0	0.3 ± 0.4	0.0 ± 0.0
Taste/aroma koko	1.7 ± 1.5	2.9 ± 2.0	3.7 ± 1.5
Sweet	1.8 ± 0.9	3.3 ± 1.9	3.0 ± 1.1
Creamy/Milky taste	1.7 ± 1.2	2.1 ± 1.4	2.5 ± 1.3
Salty	1.3 ± 0.8	1.1 ± 1.3	1.2 ± 1.2
Bitter	3.8 ± 1.7	2.7 ± 1.0	2.6 ± 1.4
Astringent	3.1 ± 2.0	1.8 ± 1.5	2.3 ± 1.3
Sourness	1.8 ± 1.2	2.1 ± 1.2	1.9 ± 1.2
Nutty taste/aroma	0.4 ± 0.8	1.0 ± 0.6	1.7 ± 1.5
Roasted taste/aroma	1.3 ± 1.2	2.0 ± 1.7	2.4 ± 1.6
Rancid taste/aroma	1.4 ± 1.0	1.0 ± 1.1	0.5 ± 0.8
Texture:hardness	3.7 ± 1.3	0.8 ± 0.8	2.8 ± 1.5
OVERALL ACCEPTABILITY	0.9 ± 1.1	1.3 ± 1.5	2.5 ± 1.8
OFF FLAVOURS	3.5 ± 3.6	0.2 ± 0.4	0.6 ± 0.9

The appearance of good quality dark chocolate is manifested by the colour intensity and glossiness (Saputra et al., 2018) and is the first attribute to be evaluated by consumers. During the acceptability test, the consumers were asked to pay attention to colour instead of glossiness as the tempering step was not carried out during chocolate preparation. The lack of tempering may also affect the hardness of chocolate produced; hence lowering its rating scale during QDA. Besides poor tempering, level of moisture or reducing sugar, incorrect cooling methods and high or fluctuating storage temperature also affect the glossiness (Torres-Moreno et al., 2012). A study by Nazaruddin et al., (2006) reported that the glossiness value increased significantly ($p < 0.05$) for chocolate stored at 27°C compared to chocolates stored at 16°C with controlled humidity at 50%. The glossiness of chocolate was not stable and not uniform at the different storage conditions.

The impact of two roasting factors; temperature and duration of cocoa beans using rotatable toaster (Jaf Inox) on the sensory acceptability of chocolate have been studied Rocha et al., (2017). Using response surface methodology, the study revealed that temperature has a higher impact instead of the duration of roasting. The rotatable toaster used in the study has a loading capacity for more than 10kg and is almost identical to the condition of a commercial roaster for cocoa beans. Meanwhile, the ovens used in the study have a loading capacity of 10L (Faber FBR-FORNO10), 23L (Hanabishi HE0-23R), 25L (Milux MOT-25) and 28L (Butterfly BEO5229), respectively. The ovens were also the basic appliances which are always use at home. Judging by the scale given by the trained panelists on roasted taste\aroma, all the ovens can be used to roast cocoa beans. However, further study should be carried out to optimize the duration and temperature of the oven. Additionally, methods on home-based chocolate preparation including conching and tempering as well as storage should be improved. Djikeng et al., (2018) have evaluated the usage of an oven and compared the effect of traditional roasting on the polyphenol content, antioxidant activity, lipid quality, proximate composition and mineral content of fermented cocoa beans. However, the study has not evaluated the sensory characteristic of the roasted cocoa beans either as liquor or chocolate.

CONCLUSIONS

The applicability of the different brands of basic ovens for cocoa beans roasting in home-based chocolate production has been studied. Four ovens Faber FBR-FORNO10, Hanabishi HE0-23R, Milux MOT-25 and Butterfly BEO5229 have respective loading capacities of 10L, 23L, 25L and 28L can be used as an alternative roaster. Although the dark chocolate received lower acceptance on the appearance and texture attributes, a consumer acceptability test for the dark chocolate prepared revealed that three out of twelve samples; sample-8, sample-6 and sample-5 respectively, received the most 'overall liking'. A quantitative descriptive analysis on the three samples exhibited that sample-8 received the highest overall acceptability with medium intensity of cocoa (3.7 ± 1.5) with low intensity of bitter (2.6 ± 1.4), astringent (2.3 ± 1.3) and sour (1.9 ± 1.2). The sample also has a slightly creamy/milky (2.5 ± 1.3) and nutty (1.7 ± 1.5) taste. Therefore, further study should be carried out to optimize the duration and temperature for each oven as the GLM ANOVA shows significant differences between brands used, temperatures, and interaction.

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