

The Development of Agarwood Leaves Extract Powder Into Chocolate Spread

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Abstract

This study developed a chocolate spread with agarwood leaves extract powder (ALEP) for its functional properties. The formulation was optimized using Design Expert software to balance physical and sensory characteristics. The process involved drying, grinding, and spray-drying the leaves, then blending with sugar, vegetable oil, and skim milk powder. Results showed that ALEP improved the spread's functional properties but reduced sweetness and introduced bitterness. However, other attributes were well accepted by consumers. The optimal formulation was 40.0% sugar, 36.8% vegetable oil, and 16.8% skim milk powder, though further refinement is needed to improve flavor and consumer appeal. This study demonstrates the potential of ALEP-enriched spreads in the functional food market with necessary sensory adjustments.

1. Introduction

This research explores the potential of incorporating agarwood leaves extract powder (ALEP) into chocolate spread, responding to the growing consumer demand for functional foods with added health benefits. Today's consumers are increasingly seeking products that offer additional health benefits, leading to a notable rise in awareness and interest regarding the health-enhancing properties of certain foods or food ingredients [1]. Chocolate, being a widely loved treat, particularly among children, has seen widespread use in various forms, including chocolate spreads. Research has shown that its leaves contain bioactive compounds with promising health benefits, such as anti-mutagenic and anti-inflammatory properties [2]. However, agarwood leaves are typically consumed as a beverage ingredient, as their powdery texture can make them challenging to incorporate into solid foods. This study aims to develop a chocolate spread that incorporates ALEP, offering a palatable and convenient way to harness the health benefits of agarwood.

The objectives of this research include optimizing the formulation of the chocolate spread using Design Expert software, with a focus on key physical properties such as texture, moisture content, and rheology to achieve the desired spread ability and consistency. Sensory evaluations are set to assess consumer acceptance through a hedonic scale method with participants from Universiti Tun Hussein Onn Pagoh. By integrating ALEP into the chocolate spread, this study seeks to create a functional food product that not only meets taste preferences but also delivers the potential health benefits associated with agarwood. This innovation aligns with global trends in the food industry, where consumers increasingly seek products that combine convenience, flavour, and functional health properties. The findings could contribute to the growth of the herbal market, particularly in Malaysia, and offer valuable insights into the feasibility of incorporating agarwood as a functional ingredient in everyday food products.

2. Research Methodology

2.1 Preparation of Agarwood Leaves Extract

In this study *Aquilaria sinensis* leaves were utilized. The leaves were carefully selected to ensure uniformity and the absence of any damage or infestation. The leaves were clean before drying. After cleaning, the leaves were dried in a smokehouse, which helped preserve their bioactive compounds and prevent microbial contamination. Once dried, the leaves were subjected to a grinding process to reduce them into a fine powder. This step increases the surface area of the leaves, making them more suitable for efficient extraction. The ground leaves were then dissolved in distilled water at a ratio of 1:10 and infused at a temperature of 27°C. The extraction process followed the method described by [3] where the mixture was heated to 95-100°C for two 10-minute sessions, with a 5-minute break in between. After the infusion, the mixture was filtered using Whatman Filter No. 1 to remove any remaining plant particles. The resulting extract was then refrigerated before undergoing spray drying to produce the final powdered agarwood leaf extract.

2.2 Spray Drying

Spray drying process was performed by adding 15% maltodextrin to the *Aquilaria* leaf extract, following the method of Papoutsis [4] and Rajabi [5] with slight modifications. The extract was spray-dried at an inlet temperature of 150-180°C, with a feed flow rate of 10-20 rpm and a nozzle size of 0.7 mm. The resulting powder was stored in an airtight container for further evaluation.

2.3 Production of Chocolate Spread

The optimization of the chocolate spread formulation focuses on sugar, vegetable oil, and skim milk powder content to achieve the desired characteristics and flavor. The typical formulation consists of 38-42% sugar, 25-40% vegetable oil, and 12-20% skim milk powder [6]. Additionally, it includes 1% lecithin, 5% agarwood leaf extract powder [7], and 10% cocoa powder [8]. Cocoa powder, sugar, vegetable oil, and skim milk are combined and mixed thoroughly. Lecithin is then added and stirred in, followed by the incorporation of agarwood leaf extract powder, which is mixed until evenly distributed.

Table 1 Design of experiment

	ALEP Plant extract (%)	Lecithin (%)	Cocoa powder (%)	Sugar (%)	Vegetable oil (%)	Skim milk powder (%)
1	4	2	10	38.00	38.32	17.68
2	4	2	10	38.00	36.49	19.51
3	4	2	10	38.00	40.00	15.96
4	4	2	10	39.42	34.59	20.00
5	4	2	10	39.42	34.59	20.00
6	4	2	10	39.78	40.00	14.22
7	4	2	10	39.78	40.00	14.22
8	4	2	10	39.86	38.19	15.95
9	4	2	10	39.86	38.19	15.95
10	4	2	10	41.36	36.33	16.33
11	4	2	10	41.36	36.33	16.33
12	4	2	10	41.36	36.33	16.33
13	4	2	10	41.99	38.03	13.98
14	4	2	10	42.00	34.07	17.93
15	4	2	10	42.00	40.00	12.00
16	4	2	10	42.00	32.00	20.00

2.4 Physical Properties Analysis

Physical properties such as texture, moisture content and viscosity of chocolate spread incorporated with agarwood leaves extract powder are measured to evaluate the physical characteristics. Each sample formulations are analyzed in triplicate.

2.4.1 Determination of Texture

According to [9], texture parameters such as hardness, consistency, and adhesiveness were measured using a TA-XT plus Texture Analyzer (Stable Micro Systems, Surrey, England). For the chocolate spread with ALEP, 5 grams of sample were analyzed at room temperature using a conical probe. The probe was lowered to contact the sample's surface and applied compression at 0.5 mm/s to a depth of 10 mm, followed by a second compression five seconds later. The tests were performed in triplicate, and the data were recorded and analyzed.

2.4.2 Determination of Viscosity

Viscosity of chocolate spread with agarwood leaves extract powder were determined by using the viscometer (Brookfield Digital Viscometer) with the viscometer first calibrated according to the manufacturer's instructions. The viscosity of 500 ml of chocolate spread was measured by using this method. Spindle 07 was used to take measurement at 100 rpm. The process was conducted at a consistent temperature to prevent variations in viscosity, as it is highly temperature-dependent [10]. Finally, the viscosity data obtained were analysed to assess the texture of the chocolate spread.

2.4.3 Determination of Moisture Content

The moisture content of the chocolate samples was determined using the AND moisture analyzer (MX-50, A&D, Japan) as described by Asghar [13]. Approximately 1 gram of the sample was placed on the analyzer's pan, ensuring even distribution. The device was calibrated to zero, and the drying temperature was set to 140°C. The moisture content was recorded in triplicate.

2.5 Sensory Evaluation

The experiment was conducted at the sensory analysis laboratory of Universiti Tun Hussein Onn Malaysia (UTHM) Pagoh. Sixty untrained panelists evaluated the chocolate spread samples incorporated with agarwood leaf extract powder. Prior to the test, the panelists received a brief training on the Hedonic test methodology and the experimental procedure. Each sample was assigned a three-digit code, and the panelists were instructed to neutralize their taste between samples using mineral water and bread [11]. This test evaluates the intensity of different concentrations of agarwood leaf extract in chocolate spread. Panelists assess the samples based on appearance, sweetness, aroma, bitterness, aftertaste, and overall acceptability. A seven-point hedonic scale is used (1 = very much dislike, 7 = very much like) [12].

2.6 Statistical Analysis

The data from the study were collected and entered Microsoft 365 Excel for analysis. One-way ANOVA was used to analyze the differences between the attributes, such as appearance, aroma, sweetness, bitterness, aftertaste, and overall acceptance.

3. Result and Discussion

3.1 Model Fitting

The optimization of chocolate spread incorporating agarwood leaves extract powder was conducted with a focus on three key responses: texture, viscosity, and moisture content. These responses were measured using a series of experimental runs, and the model summary statistics are presented in Table 2. The table includes important metrics such as standard deviation (SD), mean values, R^2 , adjusted R^2 , and predicted R^2 for each response, providing insight into the effectiveness and reliability of the model used for optimization.

The texture of the chocolate spread demonstrated the best statistical results in the model. The standard deviation (SD) of 0.0013 is extremely low, indicating minimal variability in the texture measurements. The mean texture value was found to be 6.55, suggesting a moderately consistent texture across the samples. More importantly, the model showed a perfect fit for the texture response, with an R^2 value of 1.0000. This indicates that the model explains all the variance in the texture, making it highly reliable. The adjusted R^2 value of 1.0000 further confirms the robustness of the model, as it adjusts for the number of predictors used. Additionally, the predicted R^2 value of 0.9197 suggests that the model has a strong predictive ability, with a slight reduction from the R^2 , indicating good generalizability. Viscosity, on the other hand, presented a more complex scenario. The standard deviation for viscosity was significantly higher at 415.81, reflecting greater variability in the viscosity measurements compared to texture. The mean viscosity value was 7066.06, which is substantially higher than the texture measurement, indicating a thicker consistency for the chocolate spread. The R^2 value for viscosity was 0.5818, which means the model only explains about 58% of the variance in viscosity, suggesting a moderate fit. However, the adjusted R^2 of 0.1039 is quite low, indicating that after accounting for the number of predictors, the

model does not fit the viscosity data as well as it does for texture. Furthermore, the negative predicted R^2 of -27.1600 signifies poor predictive power, indicating that the model may not be reliable for predicting viscosity in future samples. The moisture content of the chocolate spread exhibited a strong model fit, with an R^2 value of 0.9417, suggesting that 94% of the variance in moisture content is explained by the model. This indicates a high degree of reliability for this response. The adjusted R^2 of 0.8541, while lower than the R^2 , still reflects a good fit, though it is slightly reduced when accounting for the number of predictors. However, the predicted R^2 for moisture content is highly negative at -244.1261, indicating that despite the strong model fit in terms of variance explanation, the model has very poor predictive capability for moisture content. This suggests that while the model effectively explains moisture content in the current dataset, it may not be reliable for predicting moisture content in new samples.

Table 2 Model summary statistical for three responses

	SD	Mean	R^2	Adjusted R^2	Predicted R^2
Texture	0.0013	6.55	1.0000	1.0000	0.9197
Viscosity	415.81	7066.06	0.5818	0.1039	-27.1600
Moisture content	0.4310	17.03	0.9417	0.8541	-244.1261

The ANOVA results presented in Table 3 highlight the significance of the cubic model in predicting the texture, viscosity, and moisture content of chocolate spread incorporating agarwood leaf extract powder. For texture, the F-value of 34868.98 and p -value of <0.0001 indicate a highly significant model fit. The low residual value (9.447E-06) suggests that the model effectively captures the variability, demonstrating strong reliability for optimizing texture. In the case of viscosity, the F-value of 5.74 and p -value of 0.0163 show a statistically significant effect, although the higher residual (6.745E+07) and lack of fit suggest unexplained variability. This indicates the need for model refinement to improve its accuracy in predicting viscosity, possibly by incorporating additional influencing factors. For moisture content, the F-value of 11.4 and p -value of 0.0039 confirm the model's effectiveness, with a low residual (0.0001) highlighting its strong predictive capability. This is critical for ensuring product stability and shelf life.

Table 3 Summary of ANOVA for each response

Response variable	Sum of square	Degree of freedom	Mean square	F-value	p -value	
Texture (g)	0.4941	9	0.0549	34868.98	<0.0001	Significant
Residual	9.447E-06	6	1.575E-06	-	-	
Lack of fit	9.447E-06	1	9.447E-06	-	-	
Viscosity (cP)	4.423E+08	8	5.529E+07	5.74	0.0163	Significant
Residual	6.745E+07	7	-	-	-	
Lack of fit	6.745E+07	2	-	-	-	
moisture content (%)	0.0009	9	0.0001	11.4	0.0039	Significant
Residual	0.0001	6	9.029E-06	-	-	
Lack of fit	0.0001	1	0.0001	-	-7	

3.2 Physical properties of chocolate spread

Table 4 presents an analysis of the texture, viscosity, and moisture content of chocolate spreads with agarwood leaf extract powder (ALEP). These parameters are essential for evaluating the sensory, rheological, and physical properties that influence consumer appeal and product performance. Table 4 shows mean values and standard deviations for 16 samples, highlighting variations due to ingredient composition. Texture values reflect spreadability, viscosity indicates flow behavior, and moisture content affects texture and shelf stability. Statistical significance ($p < 0.05$) emphasizes the importance of these differences in understanding the impact of ALEP. This

data helps identify formulations with the optimal balance of these key properties for high-quality chocolate spreads.

Table 4 Texture, viscosity, and moisture content of chocolate spread with ALEP

Sample	Response 1	Response 2	Response 3
	Texture	Viscosity	Moisture content
1	6.609	42,633.3	17.870
2	6.932	43,560.0	16.733
3	6.385	33,300.0	16.747
4	6.857	28,427.0	16.767
5	6.857	28,427.0	16.767
6	6.509	38,163.3	17.857
7	6.509	38,163.3	17.857
8	6.509	42,483.3	16.503
9	6.509	42,483.3	16.503
10	6.559	40,300.0	15.327
11	6.559	40,300.0	15.327
12	6.559	40,300.0	15.327
13	6.310	30,283.0	17.603
14	6.335	27,283.3	19.013
15	6.559	35,666.7	18.740
16	6.434	43,166.7	17.567

3.3 Texture of Chocolate Spread

Texture is crucial for consumer acceptance, influencing spreadability and stability [2]. The texture of chocolate spread with agarwood leaves extract powder (ALEP) is influenced by ingredient concentrations and processing conditions, as shown in the 3D graph. The Z-axis represents texture values, ranging from 6.31 (softer, blue) to 6.932 (firmer, red), with red areas indicating optimal texture. The graph reveals a non-linear relationship, where texture increases and then decreases based on the combination of ALEP and other factors. The table provides texture values for 16 samples, with Sample 2 (6.932) showing the best texture, consistent with the red peak in the graph. Sample 13 (6.310) corresponds to softer regions in the graph. These insights suggest that higher ALEP concentrations or specific processing conditions improve texture, but exceeding certain limits may lead to undesirable softness.

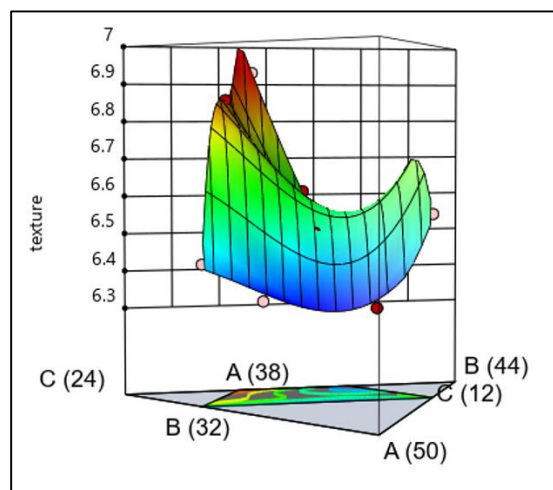


Fig. 1 3D graph Response Surface texture of chocolate spread

3.4 Viscosity of chocolate spread

Rheological properties, such as viscosity, are crucial for the texture and spreadability of chocolate spreads [14]. The viscosity of chocolate spread with agarwood leaves extract powder (ALEP) is influenced by ingredient concentrations and processing conditions, as shown in both the 3D graph. The viscosity values in the table range from $27,283 \pm 11.4$ to $43,560 \pm 34.6$, corresponding to the blue (low viscosity) and red (high viscosity) regions on the graph. Key observations show that high viscosity values, like Sample 2 (43,560), align with red areas on the graph, indicating a thicker, less spreadable spread. In contrast, low viscosity values, such as Sample 14 (27,283), match the blue regions, suggesting a thinner, more spreadable texture. The data from the table and graph reflect non-linear trends, where viscosity fluctuates based on ALEP levels and processing conditions. Formulations with higher viscosity may be too thick for general use, while lower viscosity may be preferred for spreadability but could risk product instability. The optimal viscosity appears to lie between these extremes, as seen in samples with viscosities around 38,000–42,000, offering a good balance of spreadability and stability.

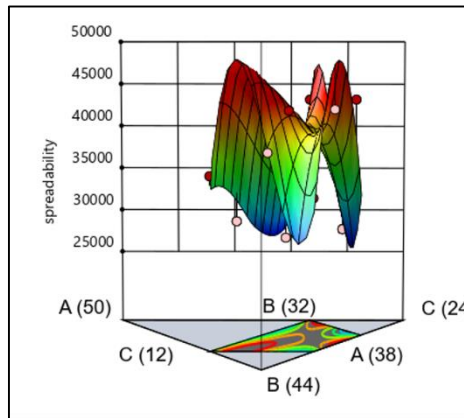


Fig 2 3D graph Response Surface viscosity of chocolate spread

3.5 Moisture Content of Chocolate Spread

Moisture content is crucial in determining the texture, shelf life, and stability of chocolate spreads. In the analyzed samples containing agarwood leaves extract powder (ALEP), moisture content ranged from 15.32% to 19.01%. Higher moisture, such as in Sample 14 (19.01), leads to softer textures but risks spoilage, while lower levels, like in Sample 9 (15.32), contribute to firmness and extended shelf life. The variability highlights the influence of ALEP and other ingredients on water retention. Moderate moisture levels, such as Sample 2 (16.73), provide an ideal balance for spread ability and stability. Managing moisture through formulation and processing ensures a product that meets consumer preferences while remaining safe and durable.

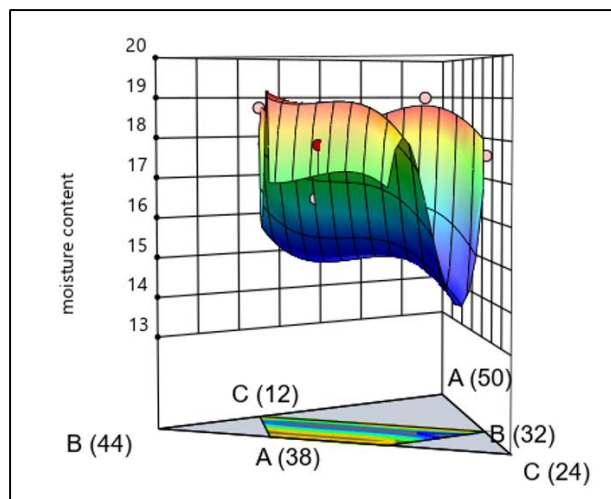


Fig 3 3D graph Response Surface moisture content of chocolate spread

3.6 Sensory evaluation

The sensory evaluation results of samples 806 and 234, presented in Table 5, reveal several key differences in consumer perceptions across various attributes, such as appearance, sweetness, aroma, bitterness, aftertaste, and

overall acceptance. Sample 234 scored higher than sample 806 in all attributes, including sweetness (6.18 compared to 5.95), aroma (5.93 compared to 5.38), bitterness (5.22 compared to 4.73), aftertaste (6.18 compared to 5.82), and overall acceptance (6.40 compared to 5.97), with all differences being statistically significant. The most notable improvement was in bitterness, where sample 234 showed a lower bitterness score, making it more favorable to consumers.

Table 5 The mean of sensory attributes measured for chocolate spread with ALEP.

Sample	Appearance	Sweetness	Aroma	Bitterness	Aftertaste	Overall Acceptance
806	5.805±1.055 ^A	5.950±1.032 ^A	5.383±1.391 ^B	4.733±1.765 ^A	5.817±1.200 ^A	5.967±0.991 ^B
234	5.967±0.991 ^A	6.183±0.983 ^A	5.933±1.177 ^A	5.217±1.698 ^A	6.183±1.049 ^A	6.400±0.887 ^A

Figure 4 show a spider web chart of sensory results for chocolate spreads with and without ALEP. The chart compares their performance across several sensory attributes, including appearance, sweetness, aroma, bitterness, aftertaste, and overall acceptance. In terms of appearance, both samples scored similarly, indicating that the addition of agarwood leaves extract powder in Sample 234 did not significantly alter the visual appeal of the chocolate spread. This suggests that the extract has no noticeable impact on the product's look, which is beneficial for maintaining consumer expectations. For sweetness, Sample 234 achieved a slightly higher score compared to Sample 806. This indicates that the addition of the agarwood leaves extract powder might have subtly enhanced the sweetness profile, making it more appealing to consumers. Similarly, Sample 234 outperformed Sample 806 in aroma, suggesting that the extract contributed positively to the fragrance, likely adding unique and desirable notes that enriched the sensory experience. However, bitterness was notably higher in Sample 234. This can be attributed to the inherent bitterness of the agarwood leaves extract. While bitterness is often perceived negatively, it can appeal to certain consumers who prefer complex and sophisticated flavours profiles. The higher bitterness score could influence the overall acceptance of Sample 234, depending on consumer preferences. The aftertaste of Sample 234 also scored higher than that of Sample 806, indicating that the extract powder contributed to a more favourable lingering taste. This improvement in aftertaste might compensate for the increased bitterness, as it enhances the overall flavours experience. Overall, Sample 234 scored well across most attributes, showing that the addition of agarwood leaves extract powder positively influenced the sensory qualities of the chocolate spread. However, the higher bitterness might limit its acceptance among consumers who prefer milder flavours. In contrast, Sample 806, without the extract, performed consistently but lacked the distinctive enhancements provided by the extract. These findings suggest that while the agarwood leaves extract powder introduces unique sensory qualities, its bitterness must be carefully balanced to optimize overall acceptance.

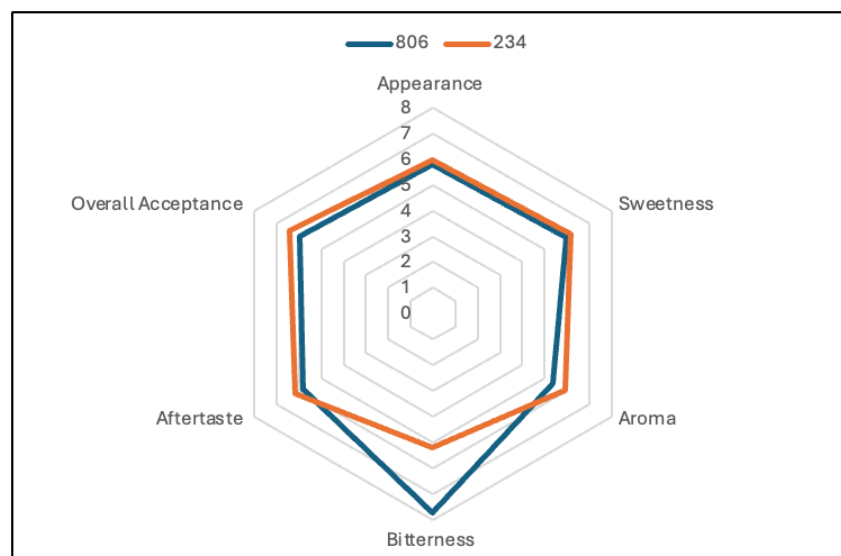


Fig. 4 Spider Web Chart (Sensory evaluation)

4. Conclusion

This study developed a chocolate spread incorporating agarwood leaf extract powder (ALEP), optimized using Design Expert software. The optimal formulation consisted of 40.0% sugar powder, 36.8% vegetable oil, and 16.8% skim milk powder. Sensory testing of the optimized spread revealed that ALEP enhanced the flavor, with consumers accepting all attributes, though the bitterness was slightly low. Despite this, ALEP demonstrated

potential health benefits, such as antioxidant properties, without negatively affecting overall acceptance. The aftertaste was comparable to the control, indicating that the spread could appeal to health-conscious consumers without sacrificing flavor. This study highlights the potential for ALEP-enriched products and recommends examining the nutritional profile of agarwood leaf extract powder to evaluate its health benefits and determine its suitability for consumption.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Ain Fairuz, Balkis A Talip; **data collection:** Ain Fairuz; **analysis and interpretation of results:** Ain Fairuz; **draft manuscript preparation:** Ain Fairuz, Balkis A Talip. All authors reviewed the results and approved the final version of the manuscript.

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