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Extended Abstract

# Optimization of Fortified Milk Chocolate Formulation with Chia Seed Oil, Vitamin D3, and Calcium by Surface Response Method

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## Abstract

In the present research, the optimization of formulation of fortified chocolate using Chia seed Oil as source of Omega-3, vitamin D3 and calcium was investigated by surface response method .Different amounts of calcium (60, 95 and 130 mg), vitamin D3 (0.5, 0.75 and 1 $\mu$g) and Chia Oil (1, 3 and 5 mg) were added to the chocolate in the 20 formulations designed by Design Expert software and the sensory properties of the fortified chocolates were then tested by the evaluators. Based on the analysis of response surface method, 24 optimized samples were proposed by the software, all of which contained Omega-3 in the minimum range (1 mg) and calcium in the maximum range (130 mg) and three formulas were selected that they differed only in the amounts of vitamin D3 (0.5, 0.75 and 1 $\mu$g). Texture and thermal analysis, colorimetery, moisture, water activity and peroxide value tests were performed on these samples at first and 3 months later. Evaluation of sensory properties showed that the taste, texture and overall acceptance parameters of fortified chocolates were reduced compared to control ($P$<0.05). The whiteness index and water activity compared to the control were increased and decreased, respectively. However, the hardness and the peroxide values of the treatments were not changed significantly with respect to the control. The start temperature of melting of the fortified chocolate decreased compared to the control, while their melting points were the same. Due to taste and flavor of Omega-3, the overall acceptability of the fortified chocolates seems to decrease.

**Keywords:** Fortification, Functional, Sensory evaluation

## Introduction

Chocolate is one of the most widely consumed in the diet and is a good product for enrichment. Chocolate is fortified with a variety of mineral micronutrients such as iron, copper, magnesium and also various vitamins such as A or D. In a research white chocolate was enriched with omega-3 fatty acids after the conching process and found that white chocolate could be a carrier for bioactive substances that are heat-sensitive (Toker *et al*., 2018). Enrichment of dark chocolate with (9%) of almond, linseed, and quinoa revealed the chocolates with different formulation, except those enriched with flaxseed, showed acceptance and a desirable level of appearance (Freitas *et al*., 2016).

This research was done with the aim of optimizing the formulation and investigating physicochemical properties of fortified milk chocolate using chia seed oil (CSO) as a source of omega-3 as well as vitamin D3 (VD3) and calcium by surface response method after production and after three months of storage.

## Materials and methods

Different amounts of calcium carbonate, VD3 and CSO were added to the chocolate formulation and mixed based on the treatment composition obtained from Design Expert software (version 7). The central composite design was used to optimize different levels of VD3, CSO and calcium on the sensory properties of chocolate produced. Quadratic polynomials were used to fit the experimental data and predict the answers. Evaluation sensory of the chocolates were done in terms of taste, texture, color and overall acceptance by 5-point hedonic test (Larmond, 1977).

The color indices of L*, a*, b* chocolate samples were measured using a colorimeter (WF-30, China Iwave). Color differences (ΔE) and whiteness index (WI) were calculated based on Equations 1 and 2 (Jeyarani, Banerjee, Ravi, & Krishna, 2015).

$$\Delta E= [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{0.5} \quad (1)$$

$$WI=100- [(100 - L^*)^2 + (a^{*2}) + (b^{*2})]^{0.5} \quad (2)$$

Water activity of chocolates was determined using a water activity measuring device (Novasina, lab master-Standard, Swisszerland). Moisture content of chocolates was determined by vacuum oven method until reaching a constant weight (Salehi, 2018). Texture analysis of chocolate samples were done by compression method (TA.XTplus, Stable Micro Systems, UK) (Konar, Poyrazoğlu, & Artik, 2015). Oil peroxide value was measured by iodometric method (AOAC, 2005). Thermal properties of chocolate samples were evaluated using differential scanning calorimeter (Mettler Toledo, Model DSCI, Switzerland). Statistical analyses were performed with a simple random design in the form of factorial experiments. Mean comparisons were performed by Tukey test at 95% confidence level with the help of Minitab software.

## Results and discussion

The 20 formulations obtained by RSM for sensory evaluation. Then, based on the results of sensory evaluation, the quadratic model was identified as the best model for fitting the responses of this stage. For optimization, the amplitude of the variables was considered in the range used in the experiments and the maximum score of each sensory response was considered. About 24 optimal formulas were suggested by the software, in all of which the amount of CSO was considered in the minimum range (1 mg) and calcium was in the maximum range (130 mg). Therefore, three of these 24 optimal formulas suggested by the software were selected, which differed only in the amount of VD3 (1, 0.75, 0.5 $\mu$g) which were coded as $n_1$, $n_2$, $n_3$, respectively and control sample was coded as $n_0$.

Sensory testing showed that adding VD3 and CSO to chocolates did not significant on their color (Table 1). But the taste, texture and overall acceptance decreased compared to the control chocolate. Accordingly, the sensory properties of fortified chocolates were reduced significantly compared to the control after three months of storage. This is due to the presence of vitamin D3 as well as chia seed oil, which cause a soften texture in chocolate (Ilmi, Praseptiangga, & R A Muhammad, 2017).

**Table 1.** Sensory properties of the fortified chocolates based on three formulas proposed by the software (Mean±SD)

| Sample | Time | Taste | Color | Texture | Total Acceptance |
|---|---|---|---|---|---|
| $n_0$ | First | 4.85±0.21$^{a}$ | 4.10±0.12$^{a}$ | 4.81±0.09$^{a}$ | 4.85±0.20$^{a}$ |
| | Stored | 4.26±0.56$^{ab}$ | 4.00±0.79$^{a}$ | 4.29±0.91$^{a}$ | 4.25±0.65$^{ab}$ |
| $n_1$ | First | 3.65±0.40$^{b}$ | 3.75±0.61$^{a}$ | 3.84±0.74$^{b}$ | 3.68±0.75$^{b}$ |
| | Stored | 3.03±0.14$^{c}$ | 3.53±0.66$^{a}$ | 3.21±0.78$^{bc}$ | 3.01±0.10$^{c}$ |
| $n_2$ | First | 3.82±0.25$^{b}$ | 3.72±0.59$^{a}$ | 3.97±0.56$^{b}$ | 3.98±0.64$^{b}$ |
| | Stored | 3.07±0.21$^{c}$ | 3.26±0.53$^{ab}$ | 3.33±0.22$^{bc}$ | 3.09±0.22$^{c}$ |
| $n_3$ | First | 3.90±0.41$^{b}$ | 3.69±0.88$^{a}$ | 4.00±0.56$^{b}$ | 4.00±0.32$^{b}$ |
| | Stored | 3.08±0.23$^{c}$ | 3.35±0.72$^{ab}$ | 3.29±0.63$^{bc}$ | 3.11±0.31$^{c}$ |

* Different letters in each column means significant difference ($P$ <0.05).

Physico-chemical properties of the chocolates were given in Table (2). The color differences between chocolate samples (ΔE) at first production and after storage in three samples increased significantly compared to the control ($P$<0.05). This may due to the content of the added ingredients to the chocolate formulation (Toker *et al*., 2018). While, the white index in both the beginning of preparation and three months later compared to the control showed a significant increase ($P$<0.05) (Jeyarani *et al*., 2015).

**Table 2.** Physicochemical properties of the fortified chocolates (Mean±SD)

| Sample | Time | Hardness (g) | PV | ΔE | WI | Aw | Moisture |
|---|---|---|---|---|---|---|---|
| $n_0$ | First | 33788±1239$^{a}$ | 0.21±0.02$^{bc}$ | 0.11±0.09$^{b}$ | 19.37±0.15$^{b}$ | 0.302±0.003$^{a}$ | 1.93±0.02$^{bc}$ |
| | Storage | 30527±794$^{ab}$ | 0.38±0.03$^{ab}$ | 0.12±0.10$^{b}$ | 16.93±0.08$^{b}$ | 0.213±0.002$^{f}$ | 1.89±0.02$^{c}$ |
| $n_1$ | First | 24796±809$^{bc}$ | 0.33±0.1$^{abc}$ | 8.96±0.26$^{a}$ | 27.06±0.59$^{a}$ | 0.286±0.001$^{b}$ | 1.12±0.07$^{d}$ |
| | Storage | 22982±292$^{c}$ | 0.43±0.09$^{a}$ | 9.36±0.52$^{a}$ | 24.67±0.58$^{a}$ | 0.219±0.002$^{f}$ | 1.00±0.02$^{d}$ |
| $n_2$ | First | 26349±4159$^{bc}$ | 0.30±0.02$^{abc}$ | 8.16±0.30$^{a}$ | 26.15±0.31$^{a}$ | 0.275±0.005$^{cd}$ | 2.07±0.07$^{a}$ |
| | Storage | 24145±4073$^{c}$ | 0.35±0.06$^{bc}$ | 10.42±0.16$^{a}$ | 25.83±0.21$^{a}$ | 0.252±0.002$^{e}$ | 1.99±0.06$^{ab}$ |
| $n_3$ | First | 29868±1128$^{ab}$ | 0.35±0.05$^{b}$ | 7.80±4.58$^{a}$ | 26.74±4.29$^{a}$ | 0.280±0.004$^{bc}$ | 1.87±0.07$^{c}$ |
| | Storage | 27680±1441$^{abc}$ | 0.44±0.06$^{bc}$ | 9.19±5.20$^{a}$ | 25.64±4.74$^{a}$ | 0.268±0.007$^{d}$ | 1.82±0.06$^{c}$ |

*Different letters in each column means significant difference ($P$<0.05).

The fortified chocolates displayed a significant decrease ($P$<0.05) in water activity compared to the control. The amount of water activity of chocolates after three months was significantly reduced compared to their initial value. Also, the moisture content of chocolate samples was different from the control, but in all samples and the control, the moisture content decreased after three months compared to its original value bot not significantly (Salehi, 2018).

Texture analysis showed a reduction in hardness compared to the control group. Three months storage caused significant changes with a decreasing in the hardness of chocolates ($P$<0.05) (Konar *et al*., 2015). Peroxide values for fortified chocolate samples increased but not significantly compared to the control sample at the first preparation and after storage.

The thermal behavior diagrams of fortified and control chocolate showed one endothermic peak in the range of 0 to 70 °C (Fig. 1). Also, based on these diagrams, the onset temperature of melting in control chocolate was 27.54 °C, while in fortified milk chocolate this temperature was set at 25.72 °C. The comparison of the thermal behavior diagrams showed the thermogram peak of fortified chocolate is slightly wider. These behaviors may attribute to the presence of components in chocolate and differences in their thermal behavior, which has caused changes in the melting peak of the chocolate (Smith, 2016).

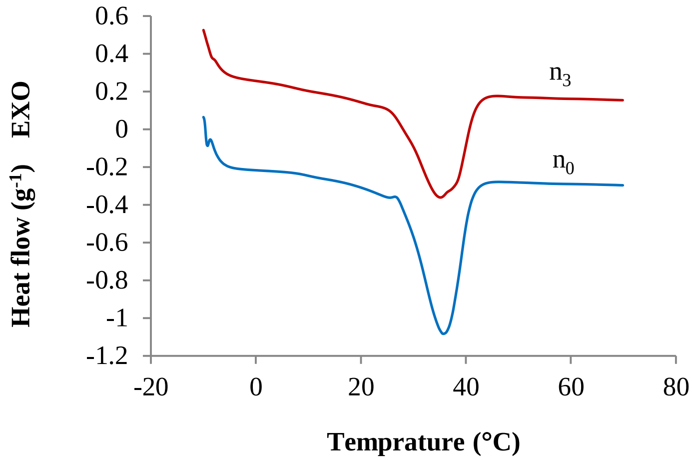


**Fig. 1.** DSC thermograms for fortified and control chocolates

## Conclusions

Based on the findings, it seems that the decrease in overall acceptance of fortified chocolates is due to the omega-3 flavor added to the chocolate formulation, and therefore more research should be done to make fortify chocolate with this substance through methods that cover the taste of this component.

## References


AOAC. (2005). Official Method Of Sampling and Analysis of Commercial Fats and Oils.

Freitas, J. B. d., Matos Souza, J. C. d., Velloso, L. A., Simão, R. A. S., Fernandes, D. C., Alves, A. M., & Naves, M. M. V. (2016). Acceptability and nutritional value of dark chocolate enriched with baru almonds, flaxseed and quinoa. *Vertices,, 17*(3), 99-109. doi:https://doi.org/10.19180/1809-2667.v17n315-05

Ilmi, A., Praseptiangga, D., & R A Muhammad, D. (2017). Sensory Attributes and Preliminary Characterization of Milk Chocolate Bar Enriched with Cinnamon Essential Oil. *IOP Conference Series: Materials Science and Engineering, 193*, 012031. doi:https://doi.org/10.1088/1757-899X/193/1/012031

Jeyarani, T., Banerjee, T., Ravi, R., & Krishna, A. G. (2015). Omega-3 fatty acids enriched chocolate spreads using soybean and coconut oils. *J Food Sci Technol, 52*(2), 1082-1088. doi:https://doi.org/10.1007/s13197-013-1053-4

Konar, N., Poyrazoğlu, E. S., & Artik, N. (2015). Influence of calcium fortification on physical and rheological properties of sucrose-free prebiotic milk chocolates containing inulin and maltitol. . *Journal of food science and technology, 52* (4), 2033-2042.

Larmond, E. (1977). *Laboratory method for sensory evaluation of food*. Ottawa, Canada: Food Research Institute.

Salehi, F. (2018). Color changes kinetics during deep fat frying of carrot slice. *Heat and Mass Transfer, 54*(11), 3421-3426. doi:https://doi.org/10.1007/s00231-018-2382-7

Smith, M. J. (2016). Using Differential Scanning Calorimetry To Explore the Phase Behavior of Chocolate. *Journal of Chemical Education, 93*(5), 898-902. doi:https://doi.org/10.1021/acs.jchemed.5b00284

Toker, O. S., Konar, N., Pirouzian, H. R., Oba, S., Polat, D. G., Palabiyik, İ., . . . Sagdic, O. (2018). Developing functional white chocolate by incorporating different forms of EPA and DHA - Effects on product quality. *LWT - Food Science and Technology, 87*, 177-185. doi:https://doi.org/10.1016/j.lwt.2017.08.087