

**OPTIMIZATION OF XANTHAN GUM, CORN STARCH AND  
GLYCERIN BLENDS ON THE PHYSICOCHEMICAL  
PROPERTIES AND SENSORY ACCEPTABILITY OF DARK  
CHOCOLATE**

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The effects of cocoa butter substitution using xanthan gum (XG), corn starch (CS) and glycerin (GL) blends on the physicochemical and sensory properties of dark chocolate were determined. In this study, 11 blends with different proportions of XG, CS and GL were prepared according to D-Optimal mixture design as a purpose of cocoa butter substitution in dark chocolate at 5%, 10% and 15% level. Summing up, 33 chocolate formulations and a control sample containing 15% cocoa butter (control sample) were analyzed for their hardness, rheological properties and melting point. Accompanied by the reduction of cocoa butter, the incorporation of XG, CS and GL raised the solid fractions in chocolate system and resulted in consequential increased hardness (4.58-13.49kN/m<sup>2</sup>) and flow properties (yield stress: 7.82-10.53 Pa and viscosity: 2.37-3.73Pa.s). Increasing viscosity in chocolate requires more energy (higher melting point) to melt (34.10-41.06°C). Optimization of blends resolved four new different proportions consisting 10% of XG, CS and GL blends where all responses were fitted to cubic model. As compared to the control sample, the optimized

samples appeared lighter in colour ( $L^* = 38.31-38.59$ ). Fat bloom resistances were observed in optimized samples up to 12 weeks of storage ( $25.0 \pm 1.0^\circ\text{C}$ ). No appreciable polymorphic forms were observed in the optimized samples as the fat completely wrapped by polymers network. The reduction of cocoa butter while incorporating XG, CS and GL resulted in increasing moisture (3.00 – 3.12%), ash (2.01 – 2.20%), protein (4.96 – 5.15%), dietary fiber (0.64 – 0.84%) and carbohydrate (65.78 - 67.10%) content jointly with the reduction by 50.00% in fat and 15.43% in calorie content. Control sample was more accepted over optimized samples in terms of hardness, melt-in-mouth, flavour, aftertaste and overall acceptability attributes whereas the most accepted colour, glossiness and melt-on-hand attributes were of optimal samples. This study suggested that the use of XG, CS and GL is highly potential to develop reduced fat and reduced calorie dark chocolate.

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**PENGOPTIMUMAN CAMPURAN GAM XANTHAN, KANJI JAGUNG DAN GLISERIN TERHADAP CIRI-CIRI FIZIKOKIMIA DAN PENERIMAAN SENSORI COKLAT GELAP**

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Kesan penggantian koko mentega menggunakan campuran gam xanthan (XG), kanji jagung (CS) dan gliserin (GL) terhadap ciri-ciri fizikokimia dan sensori coklat gelap telah ditentukan. Dalam kajian ini, 11 campuran dengan perkadaran yang berbeza terdiri daripada XG, CS dan GL telah disediakan berdasarkan rekabentuk campuran D-Optimal sebagai tujuan penggantian mentega koko dalam coklat gelap pada tahap 5%, 10% dan 15%. Secara keseluruhan, 33 formulasi coklat dan sampel kawalan yang mengandungi 15% mentega koko dianalisis untuk kekerasan, sifat reologi dan takat lebur. Seiring dengan pengurangan mentega koko, penggunaan XG, CS dan GL menaikkan pecahan pepejal dalam sistem coklat dan menyebabkan peningkatan kekerasan (4.58-13.49kN/m<sup>2</sup>) dan sifat aliran (hasil tekanan: 7.82-10.53Pa dan kelikatan : 2.37-3.73Pa.s). Peningkatan kelikatan dalam coklat memerlukan lebih tenaga (takat lebur yang lebih tinggi) untuk mencair (34.10-41.06°C). Pengoptimuman campuran menghasilkan empat perkadaran baru yang berbeza terdiri 10% daripada XG, CS dan GL di mana semua respon dipadankan dengan model kubik. Berbanding dengan sampel

kawalan, sampel optimum kelihatan lebih cerah ( $L^*=38.31-38.59$ ). Ketahanan terhadap bebunga lemak sehingga 12 minggu penyimpanan ( $25.0\pm 1.0^\circ\text{C}$ ) dapat diperhatikan pada sampel optimum. Tiada bentuk polimorfik ketara diperhatikan dalam sampel optimum kerana lemak terperangkap sepenuhnya di dalam rangkaian polimer. Pengurangan mentega koko dan penggunaan XG, CS dan GL menyebabkan meningkatkan kandungan kelembapan (3.00-3.12%), abu (2.01-2.20%), protein (4.96-5.15%), diet serat (0.64-0.84%) dan karbohidrat (65.78–67.10%) berserta pengurangan sebanyak 50.00% kandungan lemak dan 15.43% kandungan kalori. Sampel kawalan adalah lebih diterima berbanding sampel optimum dari segi penerimaan kekerasan, cair dalam mulut, rasa, kesan lepas rasa dan penerimaan keseluruhan manakala warna, kekilatan dan cair atas tangan yang paling diterima ditunjukkan oleh sampel optimum. Kajian ini mencadangkan penggunaan XG, CS dan GL adalah sangat berpotensi dalam penghasilan coklat gelap kurang lemak dan kurang kalori.