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Thermodynamic properties of mixed origin fat blends

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The role of fats is to provide the desired textural properties of foodstuffs. The effect on the modification of texture is based on the characteristics of solidification and melting. In order to fulfil the desired effect, the blending of different types of fats is the simplest way. The aim of the present work is to investigate the melting and solidifying properties of poultry fats mixed with different vegetable fats. Rendered poultry fat was blended with cocoa butter and palm mid fraction (PMF). Mixing ratios were as poultry fat% - vegetable fat% by 100/0, 75/25, 50/50, 25/75 and 0/100.

Melting and solidification were detected by differential scanning calorimetry (Setaram evo 3 DSC apparatus). Exotherm and endotherm peaks were detected as well as enthalpies were calculated.

During solidification of poultry fat-cocoa butter mixtures the effect of cocoa butter was observable. Increasing the amount of cocoa butter in the blends resulted in higher releasing of heat. The crystallization pattern was dominated by the cocoa butter. On the other hand, the effect of palm mid fraction in the fat mixtures prevailed gradually.

The melting of poultry fat-cocoa butter mixtures followed the type of the cocoa butter. 50% cocoa butter in the blend resulted almost the same crystal structure than the pure cocoa butter. In case of poultry fat-palm mid fraction blends two endotherm peaks were present in the blends similarly to the pure palm mid fraction. Total enthalpy increased according to the increased ratio of palm mid fraction.

Keywords: solidification and melting of fat mixtures, mixtures of poultry and vegetable fats, textural properties of fat mixtures, melting enthalpy of fat mixtures.

INTRODUCTION

Goose fat is a valuable food material due to its smooth texture and pleasant sensory attributions [1-4]. In some food products the fat component is a mixture of vegetable and animal fats especially in complex systems e.g.: patés, spreads, fillings of bakery products etc.

Interaction between fats of different origin in fat blends can modify physical properties of foods and can be in the interest in food technologists [2, 5]. The aim of the present work was to study the physical characteristics of goose fat – cocoa butter and goose fat-palm mid fraction (PMF) blends. Cocoa butter was chosen as a model for fats which consist of symmetrical triglycerides and perform sharp melting behavior; PMF represented fats that show a wide melting temperature interval.

EXPERIMENTAL

Materials

Rendered poultry fat was blended with cocoa butter and palm mid fraction (PMF). Materials were provided by local food factories. Sample preparation followed the method of David Perez-Martinez (2007). Fats were melted in order to destroy crystal memory and following that the different fats were mixed. After homogenization the samples cooled down spontaneously to 5°C and kept under this temperature for at least five days until the measurements. Mixing ratios were as poultry fat% – vegetable fat% by 100/0, 75/25, 50/50, 25/75 and 0/100. Materials were collected from a local market and a local confectionery firm.

Methods

Fatty acid composition of pure fats was analyzed by Gas Cromatograph (GC) according to the methods based on MSZ ISO 5508:1992. Type of the apparatus was HP 5890 GC System, with SGE BPX 70 column with parameters 50 m 0.22 mm 0.25 μm. Heating was from 150 °C to 210 °C (with 1.3 °C min^{-1} heating rate). Pressure: 14 psi, injector: 250 C split, split ratio: 100:1. Detector: 250 C, FID. Carrier gas was hydrogen, the flow was 0.6 cm^3 min^{-1}, injection pressure was 0.965 bars. Identification of fatty acids was based on retention times using fatty acid methyl ester standards.

Melting and solidification were detected by differential scanning calorimetry (Setaram evo 3

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DSC apparatus). Details of the measurements were: 20-25 mg of each sample was put into the 100 μl alumina sample holder. Samples were cooled to 0 °C by 1°C min^{-1} and kept at this temperature for 10 minutes. Heating was performed from 0 °C up to +80°C by 1°C min^{-1}. Samples were kept at this temperature for 30 min. and the cooling program was applied by 1°C min^{-1} to -20°C and kept under this condition for 10 min. Finally, the samples were heated up to ambient temperature. Measurements were done at constant speed during the heating and cooling processes. Results were elaborated by Callisto Processing 1.076 computer program using linear base line. Heat flow and enthalpy of exotherm and endotherm peaks were recorded and calculated.

RESULTS AND DISCUSSION

Composition

Pure fats were characterized by their fatty acid composition. Results are summarized in Table 1.

Table 1. Fatty acid composition (%) of the investigated pure fats

Fatty acid	Fatty acid composition (%)		
	Goose fat	CB	PMF
SAFA	30.5	65.1	56.6
MUFA	58.6	31.9	40.4
PUFA	10.3	2.8	2.6
Not identified	0.6	0.2	0.4

Abbreviations: CB: Cocoa Butter; PMF: Palm Mid Fraction; SAFA: saturated fatty acid; MUFA: monounsaturated fatty acid PUFA: polyunsaturated fatty acid.

Results show that CB contains the highest amount of saturates and Goose fat the least. Goose fat is rich in polyunsaturated fatty acids. Total unsaturates in Goose fat aproach 70%. PMF contained saturated and unsaturated fatty acids in a balanced ratio.

Solidification thermograms

In Figure 1. thermograms of Goose fat, Cocoa butter and their blends are shown. Figure 2. demonstrates thermograms of Goose fat – PMF.

Abbreviations: A: vegetable fat, B: 25-75% blend, C: 50-50% blend, D: 75-25% blend, E: Goose fat

Figure 1 shows that goose fat has small exotherm peaks (at 2°C and 16°C) indicating weak crystal structure. A definite effect of cocoa butter on crystallization is observable. Solidification based on the cocoa butter has a pattern.

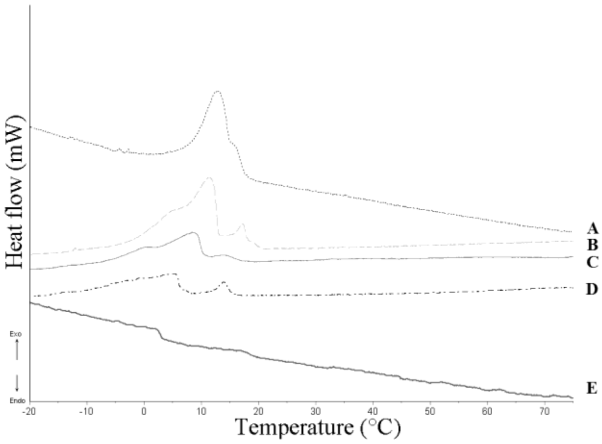

Fig. 1. Cooling thermogram of Goose fat, Cocoa Butter and their blend.
A: Cocoa Butter, **B:** 25-75% G/CB, **C:** 50-50% G/CB, **D:** 75-25% G/CB, **E:** Goose fat

Figure 2 demonstrates that during solidification PMF dominated the whole process. Another characteristic exotherm peak of PMF appeared at 75-25% (Goose fat:PMF) blend and developed according to the increasing amount of PMF

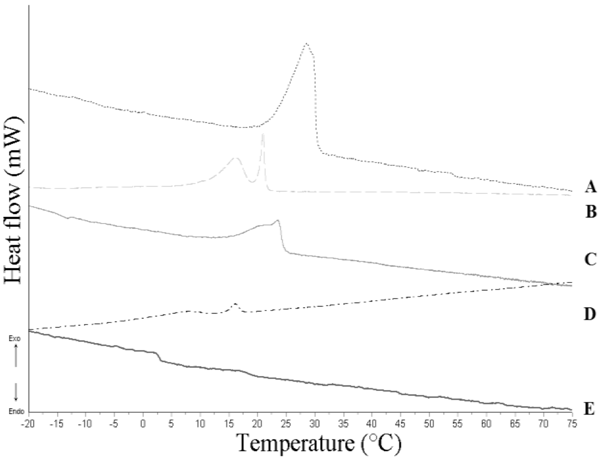

Fig.. 2. Cooling thermogram of Goose fat, PMF and their blend. **A:** PMF, **B:** 25-75% G/PMF, **C:** 50-50% G/PMF, **D:** 75-25% G/PMF, **E:** Goose fat

Average values of the solidification enthalpies of Goose fat-cocoa butter blends are shown in Figure 3. Small total enthalpy of Goose fat implies weak structure. Presence of Cocoa butter in the blend results in uniform increase in enthalpy values.

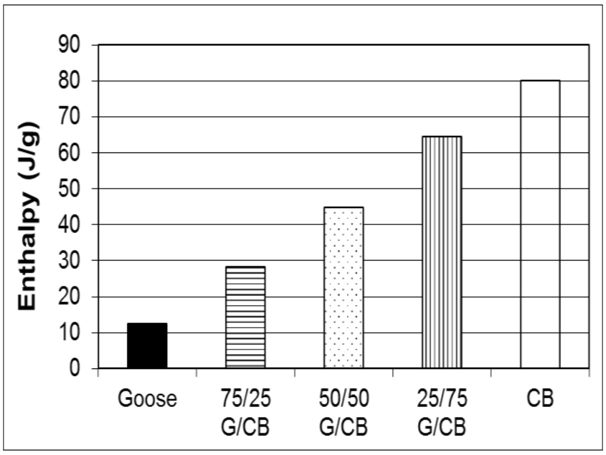

Fig. 3. Total enthalpy during solidification: Goose/Cocoa Butter.

In Figure 4 average of the total enthalpy values of solidification are summarized. PMF displays almost seven times higher enthalpy than Goose fat. Enthalpies increase stepwise by increasing the amount of PMF in the blend.

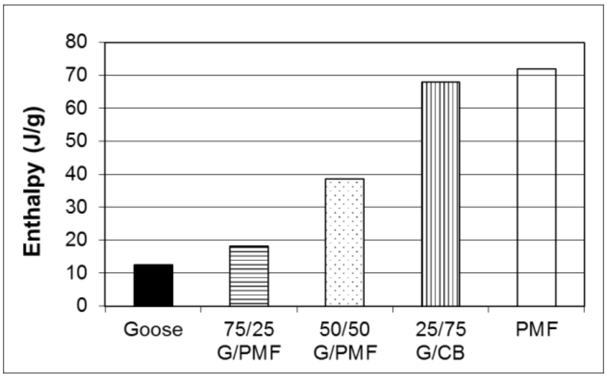

Fig. 4. Total enthalpy during solidification: Goose/PMF.

Melting thermograms

Figure 5 shows the melting thermograms of Goose fat - Cocoa butter blends. From the figure it is clear that goose fat has a weak crystal structure with two small endotherm peaks, Cocoa butter performs one big peak. Melting of the blends became gradually similar to the cocoa butter.Blends containing 50% or more Cocoa butter show only one big endotherm peak.

Figure 6 summarizes the melting thermograms of the Goose fat – PMF blends. Results prove that when the amount of PMF in the blend increases, the shape of the thermogram approaches the pure PMF. This phenomenon indicates that the whole process is dominated by PMF.

In Figure 7 is seen that Goose fat had the lowest and cocoa butter the highest total enthalpy during melting. Increasing amount of cocoa butter in the blend raised the enthalpies in a slightly exponential manner.

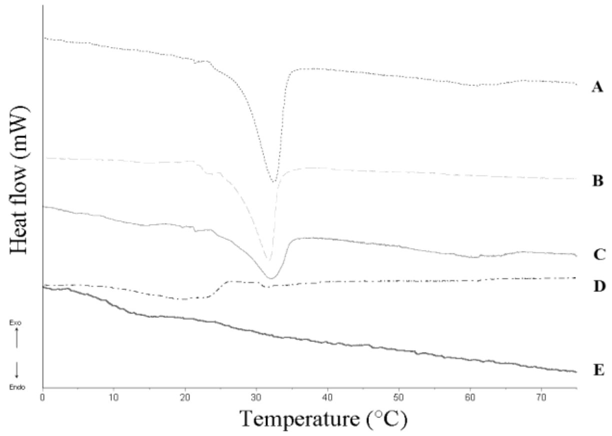

Fig. 5. Melting thermograms of Goose fat, Cocoa Butter and their blend.
A: Cocoa Butter, **B:** 25-75% G/CB, **C:** 50-50% G/CB, **D:** 75-25% G/CB, **E:** Goose fat.

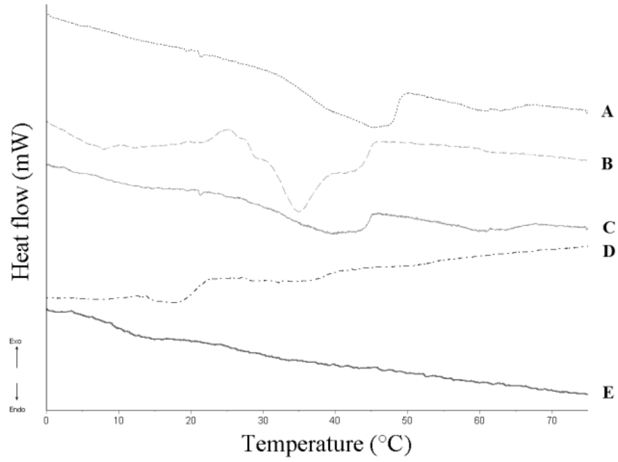

Fig. 6. Melting thermograms of Goose fat, PMF and their blend. **A:** PMF, **B:** 25-75% G/PMF, **C:** 50-50% G/PMF, **D:** 75-25% G/PMF, **E:** Goose fat

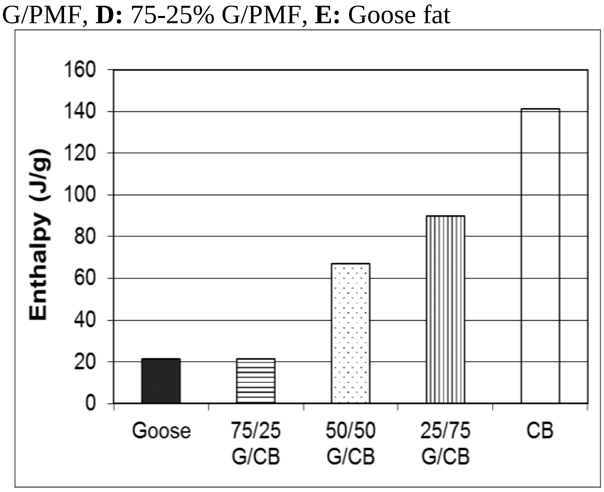

Fig. 7. Total enthalpy during melting: Goose/Cocoa Butter.

Figure 8 demonstrates that PMF caused a remarkable increase in the average of total enthalpy in the blends. Changes were exponential-like.

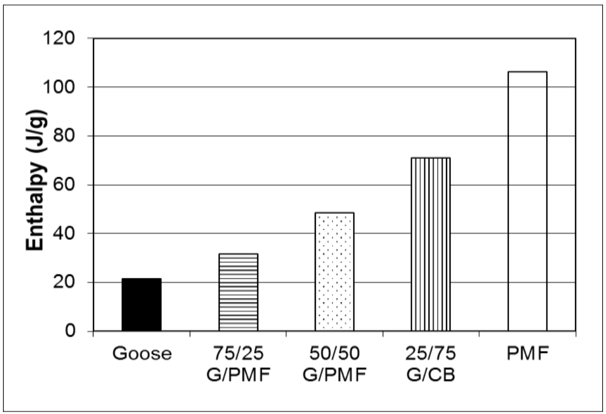

Fig. 8. Total enthalpy during melting: Goose/PMF

CONCLUSIONS

Our results proved that Goose fat has weak crystal structure, characterized as an easy-melt material. The softening effect of goose fat is rather high even if only a small amount is present in the blend. Solidification and melting process of mixed system of goose fat and cocoa butter or palm fat is dominated by the vegetable fat. Results are comparable with the other reported findings [4,5].

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ТЕРМОДИНАМИЧНИ СВОЙСТВА НА СМЕСИ ОТ МАЗНИНИ С РАЗЛИЧЕН ПРОИЗХОД

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(Резюме)

Ролята на мазнините е да осигуряват желани текстурни свойства на хранителните продукти.

Ефектът на модифициране на текстурата се дължи на характеристиките на втвърдяване и топене. Смесването на различни видове мазнини е най-простият начин за постигане на желания ефект. Целта на настоящата работа е изследване на свойствата топене и втвърдяване на птичи мазнини, смесени с различни растителни масла. Разтопена птича мазнина беше смесена с какаово масло и средна фракция на палмово масло (ПСФ). Отношенията на смесване птича мазнина % - растително масло % бяха както следва: 100/0, 75/25, 50/50, 25/75 и 0/100.

Топенето и втвърдяването бяха изследвани чрез диференциално сканираща калориметрия (апарат Setaram evo 3 DSC). За целта бяха установени екзотермичните и ендотермичните пикове и бяха изчислени енталпиите на преходите. Беше наблюдаван ефект на какаовото масло при втвърдяването на смеси птича мазнина – какаово масло. Увеличаването на съдържанието на какаово масло в сместа доведе до по-интензивно освобождаване на топлина. Процесът на кристализация беше доминиран от какаовото масло. От друга ефектът на ПСФ в смесите на мазнини се проявяваше постепенно.

Топенето на смесите от птича мазнина и какаово масло следваха фазовия преход на какаовото масло. 50% какаово масло в сместа доведе до почти същата кристална структура като тази на чистото какаово масло. В случая на смеси от птича мазнина и ПСФ бяха наблюдавани два ендотермични пика, подобни на тези на чистото ПСФ. Общата енталпия нарасна при увеличаване частта на ПСФ.