EVALUATION OF THE THERMAL STABILITY OF SOME SPREADABLE FOOD PRODUCTS

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Abstract. *In this paper, is analyzed the thermal stability in non-isothermal and isothermal conditions of various types of commercial margarines and butter and of a type of homemade butter. It was found that although the thermal decomposition onset temperatures of the butter samples in non-isothermal conditions were higher than those of margarine samples, in isothermal conditions, their behaviour changes. The mass loss percentage of margarine samples kept at 200°C for 40 or 50 minutes is lower than that of butter samples.*

Key words: *TGA, margarine, butter, thermal stability, non-isothermal and isothermal conditions*

Introduction

In recent years, clinical and epidemiological studies have shown that eating trans fatty acids is closely linked to the decrease in high-density cholesterol and to the increase in low-density cholesterol, respectively, resulting in a higher risk of suffering from coronary heart disease [1]. Most European countries require food producers to reduce the trans fat content of their food [2]. Meta-analyses have shown that replacing saturated fats with polyunsaturated essential fatty acids is highly beneficial to consumers' health [3]. The consumption of spreadable fats has been growing lately, as they are regularly eaten spread on bread or toast, generally for breakfast, or used to prepare snacks. This category of food includes butter and margarine. Margarines are made from mixtures of fats that are emulsified using milk or water in the presence of emulsifiers. Auxiliary raw materials such as salt, preservatives or hydrogenated oils are contained by most margarines. Hydrogenation is one of the best-known technologies for solidifying oils and fats. Therefore, turning liquid vegetable oils into a gelled structure is of great interest for food science, as new strategies for structuring edible oils are required by both the business and scientific environment [3]. The analysis of the thermal stability of food products is an important aspect, since they are often subjected to heat treatments [4].

In this paper, is analyzed the thermal stability in non-isothermal and isothermal conditions of commercial spreads and of a homemade butter and is collected information concerning the type of product that is recommended when thermal processing is required.

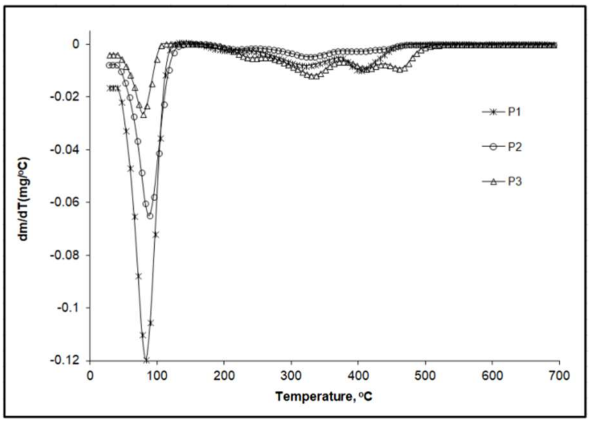
Materials and Methods

The thermal stability of some spreadable food products was analysed using a Mettler Toledo 851^e device. The tests were performed in synthetic air at a 10°C/min heating rate, within the 25-700°C temperature range. The samples used weighed 2 to 5 mg. The thermogravimetric curves were processed using the STAR^e software from Mettler Toledo in order to collect the main thermogravimetric features.

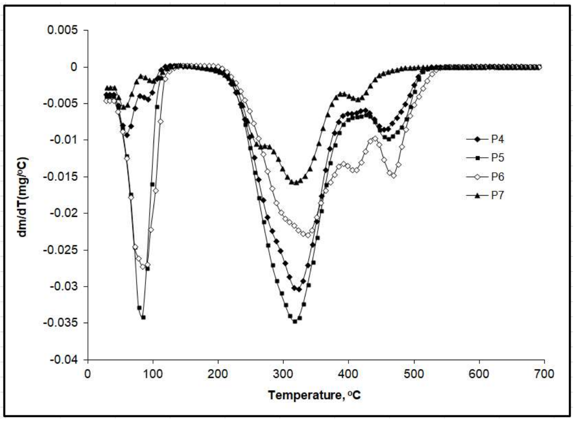
The thermal resistance of the analysed products was assessed by keeping them at 200°C for 40 and 50 minutes in an air atmosphere in the same piece of equipment. The mass loss percentage was determined. The conditions under which the thermal preparation of some food products takes place were thus simulated. The thermal stability of three types of commercial margarine (P1, P2 and P3), of three types of commercial butter (P4, P5 and P6) and of one homemade butter (P7) was analysed.

Results and Discussions

Fig.1 shows comparisons between the derivative thermogravimetric curves (DTG) of the three types of margarine and four types of butter.



a)



b)

Figure 1. DTG curves for margarines (a) and for butter b)

DTG curve analysis reveals a complex thermal decomposition mechanism involving three to five stages with different mass loss percentages. The main thermal characteristics of margarines and butter determined further to thermogravimetric curve analysis, i.e. T_{onset} – degradation onset temperature, T_{peak} – peak degradation rate temperature, T_{endset} – degradation process end temperature, W – mass loss percentage and DTA characteristics, are shown in Tab. 1. Water, which amounts to more than 70% of liquid margarines marked P1 and P2, is removed up to around 110°C. Water removal is a two-stage process in the various types of butter, being more marked in the P4 sample and in the P7 homemade butter sample. According to the data in Tab. 1, thermal decomposition sets in at about 190°C in liquid margarines, and at 213°C in solid margarine. The thermal decomposition process occurs in three successive stages that end at around 450°C for liquid margarines (P1 and P2) and at 480°C for solid margarine (P3). Polyunsaturated fatty acids decompose within the 190-300°C temperature range. The thermal decomposition of monounsaturated fatty acids occurs at temperatures ranging from 270 to 360°C, while the temperature range specific to saturated ones is 360-450°C [5].

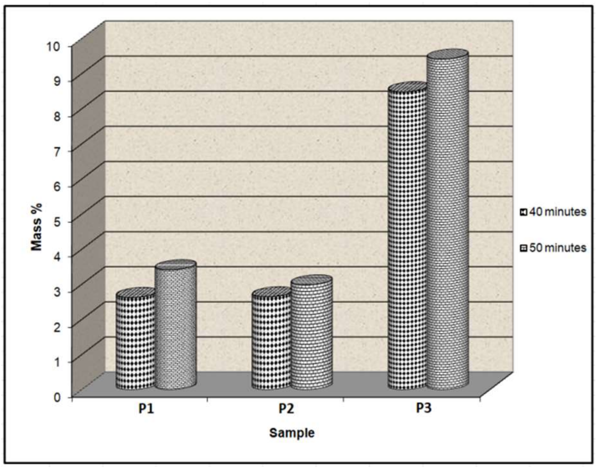
An additional process was determined in solid margarine (P3) at temperatures higher than 450°C, which may be linked to the decomposition of polymers formed during oxidation processes [6]. The amount of residue resulting from the margarine tests ranges from 3 to 5%. The analysis of the thermal decomposition of various types of butter in synthetic air atmosphere reveals, according to the data shown in Tab. 1, that the amount of water in the samples ranges between 10 and 25.5%. Thermal decomposition sets in at higher temperatures in butter than in margarine. The first 317 and 315°C temperature peaks for samples P5 and P7, respectively, are identical to what Sbihi et al. reported for goat's milk [6]. The peak temperature of the other samples is slightly higher, i.e. 321°C for P4 and 339°C for P6. This stage is associated with the decomposition of unsaturated and saturated acids, namely triacylglycerol degradation and polyunsaturated fatty acid oxidation. Stages at temperatures above 400°C may be associated with the decomposition of trans isomer fatty acids and saturated acids [7]. The amount of residue from commercial butter samples is about 2.5%. The amount of residue is greater for homemade butter, probably due to the use of a larger amount of salt as a preservative.

Table 1

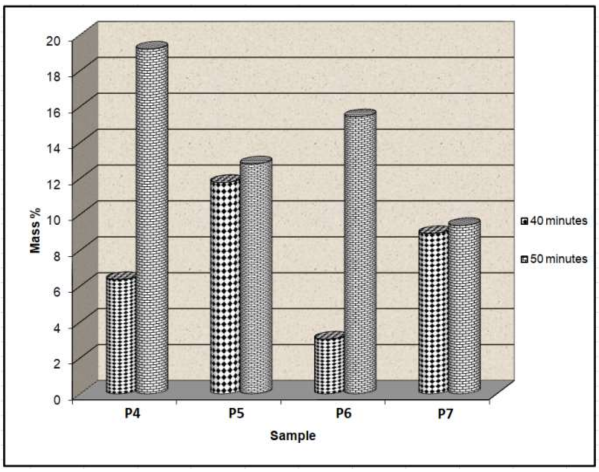
Thermogravimetric characteristics of margarines and butter

Sample	Stage	T_{onset} (ºC)	T_{peak} (ºC)	T_{endset} (ºC)	W (%)	Residue (%)	DTA characteristics
P1	I	47	83	102	74.10	***5.12***	endo
	II	***183***	200	271	3.08		exo
	III	271	320	357	9.88		exo
	IV	392	403	451	7.82		exo
P2	I	52	88	112	78.09	***4.46***	endo
	II	***201***	212	229	2.41		exo
	III	285	328	356	9.35		exo
	IV	356	407	455	5.69		exo
P3	I	49	78	89	30.14	***3.34***	endo
	II	***213***	239	293	16.29		exo
	III	293	335	355	23.60		exo
	IV	399	411	451	16.18		exo
	V	451	463	484	10.45		exo
P4	I	45	59	69	6.70	***2.56***	endo
	II	84	92	101	2.49		endo
	III	***243***	321	367	73.90		exo
	IV	443	454	497	14.35		exo
P5	I	67	82	92	22.20	***2.45***	endo
	II	***249***	315	359	63.11		exo
	III	441	458	496	12.24		exo
P6	I	58	74	85	16.78	***2.47***	endo
	II	85	87	107	8.71		exo
	III	***258***	339	364	40.11		exo
	IV	364	411	429	18.37		exo
	V	455	468	500	13.56		exo
P7	I	47	56	67	6.92	***6.94***	endo
	II	97	99	111	2.40		endo
	III	***238***	263	296	29.41		exo
	IV	296	317	360	43.43		exo
	V	397	414	449	10.90		exo

Thermal stability tests were also performed in isothermal conditions, taking into consideration the manner in which the various types of margarine and butter are used for cooking and taking into account the peak temperatures reached in the oven. Thermogravimetric curves were recorded in air at a constant temperature of 200°C for 40 minutes and 50 minutes, for all samples (Fig. 2). Under isothermal conditions, the mass loss percentage is lower in margarines than in butter. In the P4 and P6 butter samples, we found a significant increase in the mass loss percentage when the sample exposure time to 200°C increased from 40 minutes to 50 minutes. Thus, is founded that although the thermal decomposition onset temperatures of the butter samples in non-isothermal conditions were higher than those of our margarine samples, in isothermal conditions, their behaviour changes. If the cooking time of different foods is longer, it is preferable to use margarines that contain polyunsaturated essential fatty acids.



a) margarines



b) butter

Figure 2. Mass loss percentages in isothermal conditions

Conclusions

Thermal stability of butter samples in non-isothermal conditions is higher than that of margarines. Thermal decomposition of spreadable products includes three to five stages with different mass loss percentages. Under isothermal conditions, margarines have lower mass loss percentages than butter samples and their use is recommended if the preparation time of different foods is longer.

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