Evaluation of Shelf Life and Heat Treatment of Tomato Products

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Abstract: Model storage experiments of pasteurised tomato puree and ketchup were carried out. The sets of samples were boiled at 100°C, during the heating the changes of selected markers were followed and correlated with the sensory evaluation, the markers were: furosine, 2-furaldehyde, 5-hydroxymethyl-2-furaldehyde (HMF) and colour (expressed as: L, a^*, b^*, a^*/b^* and ΔE). The suitability of selected markers for the assessment of temperature impact on tomato products was evaluated. The correlation matrix for the followed markers of the tomato puree and ketchup was calculated and the courses of changes (expressed as velocity constant) of the markers were compared.

Keywords: heat treatment; HMF; furosine; colour; ketchup; tomato puree

INTRODUCTION

During processing and storage, tomato products undergo nutritional and sensorial changes. The degradation reactions of individual compounds in tomato products, such as lycopene, sugars, or ascorbic acid are very complex and very dependent on the various factors, initial content, oxygen access, presence of other compounds affecting or participating in the oxidation and non enzymatic browning reaction, the conditions of tomato paste processing and conditions of tomato ketchup production. These changes contribute, in some degree, to the typical sensorial characteristics of tomato products. The markers commonly used to evaluate heat damage and storage history in these foodstuffs are 5-hydroxy-2-furancarbaldehyde (hydroxymethylfurfural, HMF), an intermediate compound formed from Amadori rearrangement product 1-amino-1-deoxy-2-ketose, furosine (2-furoylmethyllysine), generated during acid hydrolysis of an Amadori compound, recognised as indicator of heat damage during the initial steps of the Maillard reactions, and changes of colour, e.g. expressed as ΔE or L/L_0 (Kilcast & Subramaniam 2000; Rada-Mendoza *et al*. 2004; Hough. *et al*. 2006; Quintas *et al*. 2007).

The aim of the paper was to study the kinetics of 5-hydroxymethyl-2-furancarbaldehyde, furosine, 2-furancarbaldehyde (furfural) and colour (L^*, a^*, b^*, ΔE and a^*/b^*) changes during the heating of tomato products in order to compare the suitability of selected markers as heat damage indices.

MATERIALS AND METHODS

Samples. The samples of ketchup (refractive index: 25° Brix) and tomato puree (refractive index: 32.3° Brix) from Czech market were analysed.

Colour measurement. Samples were poured into a clear glass Petri dish and colour parameters were determined using a Tristimulus colorimeter (Minolta spectrophotometer CM-2600 d). Colour change was described as L^*, a^*, b^* and $\Delta E = \sqrt{(L^* - L_0^*)^2 + (a^* - a_0^*)^2 + (b^* - b_0^*)^2}$, b^*/a^*.

HPLC determination of furosine. Furosine determination was performed following the methods described by Rufian-Henares *et al*. (2007) with one modification. Briefly, the Pyrex screw-cap vial with PTFE-faced septa was replaced by 50-ml ground-joint conical flask.

HPLC determination of HMF and furfural. HMF and furfural determination was performed fol-

Table 1. Calculated velocity constant

Marker	Order	Ketchup	Puree
		k (h^{-1})	
HMF	zero	10.387	31.482
Furfural	zero	0.1794	0.8849
Furosine	zero	0.2557	1.6716
L^*	pseudo first	0.0102	0.0228
a^*	pseudo first	0.0318	0.0526
b^*	pseudo first	0.0366	0.0511
ΔE	zero	0.6182	1.3595

lowing the methods described by Hidalgo and Pompei (2000).

RESULTS AND DISCUSSION

The sets of samples (tomato ketchup and puree) were exposed to temperature of 100°C for 4 h; during the heating the following markers: HMF, furosine, furfural and colour (L^*, a^*, b^*, ΔE and a^*/b^*) were analysed in the tomato product. The courses of changes of the followed parameters in ketchup and tomato puree samples are in the Figures 1–4. These results show that furosine and furfural are less sensitive to heating than HMF and colour changes. The kinetic data (velocity constant) calculated from the results for the both sets of samples are given in the Table 1. For the HMF, furfural, furosine and degradation and colour changes expressed as ΔE, the course followed a zero order kinetic whereas for the other colour parameters it was pseudo first order reaction kinetics. The relationships between the all followed markers expressed as linear regression coefficients are given in Table 2 for ketchup and puree, respectively. The correlations between all followed markers (excluding a^*/b^*) are very close ($r^2 > 0.93$) for the tomato puree, but not so close relationships between the colour and chemical markers were observed for the ketchup ($r^2 > 0.60$). It is probably caused by different stage of degradation reactions in ketchup, which is already more heat damaged. The reaction mixture is more complex, more degradation products are present and participate in complex changes. According to our results the chemical markers could be used for the evaluation of intensity of heat damage

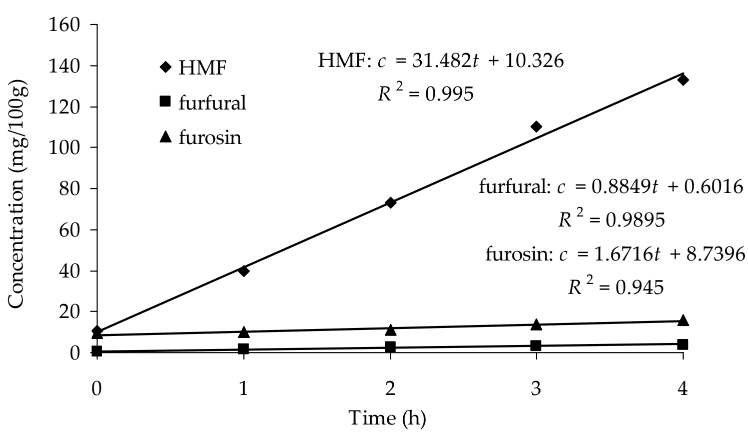

Figure 1. Changes of HMF, furfural and furosine in tomato puree during the heating

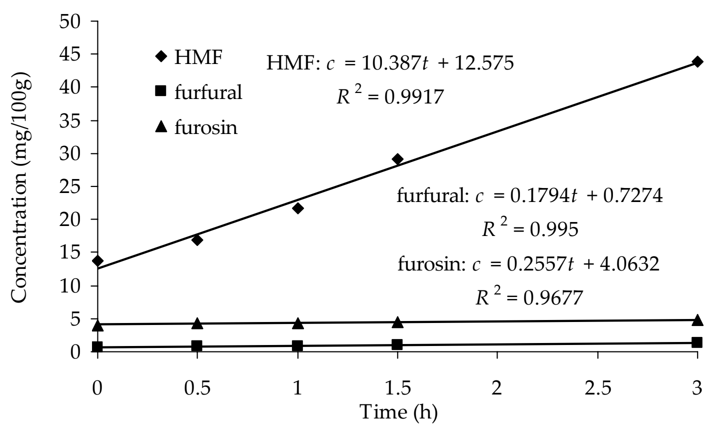

Figure 2. Changes of HMF, furfural and furosine in ketchup during the heating

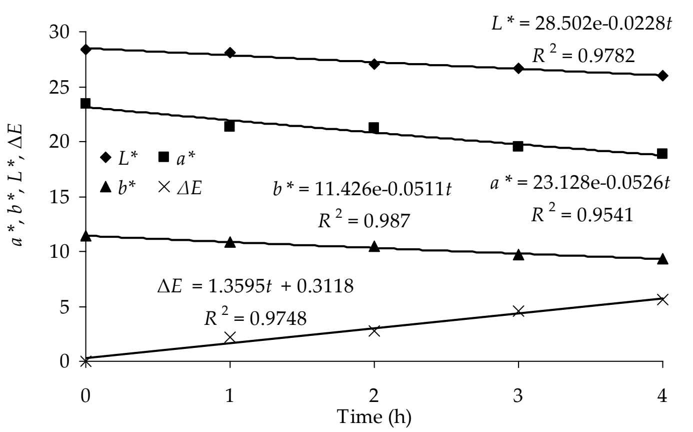

Figure 3: Changes of tomato puree colour expressed as L^*, a^*, b^* and ΔE during the heating

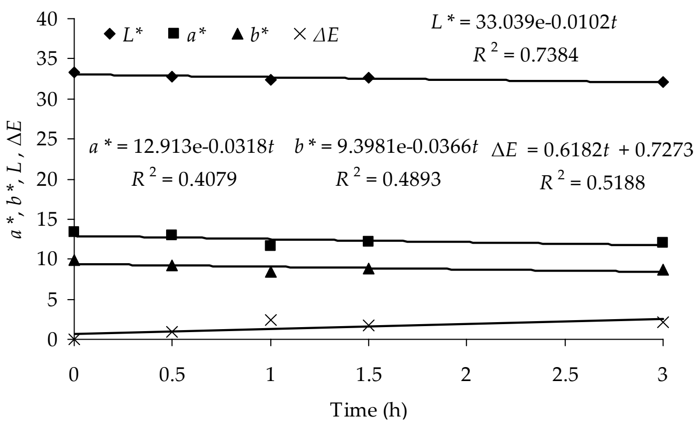

Figure 4. Changes of ketchup colour expressed as L^*, a^*, b^* and ΔE during the heating

Table 2. Correlation matrix of the followed markers in tomato puree and tomato ketchup

	HMF	Furfural	Furosine	L^*	a^*	b^*	a^*/b^*	ΔE
Tomato puree								
HMF	–	0.9965	0.9662	–0.9872	–0.9716	–0.9960	–0.1577	0.9858
Furfural	0.9965	–	0.9461	–0.9818	–0.9799	–0.9943	–0.2152	0.9913
Furosine	0.9662	0.9461	–	–0.9564	–0.9306	–0.9640	–0.1006	0.9463
L^*	–0.9872	–0.9818	–0.9564	–	0.9312	0.9700	0.0632	–0.9555
a^*	–0.9716	–0.9799	–0.9306	0.9312	–	0.9866	0.3813	–0.9973
b^*	–0.9960	–0.9943	–0.9640	0.9700	0.9866	–	0.2257	–0.9945
a^*/b^*	–0.1577	–0.2152	–0.1006	0.0632	0.3813	0.2257	–	–0.3203
ΔE	0.9858	0.9913	0.9463	–0.9555	–0.9973	–0.9945	–0.3203	–
Tomato ketchup								
HMF	–	0.9964	0.9761	–0.8113	–0.6036	–0.6554	0.4827	0.6731
furfural	0.9964	–	0.9909	–0.8489	–0.6290	–0.6909	0.5436	0.7057
furosine	0.9761	0.9909	–	–0.8891	–0.6549	–0.7323	0.6342	0.7414
L^*	–0.8113	–0.8489	–0.8891	–	0.8656	0.9287	–0.5973	–0.9344
a^*	–0.6036	–0.6290	–0.6549	0.8656	–	0.9844	–0.1898	–0.9864
b^*	–0.6554	–0.6909	–0.7323	0.9287	0.9844	–	–0.3596	–0.9984
a^*/b^*	0.4827	0.5436	0.6342	–0.5973	–0.1898	–0.3596	–	0.3413
ΔE	0.6731	0.7057	0.7414	–0.9344	–0.9864	–0.9984	0.3413	–

during the preceding processing steps and for the prediction of the products shelf life for the initial stages of tomato processing only, e.g. in the case of the tomato puree evaluation. These markers seem not to be reliable for the more processed products, such as tomato ketchup, which is more damaged and the levels of the markers are more affected by the conditions of preceding processing steps. In the case of Czech tomato ketchup recipes, which contain significant amounts of added sugar (sucrose, inverted sucrose or various glucose syrups) also the HMF could be used as heat damage criterion, it is also formed in higher concentration in processed products comparing with furosine or furfural because of higher concentration of precursors. To use the HMF level for the shelf life prediction, its levels corresponding with sensory changes, usually with distinct sensorial differences or with the unacceptable qualities of products, must be set up individually for such products, which could differ in the composition and in the conditions of processing. In comparison with chemical markers the colour seems to be more robust parameter allowing to get more general estimations.

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