

INFLUENCE OF STEAM TEMPERATURE AND TREATMENT TIME ON POTATO SOFTNESS

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Key words: thermal treatment, potatoes, texture, penetration test

The work presents evaluation of the influence of individual parameters of thermal treatment (variable time; thermal treatment in the condition of increased pressure / in steam) on chosen quality parameters of different varieties of potatoes (Satina, Asterix and Saturna). The principal aim of the research was to evaluate the influence of thermal treatment on chosen parameters (force, deformation), resulting from the characteristics of potato starch. Requirements of thermal treatment were chosen in order to achieve a suitable quality of the analysed varieties of potatoes, characterised by various amount of starch. Properties of force and deformation of the analysed potatoes were investigated with a Materials Testing Machine INSTRON 4301 (the penetration test). Analysed data strongly suggest that of all analysed varieties Asterix is of the highest nutritional value and usefulness, which may be connected with the quantity of starch observed in this variety.

INTRODUCTION

The quality of potatoes is determined not only by external features (shape, regularity, appearance of the rind), but also by internal features (content of the dry mass, sensory attributes, including taste). Varieties used as a chipses, crisps and roasted potatoes should be characterised by a high level of the features related to quality. Especially high part of the potatoes in the production is connected with the Asterix variety (crisps) and the Saturna variety (chipses).

Desirable quality of thermally-treated potatoes includes proper colour, taste and texture. Abnormal colour and excessive softening or firming cause rejection of the product by a consumer [Nourian *et al.*, 2003]. It indicates that all analyses and researches connected with the exploitation of new technologies and techniques leading to the improvement of food quality (especially in the gastronomy and the food industry) are particularly valuable. Analysis of the composition of potatoes is one of the factors of predicting the changes in the quality and structure during the process of cooking. During the process of thermal treatment, the composition of the potato, changes. The kind and extent of those changes, connected with the starch, influence the quality of thermal treatment and the quality of potatoes after that process. Starch granules are principally composed of two glucose polymers, *i.e.* amylose and amylopectin. Native starch granules typically contain around 20% of amylose and 80% of amylopectin [Jenkins & Donald, 1995]. The quantity and kind of the starch granules is connected with ability to absorb water, create internal pressures that can lead to cell separation, reduced cohesiveness and softening [Binner

et al., 2000]. That features in potatoes can result from the characteristics of potato starch, being rich in esterified phosphorus, exhibiting high swelling power, solubility, paste clarity and viscosity and having large granules (as a part of the morphological characteristics) [Singh *et al.*, 2002]. Detailed characteristics depends on the variety of potatoes [McPherson & Jane, 1999] and its cultivar [Kaur *et al.*, 2002].

The principal aim in the future should be further analysis of the influence of individual parameters of thermal treatment on quality parameters (not only the force and deformation, but also the sensory characteristics) of potatoes resulting from the characteristics of potato starch.

MATERIALS AND METHODS

Material. The object of the research were three varieties of potatoes, characterised by varied amount of starch – Satina (13% of starch), Asterix (15% of starch) and Saturna (17% of starch). The investigated material was characterised by regular shape and surface.

Thermal treatments procedure. In the research there were two thermal treatments – 1st and 2nd. The 1st thermal treatment has been conducted by two methods: the first method – condition of increased pressure (0.5 atm) with steam, temperature T=108°C, variable time (10, 12, 14 min); the second method – condition of convection in steam, temperature T=180°C, variable time (15, 18, 21 min). The 2nd thermal treatment has been conducted in two stages: the first stage – 180°C, stable time (9 min); the second stage – 220°C, stable

time (7 min). All the thermal treatments were conducted in an convection oven.

The choice of the methods of thermal treatment and its adjustment, were preceded by the introductory research, on the basis of which, the temperature and time of treatment were settled.

Analytical methods. Choosing and adjusting the thermal treatment methods were made by instrumental measurement of physical properties. Properties of force and deformation were analysed by a Materials Testing Machine INSTRON 4301 (penetration test). Instrumental test of penetration was used to evaluate textural components [Costell, 2002; Laweless & Heyman, 1999]. Measurements were made under constant conditions (diameter of sample ϕ 0.06 m, diameter of pin ϕ 0.013 m, cross head move (rate) v – 50 mm/min, shift 0.04 m).

From the plotted force-deformation curve, different texture parameters of force and firmness were derived using interpretation of force as a factor dependent on the maximum force (N) and the firmness as a factor dependent on the distance connected with the compression of product (mm) [Nourian *et al.*, 2003].

The statistical analysis was conducted using the computer program Statgraphics Plus 4.0. The force and deformation were tested by means of two-sample t test (hypothesis test) to compare potatoes of three varieties, after three times of thermal treatment.

RESULTS AND DISCUSSION

The results of the research over the influence of variable conditions of thermal treatment (two stages; 1st stage variable) suggest various effect of parameters (time, temperature, presence of increased pressure / steam) (all the results are presented in Table 1). The evaluated potato varieties were characterised by varied amount of starch (13-17%).

The effect of variable time of the 1st thermal treatment in condition of increased pressure, on the maximal strength needed to potatoes penetration after 1st and 2nd thermal treatment is shown in Table 1. The maximal strength enabled the evaluation of force of the sample. Thermal treatment under conditions of increased pressure caused a decrease of force of all the examined samples. Prolongation of the time of the 1st thermal treatment was causing further decrease of force, which was perceived as too long boiling of the sample. It can be connected with the fact that pressure-induced starch gelatinization is said to be highly sensitive to changes in temperature, pressure and treatment time [Bauer & Knorr, 2005].

The differences in starch content of the in analysed varieties of potatoes, evoked the differences in its hardness between the analysed varieties.

Dependence between time of the 1st thermal treatment and deformation of the analysed potatoes after 1st thermal treatment, under conditions of increased pressure, and after 2nd thermal treatment is shown in Table 2. The deformation of the analysed potatoes of the varieties Satina and Saturna appeared not to change significantly during that process. Increase of deformation of Asterix variety was statistically significant, but only for 14 min time of thermal treatment. It may be connected with properly chosen parameter of 14 min of thermal treatment under conditions of increased pressure for the Asterix variety.

Between the deformation of the Saturna and Asterix varieties of potatoes, after treatment under conditions of increased pressure, there was no differences observed. That fact can be connected with the similar content of starch in those varieties (15% of starch in the Asterix and 17% in the Saturna variety). For all analysed times of thermal treatment in increased pressure, significant differences in deformation were observed only for the Satina and Saturna variety – those varieties were characterised by the difference in the content of starch.

TABLE 1. The force of the analysed varieties of potatoes after thermal treatment under conditions of increased pressure and in steam.

Analysed factor	Conditions	Time (min)	Analysed variety of potatoes (mean \pm SD)			p-Value		
			Satina	Saturna	Asterix	Satina vs. Saturna	Satina vs. Asterix	Saturna vs. Asterix
Force (N)	Increased pressure	10	19 \pm 0.9	15 \pm 0.8	12 \pm 1.0	0.0045	0.0008	0.0154
		12	14 \pm 0.8	13 \pm 0.5	7 \pm 0.9	ns	0.0005	0.0005
		14	7 \pm 0.7	11 \pm 0.5	5 \pm 0.5	0.0013	0.0158	0.0001
	p-Value	10 vs. 12	0.0020	0.0213	0.0030	-	-	-
		10 vs. 14	0.0000	0.0018	0.0004	-	-	-
		12 vs. 14	0.0003	0.0080	0.0281	-	-	-
	Treatment in steam	15	12 \pm 0.7	15 \pm 0.6	16 \pm 1.2	0.0049	0.0076	ns
		18	6 \pm 0.7	15 \pm 0.5	15 \pm 0.6	0.0000	0.0000	ns
		21	10 \pm 0.5	15 \pm 0.7	9 \pm 0.7	0.0005	ns	0.0005
	p-Value	15 vs. 18	0.0005	ns	ns	-	-	-
		15 vs. 21	0.0158	ns	0.0009	-	-	-
		18 vs. 21	0.0013	ns	0.0003	-	-	-

ns = not significant at $\alpha > 0.05$

Relationship between time of thermal treatment in steam and force of the evaluated samples is shown in Table 1. Prolonging the time of treatment in the analysed conditions, caused a decrease of potatoes force. The Saturna variety was the only exception – for that variety no difference in potato's force during thermal treatment in steam was observed, which might have been connected with the highest content of starch in that variety of potatoes (17%). The decrease of force has been connected with changes in texture caused by provided energy. According to the researches, potato starch, comparing to the corn starch, gelatinizes at a lower temperature, but it requires more energy due to the higher enthalpy [Kereliuk & Sosulski, 1996].

Comparing the varieties, we observe the highest differences in the force of the Satina and Saturna variety (when differences in the content of starch are also the highest). For Satina and Asterix, differences are observed only for potatoes treated for shorter time (15, 18min), while for Saturna and Asterix – for potatoes treated for longer time (21 min).

Relationship between time of thermal treatment in steam and deformation of the evaluated samples is shown in Table 2. Prolonging the time of the 1st thermal treatment in steam, for the Satina, Saturna and Asterix variety, have caused a decrease of its deformation. For the Satina and Asterix varieties, the main decrease was observed at the beginning of the thermal treatment (until the 15th minute), while for the Saturna variety the decrease of deformation was observed after the 15th minute of treatment. The fact that for Satina and Asterix prolonging time of thermal treatment did not change significantly the deformation, may be the proof of technological usefulness of those varieties in gastronomy. For the Satina and Asterix – varieties of potatoes of the similar amount of starch, there is no difference observed between their deformation during the thermal treatment with steam, which indicates similar properties of those varieties under those conditions.

CONCLUSIONS

1. Prolonging the time of the thermal treatment in the analysed conditions, caused a decrease of potatoes force, that has been connected with changes in texture caused by provided energy. Only for the Saturna variety no difference in potato's force during thermal treatment in steam was observed.

2. The deformation of the analysed potatoes of the varieties Satina and Saturna, after thermal treatment under conditions of the increased pressure, did not change significantly during that process, while for the Asterix variety – it increased. In the treatment in steam, prolonging the time of the thermal treatment, for all the examined varieties of potatoes, caused a decrease of their deformation.

3. The best results after thermal treatment under conditions of increased pressure and in steam, gained the Asterix variety. It can be connected with its content of starch which is medium (comparing to the other analysed varieties of potatoes).

4. The analysed parameters and conditions of the thermal treatment conducted in the convection oven induce retaining the gastronomic values and usefulness of the examined varieties of potatoes.

ACKNOWLEDGEMENTS

We thank the Küppersbusch GmbH for all the assistance, cooperation and for financing the researches.

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TABLE 2. The deformation of the analysed varieties of potatoes after thermal treatment under conditions of increased pressure and in steam.

Analysed factor	Conditions	Time (min)	Analysed variety of potatoes (mean ±SD)			p-Value			
			Satina	Saturna	Asterix	Satina vs. Saturna	Satina vs. Asterix	Saturna vs. Asterix	
Deformation (mm)	Increased pressure	10	9.8 ± 0.63	7.1 ± 0.65	7.8 ± 0.57	0.0067	0.0151	ns	
		12	10 ± 0.71	7.5 ± 0.42	8.3 ± 0.42	0.0063	0.0234	ns	
		14	10.2 ± 0.85	7.6 ± 0.84	9.0 ± 0.35	0.0196	ns	ns	
	p-Value	10 vs. 12	ns	ns	ns	-	-	-	
		10 vs. 14	ns	ns	0.0360	-	-	-	
		12 vs. 14	ns	ns	ns	-	-	-	
	Treatment in steam	15	15	9.9 ± 0.81	15.4 ± 1.16	10.0 ± 0.77	0.0025	ns	0.0026
			18	5.9 ± 0.75	13.9 ± 1.43	6.7 ± 0.92	0.0010	ns	0.0010
			21	5.0 ± 0.59	10.5 ± 0.67	6.4 ± 0.85	0.0004	ns	0.0028
p-Value		15 vs. 18	0.0033	ns	0.0089	-	-	-	
		15 vs. 21	0.0011	0.0032	0.0055	-	-	-	
		18 vs. 21	ns	0.0203	ns	-	-	-	

ns = not significant at $\alpha > 0.05$

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WPLYW ZAPAROWANIA, TEMPERATURY ORAZ CZASU OBRÓBK I NA WŁAŚCIWOŚCI TEKSTURALNE ZIEMNIAKÓW

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Praca przedstawia ocenę wpływu różnych parametrów obróbki termicznej (zmienny czas, obróbka termiczna w warunkach zwiększonego ciśnienia/w parze) na zmiany parametrów jakościowych różnych odmian ziemniaków (Satina, Asterix i Saturna).

Celem pracy była ocena wpływu obróbki termicznej na zmiany parametrów (siła, odkształcenie), wynikających z charakterystyki skrobi ziemniaka. Warunki obróbki termicznej były zmieniane w zależności od osiągniętej odpowiedniej jakości analizowanych odmian ziemniaków, cechujących się różną zawartością skrobi. Pomiarów właściwości teksturalnych analizowanych ziemniaków dokonywano z wykorzystaniem maszyny wytrzymałościowej INSTRON 4301 (test penetracji). Otrzymane dane wskazywały na to, że analizowana odmiana Asterix posiada najwyższe wartości odżywcze i użytkowe, które mogą być związane z jakością skrobi badanych odmian ziemniaków.