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Changes of polysaccharide content and texture of potato during French fries production

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Abstract

The purpose of the present study was to determine the changes in non-starch polysaccharide and lignin contents of potato during French fries production and also the relationship between the texture of the finished product and half-products, as a result of processing at each stage under investigation. The samples for laboratory studies were taken from potato tubers, strips and French fries collected from nine locations of a technological line. The greatest changes in non-starch polysaccharide content and texture of potatoes resulted from blanching and frying. The texture of French fries was mainly affected by pectin and cellulose. The texture of French fries can be predicted from the measurements of the texture of potato strips after blanching.

Keywords: Potato tuber; French fries; French fries processing line; Texture; Non-starch polysaccharide; Lignin

1. Introduction

French fries are the most popular potato products in many countries. They owe their popularity to eye-appealing golden colour, good flavour and aroma of the fried potato and characteristic texture (Lisińska & Leszczyński, 1989; Talburt & Smith, 1987). The texture of French fries is mainly dependent on the quality of the raw material, although technological parameters are also very important.

Until recently studies of French fries manufacturing have primarily focussed on the mechanisms affecting colour and the factors affecting flavour and aroma of the product. The results of extensive studies on the quality characteristics mentioned above allow the manufacturers of French fries to obtain a high quality product with no difficulty. However, the mechanisms influencing the texture of French fries have not been studied extensively and need further investigation. Non-starch-polysaccharides (NSP) and lignin are, in addition to starch, the main texture-affecting constituents of the potato (Andersson, Gekas, Lind, Oliveira, & Oste, 1994), and make up to one half of the non-starch dry matter content of the potato (Lisińska & Leszczyński, 1989). van Marle, Clerkx, and Boekenstein (1992), van Marle, Der Vuurst de Vries, Wilkinson, and Yuksel (1997a), Marle et al. (1997b) studied the cellular structure of cooked potatoes and found that the changes in texture resulted from the damaged middle lamella and cell walls as well as starch gelatinization.

There are few data in the literature on changes in NSP and lignin contents and composition of potatoes, on potato half- and finished products, during the entire technological process. In general, only one of the technological processes is investigated, e.g. peeling or blanching. For this reason, it is important to carry out studies that will allow us to determine which technological processes are

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responsible for the texture of the finished product. It is still not known whether particular chemical components of the potato confer the characteristic texture of French fries or what quantitative ratios of these should be sought in the potato varieties considered suitable for French fries manufacturing.

The purpose of the present study was to determine the changes in pectins, hemicelluloses, cellulose and lignin contents of potatoes at particular stages of French fries manufacturing and also the relationship between the texture of the finished product and that of half-products obtained during a particular stage of processing.

2. Materials and methods

2.1. Samples

The samples collected for laboratory studies consisted of potato tubers, potato strips and French fries (2 kg each) from nine locations on a French fries processing line. Sample 1, consisted of potatoes before peeling; sample 2, steam-peeled potatoes (pressure 1,6 MPa time 0.5 min; sample 3, pre-cooked potatoes at 35 °C for 20 min; sample 4, potato strips (0.7×0.7 cm) by hydro-cutting; sample 5, potato strips after stage I of blanching at 72 °C for 5.0 min; sample 6, potato strips after stage II of blanching at 80 °C for 5.5 min; sample 7, pre-dried potato strips at 37 °C for 6.0 min; sample 8, French fries after stage I of frying at 180 °C for 45 s; sample 9, French fries after stage II of frying at 180 °C for 3 min. After stage I of frying, French fries were frozen at −27 °C.

2.2. Analysis

Immediately after the samples were collected from the processing line, the texture of potatoes was determined using an Instron 5544 connected to a computer equipped with a rectangular attachment for cutting. The velocity of the head with the attachment was 250 mm/s. The measurements were taken for determining the maximum shear force (F_{max}) necessary to cut the potato strips.

Pectins, cellulose, hemicelluloses and lignin contents were determined by the Dever, Bandurski, & Kiviliaan (1968) method, modified by Jaswal (1970) and Tajner-Czopek, Kita, & and Lisińska (1997) after freeze-drying of the potatoes.

2.3. Statistical analysis

The data were analyzed statistically using a Statistica 6 programme (2001). For comparison, the results obtained were analyzed using one-way analysis of variance with the application of Duncan's test ($P \leqslant 0.05$). The possible correlation between the potato texture and NSP and lignin contents in potato from particular stages of French fries processing line and also the relationship between French fries texture and potato texture from different stages of the French fries processing line were analyzed using analysis of variance (ANOVA). The differences at $P \leqslant 0.05$ were considered significant.

3. Results and discussion

Table 1 shows that NSP and lignin contents of dry matter of unpeeled potatoes were: 2.86% pectins, 2.56%, hemicelluloses, 2.71% cellulose and 2.83% lignin. After peeling, pectin and cellulose contents of potato tubers increased by 3.27% and 2.95%, respectively. Slight changes were found in the hemicelluloses content, while lignin content was about 20% lower. Kita (2002), Garrote, Silva, & Bertone (2000) reported quantitative changes in NSP and lignin during potato peeling. Kita (2002) found about 30% decrease in the sum of NSP and lignin in potato tubers after peeling them by a carboround method, while the highest losses were found in the cellulose fraction. In our studies, the potatoes were steam-peeled and the changes in polysaccharide content as compared to those measured in the raw material were

Table 1
Contents of pectins, hemicelluloses, cellulose and lignin in potato during French fries processing*

Samples	[% d.m.]			
	Pectins	Hemicelluloses	Cellulose	Lignin
Un-peeled potato	2.86a	2.56a	2.71a	2.83c
Potato after peeling	3.27b	2.63a	2.95b	2.34ab
Potato after pre-heating	3.13ab	2.62a	2.39a	2.32ab
Potato after cutting	3.29b	2.46a	2.98b	2.12a
Strips after stage I of blanching	3.98c	3.59b	5.89c	2.40abc
Strips after stage II of blanching	3.23b	3.78b	5.90c	2.87c
Strips after drying	3.19ab	4.01b	6.06cd	2.60bc
French fries after stage I of frying	3.34b	4.23b	6.39de	2.79bc
French fries after stage II of frying	3.48b	4.41b	6.46e	2.78bc

* Different letters (a,b,c) indicate significant differences in columns ($P \leqslant 0.05$).