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Determining different firmness characteristics in cooked potatoes

Increasingly ware potatoes are retailed as pre-cooked, including cooked potato slices for salad preparation. The firmness of these slices is regarded as an important quality criterium. Investigated was how this firmness could be controlled through simple methods within the production process for product condition information applicable to the cooking process.

Over 44% of ware potatoes consumed in Germany during financial year 1999/2000 were further processed to wet, deep fried, fried, deep frozen and dried products. These processed potatoes represented a consumption of 31 kg/person [1]. This trend has increased over the years. Within the wet products the proportion of cooked potato slices for salad preparation has also increased. Although firmness of such slices are a matter of individual taste and traditional standards, manufacturers have to determine standards based on a consensus of consumer wishes as well as according to raw material characteristics.

To be determined in a special trial series were:

- Standard of „bite firmness“ desired in cooked potatoes by the consumer
- The tissue characteristics causing this „bite firmness“, and
- The measurement methods suitable for determining values for the cooking process

Determining the optimum firmness of potato slices

510 visitors during the Brandenburg Agricultural Exhibitions 1999 and 2000 and Berlin Potato Day 1999 evaluated 4083 cooked potato slices for firmness. To present a broad spectrum of firmness values, 30 tuber varieties were cooked for various lengths of time. Each tester was offered eight potato slices to be eaten and was asked to evaluate their firmness. Testers had to classify the slices thus: too firm / a little too firm / just right / a little too soft / too soft. Every potato slice was tested with a penetrometer beforehand in a mobile laboratory. Based on the survey results a limit for penetrometer force of 4.7 Nr. was chosen as describing optimum firmness for the potato slices *(fig. 1)*. This formed the basis for determination of optimum cooking time.

Determination of firmness values

The *penetrometer force* was determined with a digital penetrometer from TR di Turoni & C. snc *(fig. 2)*. This force is the maximum force required for the penetration of a 3.2 mm diameter stamp through a 5 mm thick cooked potato slice. Average penetrometer force was calculated from six measurements per slice distributed diagonally over the slice cross section. Other firmness factors extrusion force, cutting force and breaking force were determined by a material testing machine TMZ2.5/TS1S from the company Zwick. Other special equipment was applied for carrying out the trials *(fig. 3)*.

Extrusion force was determined by consolidating diced tuber pieces from individual potatoes within a cylinder by a piston propelled at 90 mm/min *(fig. 3)*. The piston radius was 5 mm less than that of the cylinder inner radius. After the initial compaction phase the compressed tuber tissue was forced upwards through the gap between piston and cylinder interior wall. The extrusion force is the average force during this process.

The *cutting force* is the maximum force used for slicing through a cooked and peeled tuber with a 0.3 mm diameter wire *(fig. 3)* The velocity of the slicing action was 100 mm/min.

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Keywords

Potatoes, firmness, cooking time

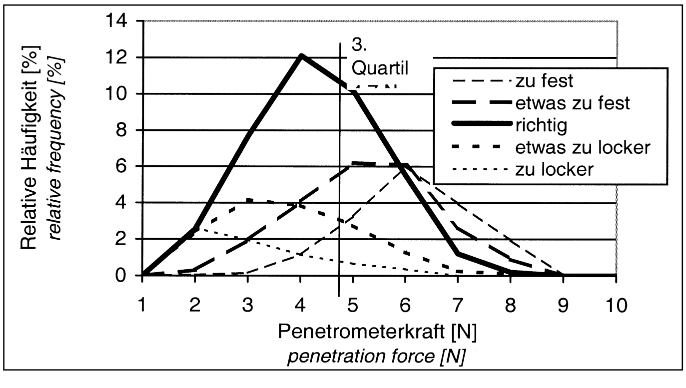

Fig. 1: Firmness assessment of cooked potato slices by tasters

Fig. 2: Digital penetrometer for determining resistance of cooked potato slices

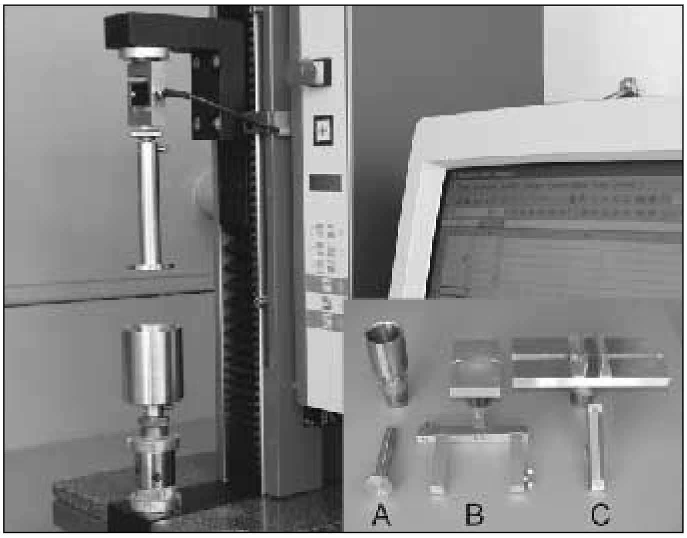

Fig. 3: Material testing machine with tools for determining the extrusion force (A), cut force (B) and fraction force (C)

The breaking force describes the maximum force that a 45° wedge requires to break a 5 mm thick potato slice with an application velocity of 90 mm/min *(fig. 3)*.

Trial material

30 different potato varieties were used for the trials. These came from a plot trial whereby the growing methods were consistent over all the plots. Starch content of individual tubers was determined by underwater weighing [2]. The trial material was in each case stored at 5 °C for 2 hours after cooking.

All firmness measurements were in each case carried out on the same tuber.

Results

It has been assumed in the literature [3] that the extrusion produced by the Kramer cell comes nearest to the human chewing process. However, the extrusion cylinder method was chosen for these trials because using the Kramer cell is methodically more complicated. In that the survey results indicating optimum penetrometer force were already available, the next step was to determine whether a secure relationship existed between the extrusion method and the easy-to-operate penetrometer method. With a correlation coefficient of r = 0.54 a certain relationship could be demonstrated. Significance level was p = 0.01 *(fig. 4)*.

The comparison with the penetrometer force with the other methods for determining firmness also led to secure, when also less marked, relationships:

• penetrometer force to breaking force r = 0.49

• penetrometer force to cutting force r = 0.4

To avoid evaluation errors, only values of cooked potatoes with a penetrometer force smaller than 4.7 Nr. were recorded. So far there is no information available regarding influence of weather fluctuations and of different cultivation methods on these relationships. Notable is the close association between tuber starch content and extrusion force *(fig. 5)*. The expected relationship between starch content and breaking was not able to be shown (r = 0.15).

Conclusions

The measurement by penetrometer of cooked potato slice penetration resistance enabled statements to be made as to whether the cooked condition of these slices produced the optimum firmness expected by consumers. The measurement of the penetrometer force can, to a certain extent, replace more involved methods of measuring firmness in cooked potato slices (extrusion force, cutting force, breaking force), according to the current results. However, investigations over several years are required under differing weather conditions and cultivation systems.

Literature

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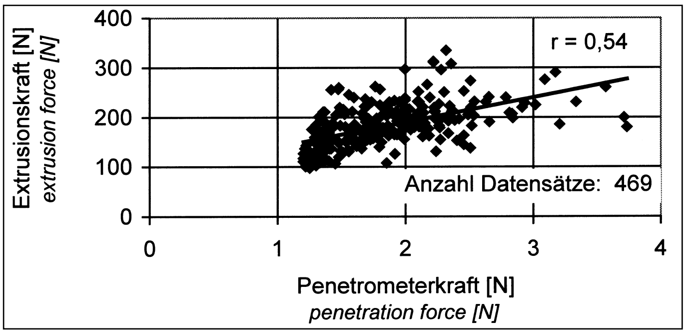

Fig. 4: Extrusion force versus penetration force of cooked potatoes

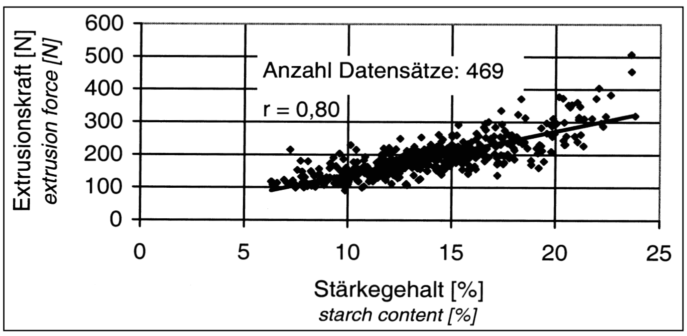

Fig. 5: Extrusion force versus starch content of cooked potatoes