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Assessing the Microtopographical Quality of Cutting Areas

The market for fresh vegetables and lettuce is growing worldwide. However, the quality of freshly cut products often does not meet consumer expectations. Cutting and peeling destroys the tissue structure and enlarges the surface susceptible to spoilage, reducing shelf life. Optimizing these process steps helps to limit produce losses. Evaluation of the cutting tools, as well as the cutting surfaces they produced, can be done through microtopographic analysis.

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Keywords

Vegetables, cutting area, surface quality, micro topography

The quality of the cutting step during preprocessing of fruits and vegetables depends on design and properties of the knife, the cutting velocity and/or the cutting direction. Furthermore, it is influenced by the preharvest produce quality. The cutting quality is usually evaluated indirectly by determination of shelf-life, cell sap loss, enzyme activity or cutting strength. The cutting strength depends on the tissue structure as well as on the product water status. An objective evaluation of tissue damage due to cutting processes is time-consuming and labour-intensive when using conventional microscopic techniques. On the other hand by using digital three-dimensional microtopographic scanning techniques a rapid quantification of the relevant surfaces is realizable. As an example slicing of carrots transverse to its longitudinal axis and the subsequent determination of the cutting quality is presented in this study.

Effects of freshness status and cutting tool

Washed carrots were purchased directly from the producer and tested after short-term storage at 4°C in vapour-saturated atmosphere. Carrot water status was varied by hydration in water and dehydrating at room climate conditions. Then the water status parameters water potential, osmotic potential and pressure potential were measured by means of Wescor dew-point hygrometer. The water content was determined according to the weighing drying method (*Table 1*). For cutting three different tools were used: a used commercial kitchen knife (KM), a new (IMN) and an already worn out (IMA) industrial blade for cutting vegetables. These blades differed mainly according to the angle of incidence of the cut flanks, the flattening at the cutting edge and surface roughness. For the kitchen knife the angle of incidence of the cut flanks was only about half as steep, but the flattening at the cutting edge (40 μm) was twice as wide as that of the industrial blades (*Fig. 1*). The two industrial blades

Table 1: Freshness state of carrots investigated

Carrot no.	Pressure potential, MPa	Water content, $g\ g_{dm}^{-1}$
1	0,39 ± 0,12	14,7 ± 1,8
2	0,30 ± 0,10	13,1 ± 1,0
3	0,23 ± 0,06	11,5 ± 1,0
4	0,11 ± 0,07	8,9 ± 0,7

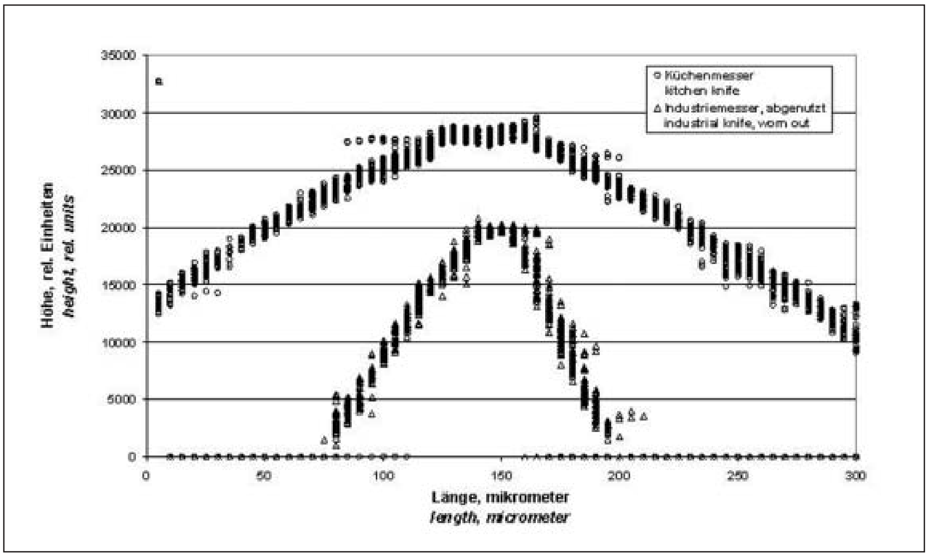

Fig. 1: Profiles of cutting tools scanned by using the micro topographic system NEMESIS V (scanning area 60 • 60 pixels spaced 5 μm)

Fig. 2: Cutting equipment for carrots with industrial knife by using a universal testing machine

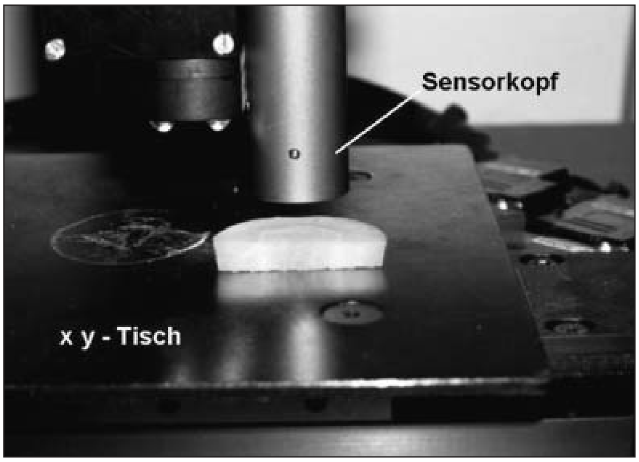

Fig. 3: Positioning of the carrot slice below the distance sensor Type CHR 150

showed different surface roughness with respect to the cut flanks, which clearly increased with the degree of abrasion. Thus a classification of the tools was possible in the order of increasing sharpness KM, IMA, IMN. Cutting the carrots was done manually with the kitchen knife. The industrial blades were fixed in a universal test machine (ZWICKI 1120). The cutting was performed with a speed of 800 mm/min (*Fig. 2*).

Microtopographic measurement

The cutting surface of the carrot was investigated using the microtopography system NEMESIS V (Precitec Optronik GmbH, Rodgau Germany) with the optical distance sensor CHR 150 [1] (*Fig. 3*). This sensor has a measuring range of 600 µm, an optical resolution of 1 to 2 µm in x and y-direction and of 0.02 µm in z-direction. On the carrot slices several square areas (in each case 1 mm^2) were scanned in steps of 10 µm. The high water content of fresh produce frequently led to missing data values and related pixel errors in the measurement results. These errors were corrected by interpolation in a preprocessing step. The subsequent data analysis was performed with standardized parameters. To evaluate the surface roughness (according to [2]) the arithmetic average roughness R_a was determined.

With increasing sharpness of the blades the average roughness of the cutting area of the carrot and the variances of the mean roughness values tended to decrease (*Fig. 4*). Cutting with the new industrial knife resulted in the lowest and best reproducible values (data not presented). This result is largely independent of the water content or the pressure potential of the carrots. Accordingly, the kitchen knife yielded the highest average roughness but was showing slightly lower roughness at a lower turgor. Here, also the highest standard deviation of roughness values was assessed. Mean surface roughness of cuttings with the worn out industrial knife were slightly higher than those of new industrial knives. Comparison of different blades does not always yield significant differences. Altogether, microtopographic analysis pointed out the advantages of the new industrial knife.

Conclusions

The analysis of the cutting quality as a function of produce freshness and the properties of the cutting tool provides new starting points to optimize cutting procedure during fresh vegetable processing. Microtopography analysis allows a rapid and objective evaluation of surface roughness regarding fresh products. Metrological problems arising from pixel errors supposable caused by the high water content of the products require a crude data pre-processing. The measurement principle reaches its limit if the samples include surfaces of small roughness and steep flank angles. In this case too little light is sent back from the surface to the sensor, so that the light intensity is below the threshold of the sensor head. An example for this fact is given with the results for the new industrial blade.

Literature

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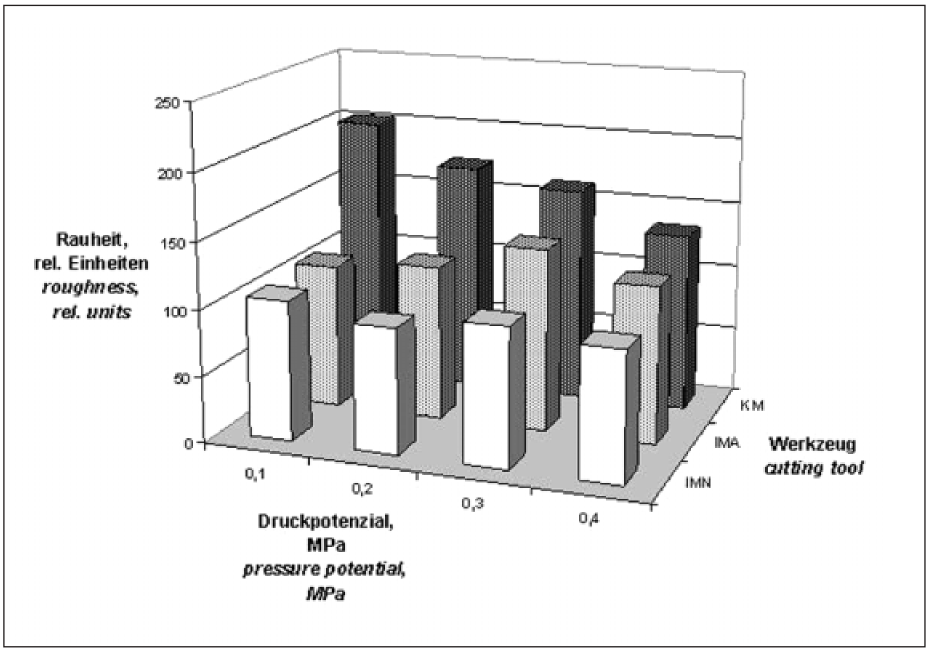

Fig. 4: Average roughness of cutting areas depending on produce state and cutting tool