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Determining impact damage and black spot in potatoes

Black spots in potato flesh are caused when cell walls are damaged through impact and pressure. Within a few days biochemical reactions lead to the creation of melanin responsible for the discoloration. Time-associated impact simulation was used to investigate a system of threshold values representing permitted mechanical stress for potatoes during harvest, storage, dressing and marketing operations. Methods of impact simulation and black spot determination were presented, as were results on the influences of impact intensity, tuber temperature, variety and starch content.

Rational and therefore financially viable potato production nowadays is unimaginable without tubers being subject to machinery-induced mechanical stresses. However suitable measures during harvest, storage, dressing and marketing operations can be taken to reliably avoid black spot in potatoes. These require more knowledge as to the thresholds of mechanical stress which can be suffered by potato tubers before mechanical damage results. Such thresholds are influenced by very many factors [1]. Aim of the investigations was to discover the influential factors which help to make a reliable prognosis regarding black spot susceptibility of a potato batch. Such knowledge would enable precautions to be taken for reliable avoidance of black spot. The temperature of tubers is especially important in the known stress profile of a dressing and marketing system. This is because this factor is most easy to manipulate of all the important influences.

Determining the stress intensity

From harvesting to packing, every tuber is subject to repeated loads of differing intensity. Depending on the quality of the system such stress can vary considerably. Stress measurement is by sensors which are inserted in the tuber flow, register all individual impacts and finally pass the data onto an evaluation system (*fig. 1*). This allows the stress profile of the system to be determined.

The current technical level of stress recording is carried out by two measurement systems:

- The sensing sphere IS 100 developed at Michigan State University records and stores dynamic stress occurrences via acceleration sensors. This system and its results have already been reported in depth in the literature [2, 3].
- The sensing sphere PMS-60 developed in the Institute for Agricultural Engineering Bornim (ATB) records static and dynamic stress occurrences via a pressure sensor. Here too, the measurement system and the results achieved through comparative evaluation of mechanisation solutions in dressing and marketing systems have been described [4, 5].

Used in the following investigation is only the measurement sphere PMS-60. This was applied parallel to potato sampling in the stress simulation.

Simulation of stress

For the precise time-associated application of mechanical stresses on potato samples, the ATB had the use of a stress simulator in the form of a vibration box through which the stress profile is able to be given in a reproducible way through the vertical lift (crankdrive), frequency and load period. In future, a servo-hydraulic test stand will also be able to be used to apply individual verti-

Fig. 1: Determining real mechanical stress in handling and marketing facilities

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Keywords

Potatoes, black spots, simulation of mechanical stress

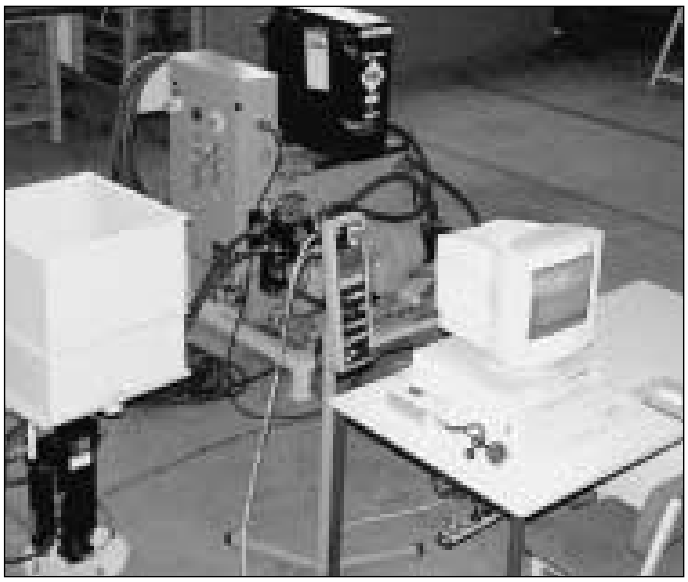

Fig. 2: Servo hydraulic test stand to produce black spots on potatos by repeated mechanical loads

cal impacts of differing degrees on a potato sample placed in a box (*fig. 2*)

Determining black spot extent

For rational measurement of different black spot affected parts of the tuber in the extensive trial series, a special image analysis system was developed in the ATB [6]. Compared with the visual evaluation method used up until now, the image analysis to a large extent helped eliminate human error during trials. This is particularly important during trial series over several years where trial personnel have to be changed. The image analysis was used to determine the proportion of black spots on the sliced largest-possible surfaces of quartered sections of every tuber. In order to have any chance at all of reliably recording the complex effects of the different influencing factors (load intensity, tuber temperature, component substances, variety) the tubers were not analysed as mixed samples but instead investigated individually and the results recorded in a data bank.

Influence of load intensity

The results of a trial series with seven potato varieties of the same origin (trial plots) exposed to a material loading over 60 s in the ATB stress simulator are demonstrated.

Despite differing frequencies, and therefore differing load intensities, the total loading was almost similar (*table 1*).

Table 1: Variants of stress for determining tendencies for developing black spots

Variants	1	2
Frequency (Hz)	6,5	9,5
Load time (s)	60	60
Number of impacts (n)	356	265
Total load (kN)	19,6	20,5
Maximum impact force (N)	174	247
Average impact force (N)	55	77

Influence of tuber temperature

The colder a tuber under mechanical loading is, the more readily it tends to discolour. This tendency is already included in advice to practical farmers [7]. However, in order to be able to estimate the minimum material temperature that has to be observed for certain potato batches, characteristic data series related to the influence of the tuber temperature have to be determined for the forecasting of black spot susceptibility (*fig. 3*).

Influence of variety

An estimation of black spot susceptibility depends on individual varieties being able to be classified into susceptibility grades. Investigations carried out for this reason confirmed variety-specific susceptibility (fig. 3). Where different potato varieties were classified according to their starch content, varieties such as Möwe (18.8%), Selma (18.3%) or Freya (17.1%) showed characteristic tendency towards black spot formation, especially where temperatures were low. Varieties Acapella (13.2%) or Arkula (12.5%) appeared nonsusceptible to black spot. That the starch was not the only influential factor for black spot susceptibility was shown by the variety Serafina. Although this genotype had only 12.4% starch content it reacted very sensitively to impact loads. The variety-specific susceptibility to black spot should be better explained in future trials when consideration is also given to other tuber ingredients such as potassium, calcium, ascorbic acid and amino acids.

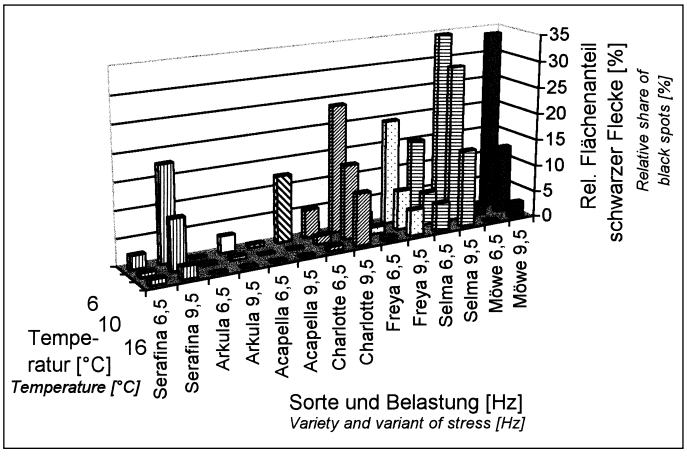

Fig. 3: Share of black spots on the surface area of slices which were subjected to different mechanical loads and temperatures

Conclusion

From the results so far:

- It appears to be possible in principle to determine black spot susceptibility in advance for individual potato batches.
- Thus, the extent to which batches must be warmed before handling in order to avoid black spot can be calculated. Excessive warming costs not only extra energy, but also leads to increased transpiration and thus to heightened weight loss.
- Before the prognostic model can be accepted as part of a crop performance programme further research results in this subject must be available.

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