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Mechanical Properties of Potatoes from Organic Farming

The demands of the consumers with regard to food quality are growing. The environmental compatibility of a cultivation technique is considered an additional quality criterion. Firmness and texture of agricultural products are suitable criteria for the evaluation of their quality. Pendulum-, penetrometer-, and plate tests are used to assess potato tubers on the basis of their mechanical properties. This study was intended to clarify to what extent these techniques of firmness measurement are also suitable for potatoes from organic farming. Trials were carried out over three years to prove the influence of the variety, organic fertilizer application, and storage duration on the firmness properties of the potato tuber.

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Keywords

Mechanical properties; penetrometer-, pendulum-, plate test; quality of potatoes; organic farming

Literature

Literature references can be called up under LT 04209 on the internet www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

After rice, wheat, and maize, the potato is the most important kind of basic food worldwide and the most significant starch-containing tuber crop [1]. From the viewpoint of nutritional physiology, it belongs to the ideal kinds of basic food which are part of a nutritious diet [2]. Worldwide, potatoes are grown on a cultivated area of approximately 18.8 million ha in 150 out of 200 countries. In the past years, production has remained stable [3].

An increasing degree of mechanization leads to growing mechanical load on the potato tubers, which results in an increasing danger of damage to the tubers, the consequences of which are secondary infection as well as mass- and quality losses [4]. For this reason, potato varieties of high firmness are also being sought in organic farming.

In all areas of potato production and -processing, high product quality is required. In order to supply the consumer with high-quality food potatoes, it is necessary to maintain freshness and quality for a long time after the harvest. Hence, storage technology is one of the most important branches of both agriculture and the food industry. Efficient quality management needs suitable quality parameters for both fresh and stored potatoes. The environmental performance of the cultivation technique is a suitable quality criterion. As compared with conventional products, organic farming products are often considered to be of higher quality, and their cultivation is promoted by agricultural policy. For this reason, a group of DFG researchers was intended to develop optimization strategies in organic farming. The following report contains selected results of the determination of mechanical potato properties.

For various purposes, the mechanical properties of agricultural products are measured using standardized methods [5, 6, 7]. The variety of different methods and techniques, such as pressure-, compression-, penetrometer-, shear-, and stress tests, are suitable for the description, characterization, and determination of texture, firmness, crispness and, hence, quality. The collective term of mechanical properties comprises all those properties which are connected with behaviour under the effect of forces.

Like all agricultural materials, the potato tuber from organic farming is a complex biological system with great variability. The composition, the dry matter content, and the tissue structure of these materials vary during growth, maturation, and storage. These influencing factors were given for the agricultural engineering trials and kept constant to the largest possible extent by the group of agronomical researchers [8].

Significant cultivation factors for high yields and high potato quality are the choice of varieties and organic fertilizing (N_{org}). Since primarily the effect of mineral fertilizers on potato firmness and, hence, -quality has been examined in the past decades, recent studies on the explicit effect of organic fertilizing are virtually not available [9, 10].

Working Hypotheses

The planning of the experiments was based on working hypotheses of the group of researchers.

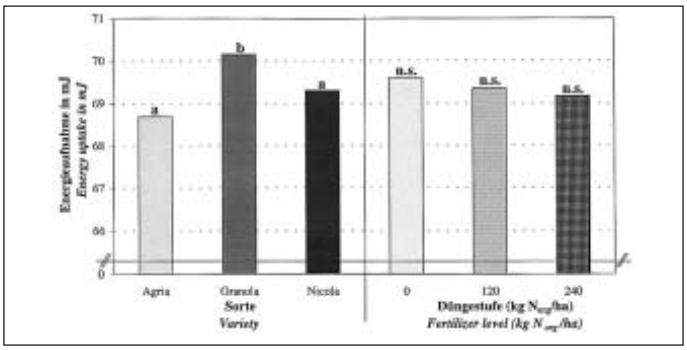

Fig. 1: Energy uptake of pendulum versus variety and fertilising level - storage time 120 days (pendulum test 1998)

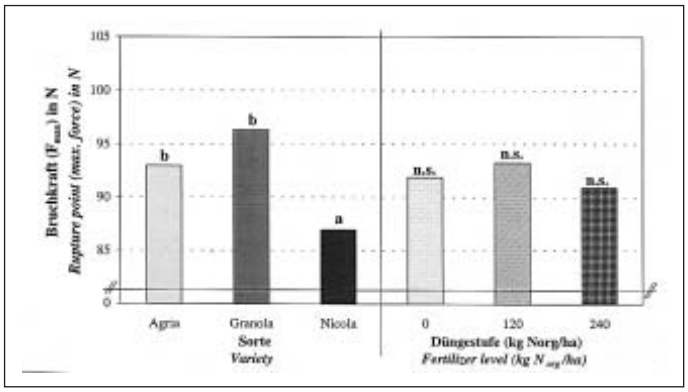

Fig. 2: Rupture point versus variety and fertilising level - storage time 120 days (penetrometer test 1999)

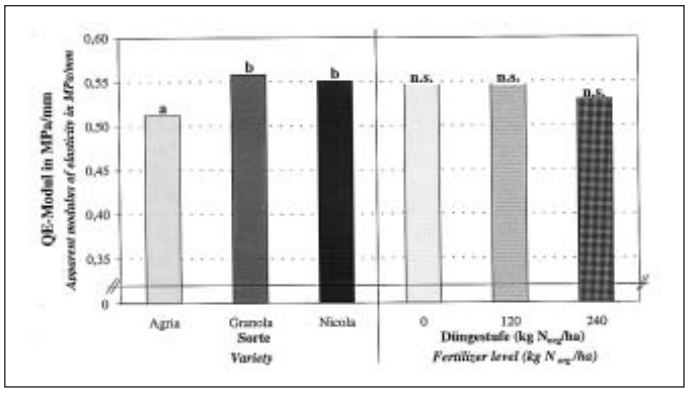

Fig. 4: Apparent modulus of elasticity versus variety and fertilising level - storage time 120 days (plate test 1999)

The mechanical properties of potato tubers from organic farming allow for an optimization process with regard to
- the variety
- the level of Norg fertilizing
- the storage duration.

Experimental Factors

The trials were planned for a period of several years (1997 until 1999). The varieties chosen were Agria as a variety of processing potatoes, Granola as a variety with primarily firm texture, and Nicola as a food potato variety with firm texture. The fertilizing levels selected were 0, 120, and 240 kg. According to the cultivation technique, short dung was used as fertilizer.

For the realization of the trials, three dates were chosen: during storage and after a storage period of 60 and 120 days.

Measuring Methods

With the aid of the three measuring methods pendulum test, penetrometer test, and plate test, four mechanical properties were measured. The pendulum test shows the dynamic load on the potato and provides the parameter „energy uptake“. The quasi-static load serves as the basis for the determination of the mechanical properties „rupture point“ and „apparent modulus of elasticity (QE module)“ (penetrometer test) and the QE module (plate test). A detailed description of the measuring method and the measuring parameters can be found in reference [11].

Results

The description of the results is restricted to two trial years (1998 and 1999) serving as examples. Corresponding to the experimental set-up, the statistical evaluation was carried out using three-factor variance analysis. In order to assess the differences between the individual levels of a factor, the Tukey test was chosen among the multi-factorial mean value comparisons. The different letters indicate significant differences. In the year 1998, the Granola variety reached a significantly higher energy uptake than the other varieties in the pendulum test carried out after 120 days (*Fig. 1*). According to the list of varieties, this variety is well storable as is known for potatoes from conventional farming. The storability of the Nicola variety, however, is poor. The level of Norg fertilizing had no significant influence.

The 1999 penetrometer test provided similar results (*Fig. 2*). After a storage duration of 120 days, fertilizing differences are not secured statistically. The Nicola variety reaches the significantly lowest rupture point [12], which confirms the results of the 1998 pendulum test.

The results of the QE modules (the same results, trial year, and test method) are shown in *Figure 3*. The QE modules of the penetrometer test confirm the result of the rupture point measurement (Fig. 2) and the pendulum test 1998 (Fig. 1).

The results of the plate test in the trial year 1999 (*Fig. 4*) show a significant influence, though no significant influence of organic fertilizing.

Summary

The studies confirm the working hypotheses according to which the measuring methods examined allow the firmness properties of potatoes from organic farming to be measured as mechanical properties. The potato varieties from organic farming chosen here can be distinguished significantly with the aid of the measuring methods pendulum test, penetrometer test, and plate test. At the N_{org} fertilizing levels, the differences could not be secured statistically in this experimental set-up. Storage duration influences potato firmness. The rupture point measurement of the penetrometer test and the QE module of the plate test enable the direction of effect to be proven [11].

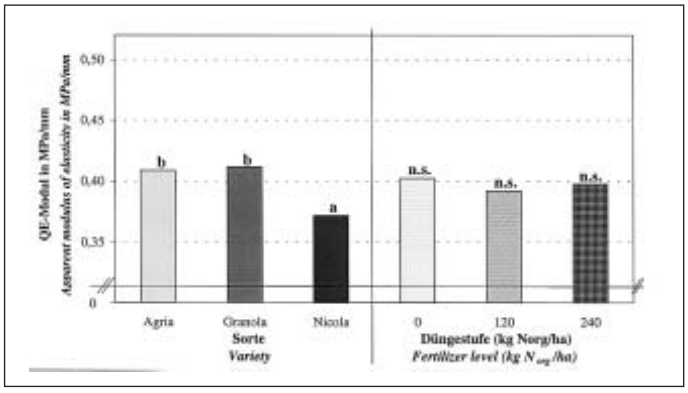

Fig. 3: Apparent modulus of elasticity versus variety and fertilising level - storage time 120 days (penetrometer test 1999)