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Quality Comparison of Mineral, Organic and Biodynamic Cultivation of Potatoes: Contents, Strength Criteria, Sensory Investigations and Picture-Creating Methods

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Introduction

Apart from technical suitability and appearance, food quality can be measured in terms of its nutritional value, the ratio of beneficial and harmful substances. Moreover, taste and shelf-life must be mentioned as quality characteristics that govern consumers behavior in the first place. The notion of "Vital-Quality" (Balzer-Graf, 1987), furthermore, might be introduced in this place as a characteristic of the vitality of foodstuff as well.

The application of biodynamic preparations is compulsory for farms managed biodynamically. This is why biodynamic preparations are utilized on approximately 20 % of all organically cultivated agricultural acreage in Germany. These preparations do not primarily provide for increased harvest, but are assumed to have a positive impact on food quality through a balanced nutritive content and good shelf life.

It has been the aim of the survey, presented in this article, to determine the influence of different fertilization strategies (mineral, organic, biodynamic) and of the intensity of fertilization on the above-mentioned nutritional criteria, viz. content, strength criteria, sensory and "vital quality" of potatoes (S*olanum tuberosum* L.).

Material and Methods

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Experimental field: This article is based on investigations that have been done on potato tubers (Variety ´Granola´) from a potato trial that is run by the Institute for Biodynamic Research (Darmstadt, Germany) for more than 18 years. The samples were collected in the years 1993-1996. The experimental field is situated 100 meters above sea level. The average annual amount of rainfall amounts to 590 mm (279 mm during May and September). The mean annual temperature is 9.5°C. The potatoes are usually irrigated, but that is sometimes insufficient in dry periods for technical reasons. The soil can be classified as a sandy orthic luvisol (Raupp, 1995). The experimental field is arranged as a split plot design with the main plots ”type of fertilizer” (mineral, organic, biodynamic) and the sub-plots ”quantity of fertilization” (50/100/150 kg N/ha). The experiment has four replicates. The mineral variants were (improperly) fertilized using potassium chloride, the organic and biodynamic variants equally used composted farmyard manure.

Sample preparation: After the harvest, the potatoes were stored outdoors for 14 days and graded. 50 tubers were washed, lengthwise cut into eighths, shock-frozen in liquid nitrogen, freeze-dried, ground, flooded with nitrogen and afterwards airtightly stored in lighttight glasses.

Methods: Dry matter was determined gravimetrically after drying at 105°C. The carbohydrates glucose, fructose and sucrose were enzymatically analyzed with a discontinuous-flow-analyzer (*HITACHI*). The density of the tubers from 1995 was determined by Koch (1997) with an underwater balance. According to Putz (1987), the density of potatoes and their starch content is closely correlated (r =0.92). Fluoride, chloride and phosphate were analyzed with an ion chromatograph (*DIONEX*). Ash content was determined gravimetrically after burning in a muffle-furnace at 550°C. Potassium was analyzed out of the ash with an atomic absorption spectrometer. Carbon and Nitrogen were measured with elementary analysis according to Dumas-Merz with with an elementary analyzer (*CARLO ERBA*). Sensory investigations were performed by the Federal Research Center for Nutrition (Karlsruhe, Germany) running tests by means of scoring rating (DIN 10952). Strength criteria was surveyed at the Institute for

Agricultural Engineering, Bonn (Koch et al., 1997). In the laboratory of Dr. Balzer-Graf (Wetzikon, Switzerland), coded variants were tested for their "vital quality" by means of picture-creating methods: sensitive crystallization and chromatograms (Balzer-Graf, 1987; Pfeiffer, 1960), as well as capillary dynamolysis, according to Wala (Engqvist, 1970).

Results

Dry matter: Throughout the test series, the biodynamically-cropped tubers surpassed the minerally and organically fertilized tubers in dry matter. Intensified fertilization generally resulted in a diminution of dry matter content in the tubers. Furthermore, particularly the results in 1995 indicate that minerally fertilized potatoes are relatively stronger affected by increased fertilization than the corresponding organic and biodynamic variants, in that they show a larger reduction of dry matter content (Figure 1). By contrast, the dry matter content of the biodynamic variants remained unchanged.

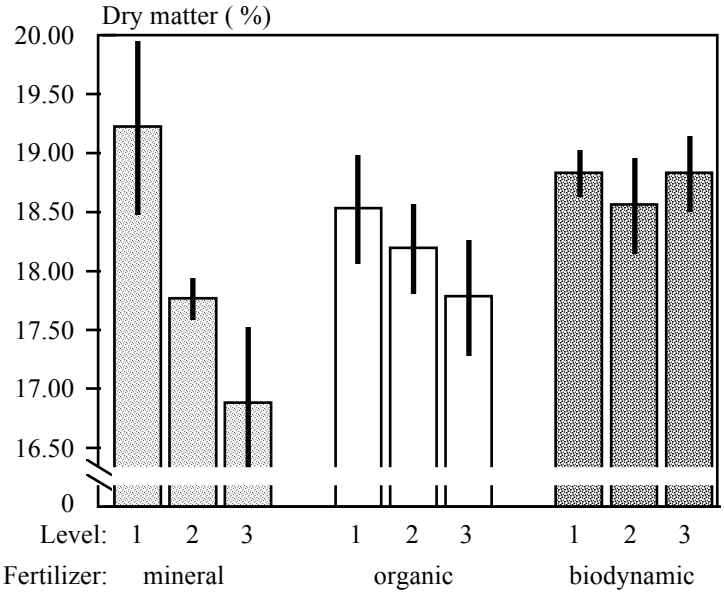

Figure 1: Dry matter content (%) of potato tubers depending on type and intensity of fertilization (Darmstadt, Germany, 1993, 1994, 1995)

Contents: Due to the fact that intensified fertilization usually increases the water content of potatoes, exerting a diluting effect, all following parameter are related to dry

matter. The tubers of 1994 have been tested for their content of glucose, fructose and sacchararose. The sucrose content of the minerally fertilized tubers showed a significant reduction by 23.5% from fertilization level 1 to level 2, while transition from level 2 to level 3 evinced no such significant reduction. Intensification of organic manuring likewise effected a significant reduction of the sucrose content passing over from fertilization level 1 to level 2, but no significant change from level 2 to level 3. Altered fertilization also caused a consistent reduction of the sucrose content for the biodynamic variants. Intensification of mineral fertilization induced a non-significant increase in glucose and fructose contents from level 1 to level 2 (20.5% and 17% rsp) (Figure 2, right). Intensification to level 3 did not result in another rise. The tubers of the organic variant displayed a non-significant increase of fructose and glucose contents from level 1 to level 3, and a decrease from level 2 to 3. The biodynamic variant showed a slightly increased glucose content in response to intensified fertilization. The fructose content, however, did not vary.

Starch content and density are found to correlate with a coefficient of 0.92 (Putz, 1987). Increased fertilization amounted to a continuous reduction of density in the tubers of the mineral and organic variants. The biodynamically fertilized variants, on the other hand, showed a reduction from level 1 to level 2, but an increase from level 2 to 3.

In all trial years increased organic and biodynamic manuring went along with a, sometimes significantly, increased chloride content. Increased mineral fertilization, by contrast, resulted in reduced chloride concentration. In total, the chloride content of the mineral variant proved to be significantly higher (by 30% in 1993, 100% in 1994, 70% in 1995) than that of the organic and biodynamic variants. This is due to the improper application of potassium chloride, which is a very inadequate mineral fertilizer for potato cultivation. The content of fluoride was, in part significantly, increased by intensified mineral fertilization in each year (from level 1 to level 3: +14% in 1993, +10% in 1994, +17% in 1995). The reaction of the other variants was inconsistent. Neither of the different cultivation strategies affected the content of phosphate.

The ash content of the tubers from 1995 was significantly increased in all variants by intensified fertilization. The ash content of the mineral variant was the lowest (in the average 4.1%, as against 4.4% for organic and 4.5% for biodynamic manuring). The ash

content of the mineral variant increased only by 11% from level 1 to level 3, whereas the organic and biodynamic variants increased by 17 %. The tubers of the other years are still being analyzed at the moment.

Intensification of mineral fertilization resulted in an increased nitrogen content (by 16%) in the 1993 test series, but this rise was much less rapid in the following years. Intensification of biodynamic manuring, on the other hand, produced a decline of the nitrogen content by 14% in the same year. The impact on the organically manured variants was only slight and inconsistent. The carbon content of the potato tubers did not respond to the different kinds of treatment.

Strength criteria: Tubers deriving from the organic plots showed the highest values followed by the biodynamic ones. Much lower values have been estimated for the tubers from the mineral plots.

Sensory Investigations: The Federal Research Center for Nutrition (Karlsruhe, Germany) investigated tubers of the years 1994 and1995 using with tests by means of scoring rating (DIN 10952). The first two years seem to suggest a negative effect of increased fertilization on the sensory qualities of food, i.e. taste, consistency, color and smell. This was particularly true for the mineral variant. The fertilization variants did not differ from each other in average.

Picture-Creating Methods: The laboratory of Dr. Balzer-Graf (Wetzikon, Switzerland) took a survey on coded tubers of the years 1994 and 1995 on the basis of picture-creating methods with regards to the characteristic ”vital quality”. From the harvest 1994 the tubers treated with preparations were unambiguously distinguished from the non-treated ones. Also the levels of fertilization were correctly identified, except that three references to wrong grouping became necessary. In 1995, too, the identification of the fertilization levels was apparent, while identification of the fertilization variants partly failed. In contrast to 1994, the tubers which were biodynamically treated were not detected completely, while the intensity of fertilization could still be identified without problems.

Conclusion

Generally, potatoes of the variety ´Granola´ responded rather slightly to the factors of the trial, hence statistical differences could be confirmed only in few cases. Tubers deriving from the mineral fertilized plots showed the strongest response to intensification of fertilization (decrease in dry matter, sucrose, chloride content and density, and an increase in glucose, fructose, fluoride and ash content). The higher availability of the mineral fertilizer might be the reason for these findings. Only in three parameters tubers from the biodynamic plots responded in the same way as the organic ones to increased fertilization (increase in the chloride and ash contents, stagnating fluoride contents). In four parameters, no or only a weak response of the biodynamic tubers have been found, whereas organic potatoes showed decreasing dry matter and sucrose contents, but no distinctive tendency in the parameters glucose and fructose. The parameter strength criteria has been assessed as the weakest in mineral fertilized potatoes. The sensory investigations did not allow to differentiate between the three cropping systems. But, however, there is a tendency of worsening sensoric quality at increased fertilization, particularly in the tubers of the mineral plots. The results of the determinations of vital quality following picture-creating methods confirmed the applicability of this assay for additional quality determinations.

A final assessment of the quality according to the different cropping systems cannot be made at this point of time. Therefore, further parameters (nitrate, potassium, amino acids, ascorbic acid) will be analyzed, which might allow a final assessment in combination with the present data. Furthermore, current trials might reveal, if other varieties respond stronger to the relevant factors.

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