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4. Discussion: Fertilization effects on product quality and examination of parameters and methods for quality assessment

Summarized by J. Raupp

FERTILIZATION EFFECTS ON CEREALS

Spring cereals have similar **yield levels** with organic and mineral fertilization, whereas winter cereals normally have lower yields with manure, compost etc. than with mineral fertilization.

As a rule the **crude protein** content in cereals is higher with mineral than with organic fertilization. Slurry, liquid manure and other organic fertilizers with a high nitrogen availability can increase the crude protein content on a similar level as it is achieved by mineral fertilizer. Application of liquid manure during flush is more effective than during tillering. The content of pure protein mostly is lower with mineral than with organic fertilization.

As regards the parameters of **baking quality** organic fertilization makes a lower gluten content and a tendency to a lower Zeleny value. The index of essential amino acids is about the same or slightly better with organic than with mineral fertilization. Gluten quality parameters, e.g. gluten elasticity, show no clear differences between organic and mineral fertilization.

Contents of **minerals** are about the same with organic and mineral fertilization, but in some cases increased values of calcium, phosphorus, magnesium and potassium have been observed.

Differences between organic and mineral fertilization generally are more pronounced in vegetative than in generative plant parts.

FERTILIZATION EFFECTS ON VEGETABLE

A **lower nitrate content** of organically fertilized vegetable compared to minerally fertilized or conventionally grown vegetable, mainly root crops, is an effect which has been observed quite often (in our experiments, other investigations and a number of literature surveys). That means, this effect occurs rather independent of site conditions, although the absolute amounts of nitrate in products can vary considerably depending on year, variety and crop.

Nitrate accumulation in products is a function of increasing supply of nitrate by fertilization and by mineralization of soil organic matter on the one hand and of reduced availability of assimilates on the other hand. Therefore, the higher the nitrogen availability is (mineral

fertilizer > liquid manure = slurry > manure > compost) and the lower assimilation intensity is (e.g. by **site conditions** and **season effects**) the more the risk of nitrate accumulation rises.

Because of a considerable variation of season and site effects on mineralization intensity that can be controlled only within a limited range high nitrate contents sometimes can also occur with organically fertilized root crops.

Potassium content may be **lower** with organic than with mineral fertilization if potassium supply by the soil and input by fertilizer are low. This may be the case in particular with compost instead of fresh manure application as potassium losses during manure handling can be high.

There is a tendency of **increased magnesium** contents by organic compared to mineral fertilization, but it mainly depends on the magnesium content in manure.

No clear effect of fertilization on **vitamin C** content has been observed.

The **physical characteristics** of surface and tissue of potato tubers has been evaluated with different methods (see below for details). The effects are relatively small. Mineral fertilization, in particular in higher levels, seems to produce softer tissue (resistance against a constant force is lower) compared to manure fertilization. Skin stability (the force which is necessary to penetrate skin) seems to be improved by biodynamic preparations. Further research is necessary (see T1).

In most cases of the German, Swiss and Swedish experiments **storage tests** with complete, undamaged products carried out under optimal storing conditions showed no clear differences between organic and mineral fertilization. In **degradation tests** with cut or grated products under non-optimal storing conditions in most cases organically fertilized vegetables look less decomposed and less changed by microbial attack than minerally fertilized vegetables. Other parameters used in these degradation tests (e.g. dry matter loss, respiration intensity) provide no clear and repeatable differences which probably is because of methodological reasons (see below). In several investigations **darkening** of potato extracts has been lower with organic than with mineral fertilization. Darkening seems to be intensified by higher levels of fertilization.

No clear differences have been obtained in **feeding experiments** with organically and minerally fertilized products . Samples of different cropping systems (organic, conventional etc.) gave more pronounced effects in food preference tests, mostly in favour of organic farming.

PARAMETERS AND METHODS

The **dry matter** content is an important reference parameter, and it is somewhat significant as well to consumers who do not want to buy watery products. Dry matter content

seems to be of a certain importance also to storage ability.

The following minerals are regarded as meaningful parameters of food quality:

- **nitrate**, **potassium**, **magnesium**, **calcium**, **phosphorus** and **chlorine** not only because of their significance for nutrition but also as indicators of plant cell properties and mineral dynamics of the cropping system;
- **sulphur** because of its significance for essential amino acids;
- **manganese**, **zinc** and **selenium** as important trace elements (concerning their relationship to fertilization see T2).

Storage experiments with complete products are useful if carried out according to the standards of organic farming (e.g. without chemical additives etc.). Considering the results obtained so far, the question is whether differences in quality other than extreme ones can be discovered under these conditions. Hence, storage or **degradation** in a **model system** (no complete products, no optimal storing conditions) may be helpful, as more clear differences are observed in such tests. However, concerning the relevance of the test system and the interpretation of degradation tests we had a long discussion of two different views without a final agreement. One group argued that stress behaviour of a product has a ceratin bridge to its quality as food because the ability to overcome an injury or to resist microbial decomposition is an indicator of the inherent vitality of a product. The other group took the position that stress behaviour has nothing to do with storage ability and quality because there is a discrepancy between results of storage losses (weight loss, spoilage) and results of degradation tests in petri dishes.

Supporting the first view (degradation tests basically are suitable quality indicators) the question is by which parameters degradation can be evaluated and what do the results say about quality (see T3)? No final answers could be given to these questions because of the basic disagreement over the role of degradation tests, but some aspects can be reported. The physiological background during degradation and microbial attack is rather unclear. It may be largely influenced by the circumstances of one single test if no standardized test system is used including a definite inoculation with microorganisms. By this means, the degree of microbial attack of a sample, quantified by a standardized scheme, could be a reliable parameter. Physiological parameters like darkening can also be useful, but the reason behind it and its significance for nutrition is unclear. A negative correlation between darkening and potassium content in tubers is not proved by our fertilization trials

The application of **picture creating methods** is a possibility to distinguish samples of different origin. But the meaning of a certain result, a certain picture is not quite clear. A high degree of experience and qualification of a person is necessary to carry out the tests and to interpret the pictures. Numerous samples of the same crop with a well known origin have to be processed in order to get reference pictures, before new samples can be assessed reliably. A commonly accepted methodology for several crops does not exist. Correlations to product components and constituents are uncertain. There is a lack of interpretation of the pictures concerning classical quality standards. Calibrating the pictures with the growth conditions of the crop (light - shadow; cosmic - earthly etc.) seems to be a valuable approach. For further tasks see T4.

Feeding experiments with animals are a suitable method to distinguish food products of different origin. However, fertilization of the crops seems to be only one factor causing different results with the animals, and probably it is not the most effective one. At any rate, products of different cropping systems (fertilization, plant protection etc.) of the Swiss experiment gave more pronounced results than products of the German experiment in which only fertilization is different. According to the present results fertility parameters of the animals do not reflect the origin of food components reliably, i.e. in every case. Possible reasons can be seen in the influences and limits of the experimental conditions (e.g. insufficient number of animals in the test groups, type of food the animals have been used to before the test, effects of the housing system etc.; see T5).

Other tests with relatively high costs and pre-conditions needed are **sensory tests** done by trained people. Carried out without this the tests have only a very restricted message. Sensory parameters are able to reflect quite complex characteristics of a product and, by this reason, are often times a useful and illustrative supplement of the analyses of single components. But it has to be considered that sensory tests are based strictly on product properties and do not reflect the individual surroundings and various expectations of eating.

A method which is rather difficult to perform and to interpret is **photon emission**. The method is possibly helpful in the assessment of physiological characteristics of organisms or parts of them. However, relatively less experience is available gained by few persons at present. Some investigations have been carried out already, but it cannot be decided definitely whether the method is capable to reveal food quality or fertilization effects (see T6).

Food processing is also a field of quality assessment methods, although the criteria mostly are not taken from nutrition. For example, parameters of **baking quality** are not relevant to human health. Besides, they have to be modified if applied to the processing of whole-meal for which these standards originally have not been worked out (see T7). Other parameters which are more meaningful and already developed shall be used, e.g. instead of crude protein, which only responds to late nitrogen supply of the crop, the index of essential amino acids is of greater importance to human nutrition. Nevertheless, the classical tests of baking quality show as a rule that products of organic farming are not inferior to conventional products.

A comprehensive approach to food quality can be to develop **quality indexes**. A weight list of parameters is a more solid assessment than results of one or single tests. The list should be specified for each product and should be based on parameters reflecting farming practices and cultivation techniques. In other words, parameters depending on fixed factors which can not or hardly be influenced by the farmer (like site conditions) are less useful from the agricultural point of view.

TASKS FOR FURTHER RESEARCH

T1: Effects of fertilization (and other cultivation factors) on histological parameters like

tissue strength and skin stability of fruits and vegetables shall be investigated as regards effective analytical methods, physiological background of the parameters and their significance for crop production and nutrition.

T2: As trace elements are constituents of organic matter a better supply with organic than with mineral fertilization may be expected. However, our experiments do not prove this assumption. Detailed experiments on this question shall be carried out.

T3: Effective and standardized test systems for degradation tests shall be developed. This work shall include research on the physiology and microbiology of degradation of vegetables and the relationship between degradation and vitality of a product.

T4: The picture creating methods shall be investigated more intensive and developed as regards the deficits mentioned above.

T5: More effort shall be done to elaborate definite conditions and requirements for feeding experiments with animals as test systems for food quality assessment.

T6: The methodology, application and theoretical background of the photon emission needs further efforts in research and technical development.

T7: As regards baking quality modified or, if necessary, new parameters shall be worked out adapted to whole-meal processing. Investigations shall be carried out whether the current baking technology can be improved in view of the special case of whole-meal products.