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Production of high quality dried products

Combination of microwaves and warm air

Because of increasing quality demands on agricultural products the continuing development and improvement of drying systems is important. Only through fast and gentle drying can the quality aspects of products be retained. The application of microwave energy, especially in combination with conventional systems, offers a possibility of reducing drying times whilst retaining or even improving product quality.

The quality of agricultural products plays a growing role in their marketing. Thus only products which previously have passed through a suitable conserving system to improve product longevity, and which have a uniformly high quality, can be marketed with assurance. The drying of agricultural products as a conservation method has been known for a long time. For fresh products with a high water content of over 80% this method is, however, only applicable within limits in that the appearance and the content of value-influencing components can in part be greatly changed so that the products are no longer acceptable to consumers. Such changes are often caused by a long drying process. Compared with other conservation methods such as, for instance, the deep freeze supply chain, drying offers notable advantages. Especially the packing, the transport and the storing of dried products are considerably simpler to accomplish. Therefore it is important to improve present drying methods or to develop new methods to reduce the drying time whilst retaining inner and outer product quality characteristics. It is possible to apply microwave energy for drying of vegetables or fruit and it is entirely reasonable that such a practice can simultaneously improve product hygiene standards. In order to investigate in more detail the application of such new methods or their combination with other known systems, trials were carried out in the drying of carrots and apples.

Drying methods

All trials were carried out in an experimental plant fully equipped with measuring technology which made possible the recording of all high-frequency and product parameters during the processing. Thus, the product substance and temperature could be continually recorded, an aspect which is imperative for the interpretation of drying experiments.

In order to prevent as far as possible the influences of different samples on the experiment, carrots and apples used were each of a single variety and origin. Alongside microwave drying on its own and the convection drying with which it was compared, more intensive trials were carried out looking at a combination of these methods for possible

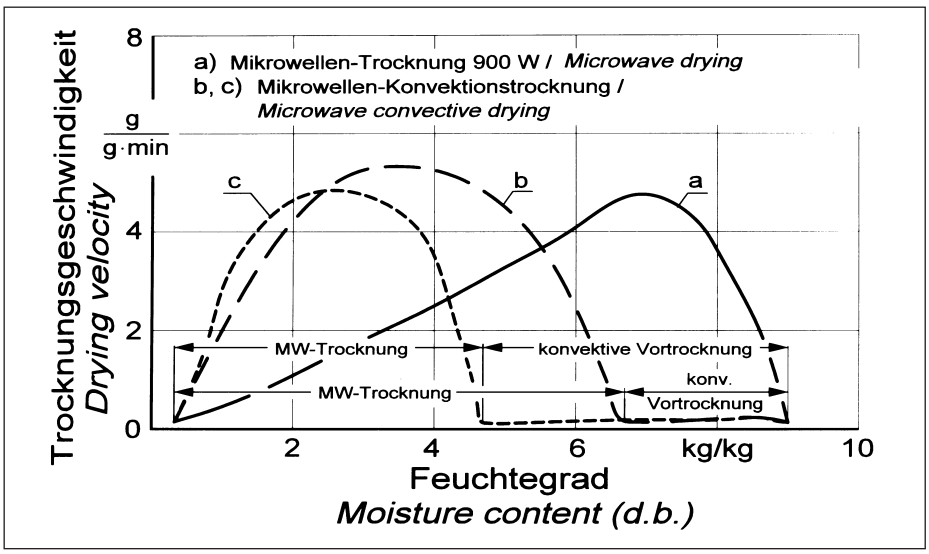

Fig. 1: Drying behaviour of carrot slices (1.5 mm) by microwave drying and microwave drying with convective pre-drying

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Keywords

Microwave, quality, drying

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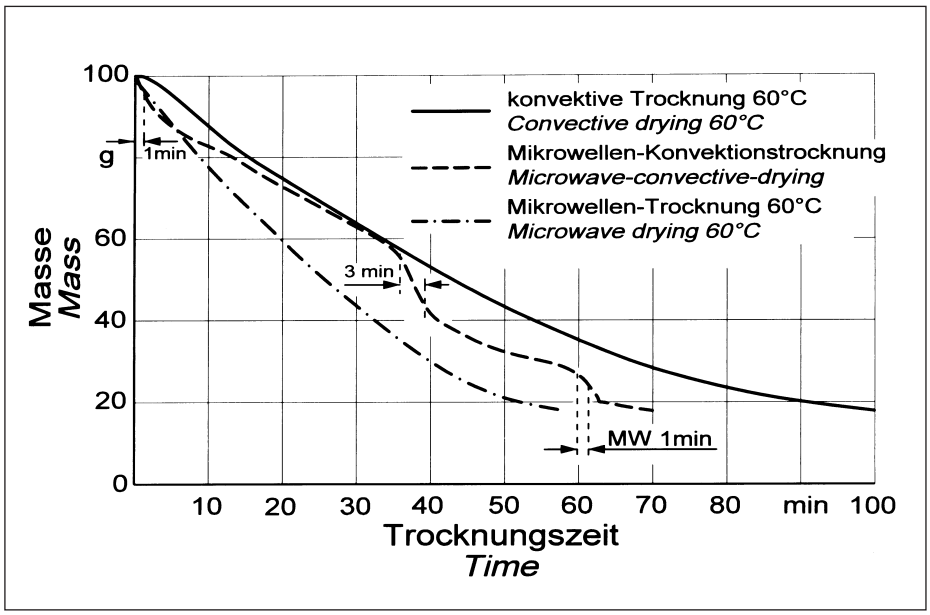

Fig. 2: Drying behaviour of apple slices (3 mm)

synergistic effects. The material for drying was sliced and evenly spread-out on the revolving sample plate. This allowed penetration of microwaves from all sides and also offered a favourable environment for convective drying. In pilot trials, it had been determined that a slice thickness of 1.5 mm for carrots and one of 3 mm for apples gave the best drying results with respect to product appearance.

Drying carrots

The comparison of microwave drying on its own with combined microwave-convective drying is presented in Figure 1. With combined drying, the convective system was used to remove 75% as well as 50% of the initial moisture content. The remaining drying process was then carried out with microwave energy. As can be clearly seen, the drying process does not correspond with the convective drying's three phases [1,2]. There were very high drying speeds of around 5 g/gDMúmin achieved although this speed was progressively reduced towards the end of the drying period. With microwave drying on its own, such high drying speeds led to a drying time of around 10 minutes only. Surprisingly, in the combined drying method with convective pre-drying withdrawing 75% or 50% of the initial moisture content and the remaining drying by microwave, drying speeds achieved were still very high and represented roughly the speeds achieved by the microwave system on its own. This performance is especially impressive because it was achieved after a quarter or even a half of the original moisture had been removed, with the remaining drying more difficult to carry out because of the materials' higher water retention ability [1].

Drying apples

For drying of 3 mm apple slices, convective drying at 60°C was compared with microwave drying on its own also at 60 °C and with a combination of the two. In that microwave drying achieved very high drying speeds with carrots in every drying phase, the combined system with apples featured short applications of the microwaves (1 min at the beginning, 3 min at 50% moisture content, 1 min at 15% moisture content). In between the applications of the microwaves, and in the final drying phase, convective heating was used (*Fig. 2*). Compared with convective drying on its own there was a notable decrease in drying time. It was plain to see from the development of the substance that, with every application of microwaves, the drying speed increased strongly in all drying phases. The reason for the high drying speeds with the microwave application probably lay in the „explosion-like" emptying of the capillaries produced by the fast heating of the product interior [2].

Quality aspects

With relation to the outer quality properties, the carrots dried by microwave or the combined process demonstrated a notably better appearance which was caused in the first place by substantially better colour intensity. This subjective impression regarding the colouring is confirmed by colour measurements. However, when drying carrots it must basically be guarded against that the temperature does not rise over 60 °C in that this can quickly lead to browning in the middle of the slice. It is, however, possible with the combined method to utilise higher temperatures of up to 70 °C after convective pre-drying to 50% of the original moisture content without changes taking place in colouring. In apple drying very little colouring differences were found between the different systems, although the microwave dried and the combined dried variants looked most like fresh apples. With apple drying too, care must be taken that the temperature does not exceed 60 °C in order to avoid surface browning.

An important quality characteristic of products is represented by their rehydration properties. The rehydration value (R-value) is a measurement of the moisture content which can be achieved when soaking of dried products takes place under defined conditions, (50°C water temperature, 15 min treatment time). The R-values vary with one another only to a very small extent with the different treatment methods, although with convectively dried apples slightly higher remoisturisation was possible compared with microwave drying, despite a stronger hardening of the surface with the former.

Analyses of the contents showed that the vitamin C content was substantially reduced by all drying processes with apples and carrots. Especially with the carrot slices convective drying resulted in least reduction of vitamin C. Microwave drying on its own showed, on the other hand, the greatest loss. The same tendency was noted with the apple slices whereby, however, the difference between the individual treatment methods was notably less marked. The content of saccharose, glucose and fructose was hardly changed by all the treatments. This was also affirmed by lack of browning on the products which is caused by the non-enzymic Maillard Reaction of glucose and fructose. Comparing the dried products with fresh material, it could also be determined that there was no change in protein content nor in amino acid composition. It has also been demonstrated with other products that quality characteristics are not reduced through application of microwave energy [3, 4, 5].

Conclusion and outlook

The use of microwaves for drying plant products presents a possibility of producing high quality food materials. Especially concerning the appearance of the product, a very important quality characteristic, microwave drying offers an improvement compared with convective drying, without any reduction in value-influencing components. The internal heating due to the action of the microwaves leads to very short drying times so that material changes that could affect the quality are quickly controlled. The combination with the conventional drying method represented an especially interesting starting point for the production of high value items from the processing as well as the quality aspect. However, care must be taken that each drying technique is matched to the appropriate product.