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Topic 2 - Product and process quality in Organic Agriculture: methods and challenges

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DEVELOPMENT OF SUSTAINABLE DRYING STRATEGIES FOR BEEF DRYING

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Abstract: *Organic food is regarded as more sustainable compared to other processing forms, however, usually only the production on farm is considered and not the postharvest processing steps. Often, food processing steps do not differ in organic processing compared to conventional food processing which could impact the quality and the sustainability of the product. Innovative approaches that focus on individualized processes by non-invasive measurements during processing, could enable improvements for both product quality and sustainability. In this study the usability of hyperspectral imaging in terms of drying of salted beef samples was investigated. Beef slices were dipped in salt solution and dried at 50, 60 and 70 °C. The question was if it is possible to build prediction models for moisture content (MC) and colour parameters, although the drying behaviour is different. The results indicate the possibility for implementing non-invasive product monitoring during processing to enable individual and therefore sustainable processes.*

Introduction: Consumers expect organic produce to be produced in a sustainable way with less environmental impact compared to conventional produce. However, usually, sustainability on farm is regarded and less the postharvest side such as processing and packaging. Organic regulations focus mainly on the production on farm rather than on the organic food processing, like for example the EC. Further, organic associations require gentle handling but provide no clear definitions on how to achieve this.

Drying is an important preservation method for food to guarantee long shelf life and avoid post-harvest losses. However, 15-25 % of the industrial energy demand is required for drying processes and efficiency in food drying is observed with 35-45 % which leads to high energy demands related to the product outcome (Mujumdar, 2007). On the other hand, inefficient drying can lead to reduced quality of the final products regarding sensorial and nutritional value, stability, etc. To gain more efficiency, processors need to be aware of the changes inside the product to know exactly when the process should be stopped or to control drying parameters during processing. Product related drying was already observed to obtain increased product qualities and process efficiencies (Sturm 2014). Invasive product measurements to observe product parameters are usually destructive, interrupt the processing and could risk the safety of the final product. Spectral measurements can be used as a basis for non-invasive measurements since spectral data can be correlated to product parameters during drying (von Gersdorff et al., 2018) and therefore enable measurement of product parameters in real time, which can further result in so called smart drying systems since the process is directly controlled by the changes inside the product.

Beef is an inhomogeneous product and processing leads to changes which are less controllable in the organic sector than in conventional processing due to restrictions in preservatives. Therefore, robust models that are valid for different processing conditions are mandatory to develop sustainable and efficient drying techniques for beef.

Material and methods: For each drying temperature, the roast beef (longissimus dorsi) of four cattle of Uckermarker breed was used to gain four repetitions of each temperature. The beef was shock frozen and stored at -18 °C until use. Prior to drying it was thawed and sliced into slices of 5 mm thickness (Graef, Allesschneider Vivo V 20, Germany) and cut with a knife into pieces of 50 x 50 mm^2. The slices were dipped into a 10 % salt solution (m/v) and stored over night at 2 °C. The drying took place in an electrical convective tray dryer (HT mini, Innotech Ingenieursgesellschaft mbH, Germany).

There were several measurements conducted to the samples before the salt pre-treatment, after the storage period overnight and during the drying process. During drying the measurements were applied every 20 minutes during the first hour of drying, every 30 min during the second hour of drying and hourly until a moisture content (MC, wet base) of 15-20 % was reached. To calculate the final moisture content, the samples were dried at 105 °C for 24 hours. The moisture ratio (MR) was calculated for a better comparison of the drying behaviour.

The measurements were weighing the slices with a balance (lab scales, E2000D, Sartorius, Germany), CIELab measurements of L a* and b* values with a chromameter (CR-400, Minolta, Japan) at three points to calculate average values and further calculate the total colour change ∆E. To gain the spectral data, the beef slices were imaged with a hyperspectral imaging camera (ImSpector V10E PFD, SPECIM, Finland) that was connected to linear translation stage (SPECIM Spectral Imaging Ltd., Finland). The images were taken with a 35 mm lens (Xenoplan 1.9/35, Schneider Optische Werke GmbH, Germany), the tray with a distance of 27 cm below the lens moved with a speed of 8 mm/s which resulted in the capturing of spectral data of 400 – 1010 nm in 1.5 nm increments. The data was processed with the Matlab software package (Matlab R2013a), detailed information can be found in von Gersdorff et al. (2018). The analysed relative reference data as well as the measured MC and CIELab values was then used to build PLSR (partial least square regression) prediction models with Rstudio software (Rstudio, Inc., 2011), 70 % of the data was used to build the model, and the remaining 30 % were used for model validation.

Results: As expected samples dried at 70 °C dried faster than those dried at 50 or 60 °C (Fig. 1a)). However, there is hardly a difference visible between samples dried at 50 and 60 °C. Fig 1 b) shows clearly that there is a difference in the development of colour for beef slices dried at different temperatures. After the pre-treatment with the salt solution and storage overnight (MR=1), the change was very small. Until a MR of 0.5 a difference is hardly visible between the three heat treatments. However, with decreasing MRs, salted beef slices dried at 50 °C show a total colour change ∆E that is different to samples dried at 60 or 70 °C which indicates that long processing times impact the final quality of a product. The curves of ∆E for beef dried at 60 and 70 °C differ after a MR of 0.3 is reached that might be due to increasing denaturation of muscle colourants induced by higher temperatures. After the drying process, the lowest ∆E can be observed for beef slices dried at 60 °C and show that both, too high and to low air temperatures impact the final product of drying processes.

Fig. 1: Development of a) moisture ratio (MR) as a function of time and b) development of ∆E as a function of MR of salted beef slices dried at different temperatures.

The observations show clearly that the drying air temperature impacts the drying behaviour of beef. However, it was possible to build PLSR models to predict the parameters MC, L, a* and b* on the basis of the spectral reflectance independent of the drying temperature (Fig 2 a)-d)). The high R^2 indicate that the prediction models fit well which is supported by very low root mean square errors (RMSE). For MC the RMSE is 6.138, for L 1.907, for a* 1.813 and for b* the RMSE is 0.977.

Fig. 2: Measured vs. predicted MC, L-, a*- and b*-values gained from PLSR models build for salted beef slices dried at 50, 60 and 70 °C.

Discussion: The results show clearly that the temperature impacts the drying behaviour and the colour change of salted beef samples during drying. Therefore, it was not clear if it is possible to use the non invasive technique of hyperspectral imaging to monitor the parameters MC and colour during the drying process. MC is important to secure a shelf stable final product, but also influences the chewiness and together with the colour (L, a*- and b*-values), which represents a main parameter for the product appearance, might impact the consumers preference or buying decision. However, MC and colour can also be used as control parameters during processing. The results of the PLSR clarifies that independent of the drying temperature a single prediction model can be used for each parameter which allows the development of spectral techniques to monitor and control the process in an advanced way based on the monitoring results which will enable the increase of the product quality by avoidance of over drying or insufficient drying. Furthermore, process efficiency will be increased since the processing stops not after a certain time but when the product reached the required final moisture content. Non-invasive measurements further provide the possibility to develop smart drying control systems in that real-time monitoring produces data that directly feeds back into the control of the drying process. That enables individual drying processes which take both the raw material as well as the individual changes during processing into account to increase the efficiency and therefore the sustainability of beef drying processes.

Conclusions: The study shows that despite different drying temperatures, it is possible to build accurate prediction models that enable the application of hyperspectral imaging for the non-invasive monitoring of beef drying processes. This enables the implementation of smart drying applications which will use product parameters to develop individual control strategies for each drying process. Future work might focus on wavelengths selection to develop simpler models based only on a few wavelengths to predict quality parameters and thus to enable simple and low cost applications that are also applicable for farmers and SMEs. Smart drying applications will help to increase product quality and process efficiency and will expand the idea of sustainability of organic farming also in the processing of organic products and will put the organic sector into a pioneering position.

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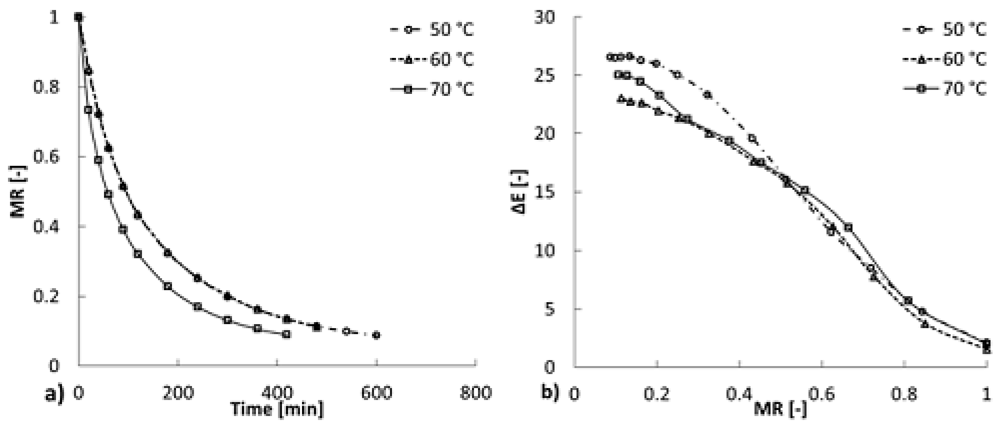
Image 1:



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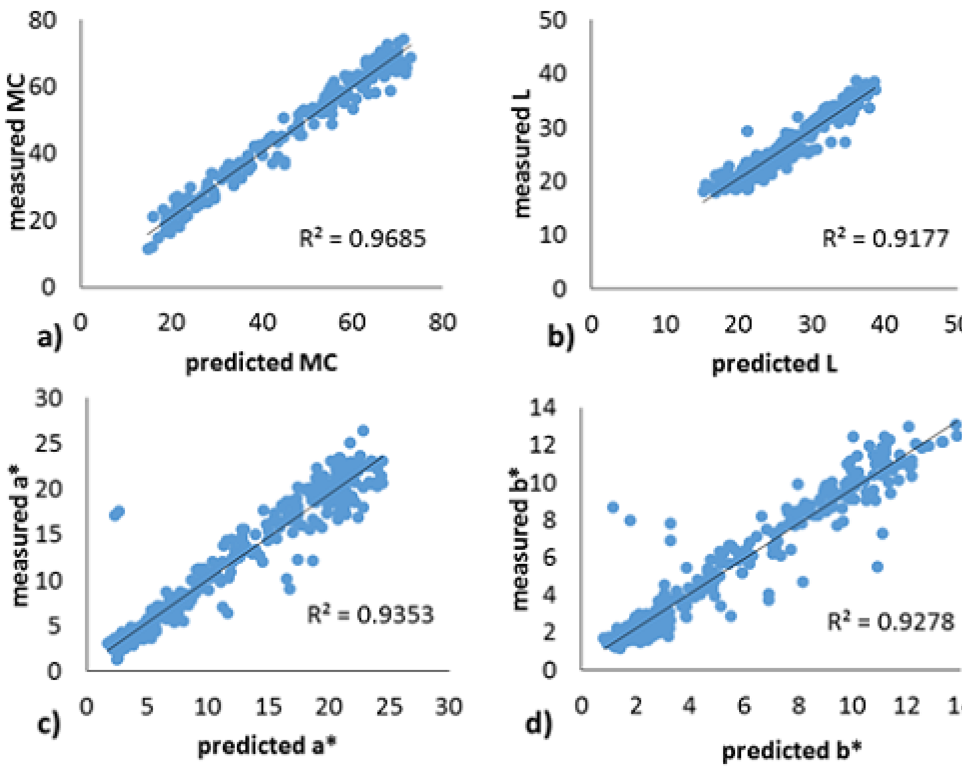

Disclosure of Interest: None Declared

Keywords: beef drying, hyperspectral imaging, PLSR, product monitoring