ANALYSIS OF DIFFERENT FLUID DYNAMIC AIRFLOW PATTERNS IN RIPENING CHAMBERS

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Background

Due to quality and safety issues the ripening phase is the most critical stage in the process of producing dry sausages. In contrast to the traditional ways of manufacturing, dry sausages nowadays are ripened and dried in modern multifunctional chambers under defined conditions (temperature, relative humidity, airflow velocity, etc.) and a defined period of time, which depends on the product [1]. However, one of the main issues in the design and operation of modern ripening chambers is to achieve a homogeneous drying flow over the chamber length and height and knowledge about it's influence on the ripening process from an engineering point of view. In spite of several innovations regarding the influence of ripening conditions on the main chemical and microbiological characteristics [2, 3, 4, 5], very few research has been done about the influence of fluid dynamics inside a ripening chamber [6]. The importance of a homogeneous airflow during the drying process is mentioned [3, 4, 5] but none of the references dealt with the allocation of the air velocity in the chamber, especially in the space between the sausages.

Objectives

In this project a method for quality maintenance in dry sausage production through the analysis of airflow patterns in ripening chambers is investigated. Therefore, a method of measuring the air velocity during the regular production in ripening chambers was developed. This study compares the effect of different airflow directions in a newly developed type of ripening chamber.

Methods

Ripening chamber

Conventional ripening chambers work on a basic principle: Inlet air flow enter the chamber via two separate nozzles batteries, located at both sides of the ceiling. A rotary valve periodically varies the amount and ratio of air exiting the two feeding ducts. The inlet air flows descend vertically along the side walls and are diverted at the chamber bottom into a horizontal flow. Both jets merge over the bottom. The merging point is shifted periodically over chamber width by the variation of the ratio of the air inlet flows between both sides. In the following upward zone the air stream flows through the sausages towards an exhaust channel located on the ceiling midsection.

In this flow type, dry air gets transported to the lower chamber areas with high velocity. Passing the sausages, the flow decelerates and due to water transfer from the sausages the saturation level of the humidity rises simultaneously. This results in an inhomogeneous drying over the height of the trolleys.

For this reason, a new type of ripening chamber (Ness & Co. GmbH, Remshalden, Germany) was developed, which uses two additional inlet nozzles batteries installed horizontally (Fig. 1). The airflow here is also distributed periodically between the two feeding ducts by a valve. The jets merge in the headspace and pass the sausages from the top to the bottom of the rack. Afterwards the air stream flows along the floor towards an exhaust duct located at the bottom of the left side of the chamber. Through a periodic change between these two flow types (vertical and horizontal), drying errors can be avoided. This chamber contains 60 trolleys (three in a row) loaded with 12 tons of sausages in total.

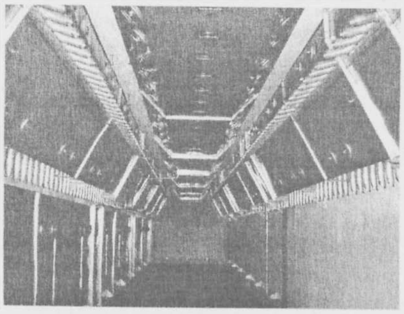

Fig. 1: Newly designed ripening chamber with horizontal and vertical inlet nozzles batteries

Measurement of air velocity

The air velocity was measured with a air velocity transducer (Model 8455 TSI Inc., St. Paul, USA). Three sensors were fixed to a square steel bar at intervals of 20 cm (Fig. 2). Three of these bars were hanged in a trolley at different levels (bottom, middle, top). The data were recorded by a data acquisition unit (HP 34970A Hewlett Packard, USA). By averaging the measurements of each level, the reliability of the measurement was increased. The trolley with the sensors is placed in different positions inside the chamber, in the case shown here, in the left position in the second row.

The inlet airflow velocity was measured with a sensor placed in a tube attached to a inlet nozzle in airflow direction. To avoid flow profile disturbances the distance between inlet of the tube and sensor had to be at least 7.5 times the tube diameter (Fig. 3).

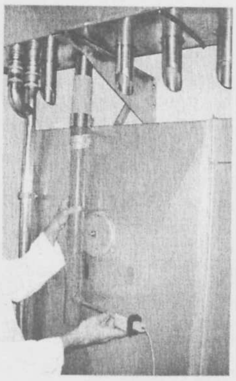

Fig. 3: Tube with sensor for measuring the inlet air flow

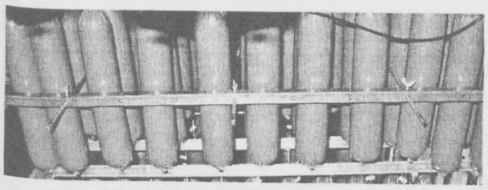

Fig. 2: Attachment of the sensors for measuring the airflow velocity

Results and discussion

In the diagrams (Fig. 4, 5) a comparison between vertical (a) and horizontal (b) air injection is made. The direction of the airflow can also be seen in the two diagrams. For horizontal inlet air flow the velocity in the top level of the trolley is the highest and decreases towards the bottom, while it is vice versa for vertical inlet flow. The values of the air velocities in the different levels were higher in horizontal than in vertical flow. This can be explained by the fact that the distance between the nozzles and the product is smaller for the horizontal inlet condition. For vertical inlet the air has to be redirected twice before coming in contact with the product, which indicates a large loss of kinetic energy. Furthermore the differences between the velocity values of the several levels are larger for horizontal flow.

The vertical flow velocity in the trolleys is minimal, when the inlet airflow velocity is at it's maximum value and vice versa. The motion of the rotary valve can be identified in the curve of the inlet velocity. The rotation of this valve is adjusted so that at the bottom dead center the inlet velocity is still 6 m/s.

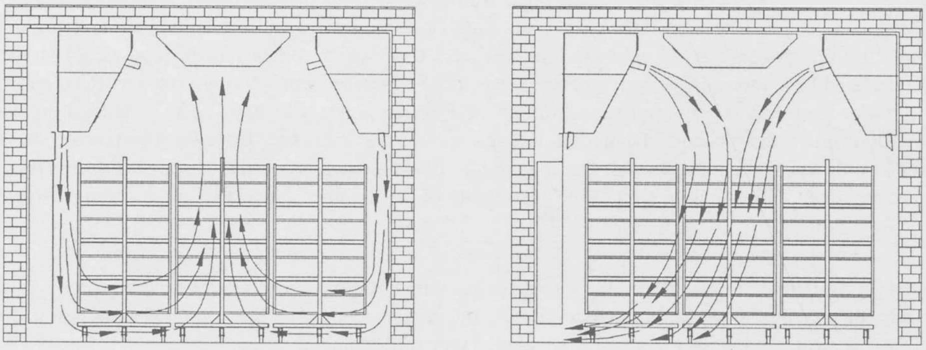

Fig. 4: Vertical (a) and horizontal (b) inlet airflow

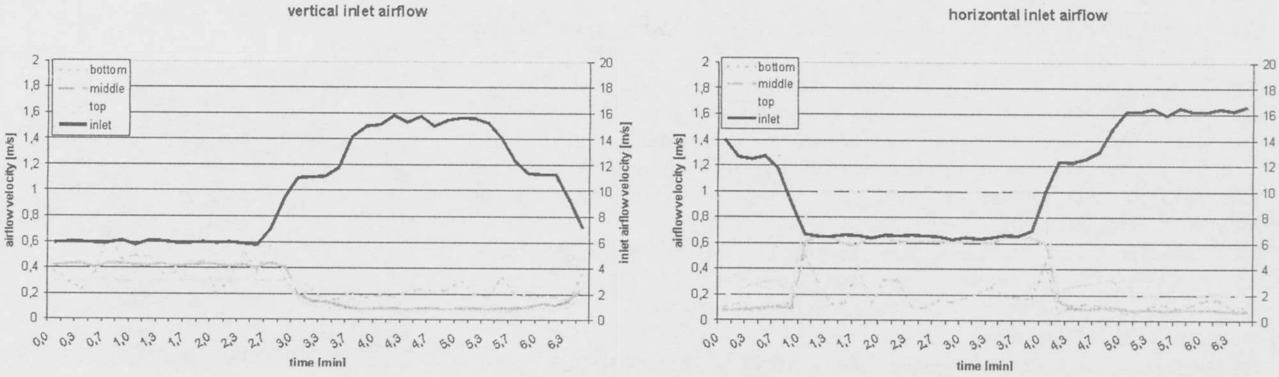

Fig. 5: Comparison of vertical (a) and horizontal (b) inlet airflow

For these reasons the periodic change from horizontal to vertical inlet airflow is an adequate means to supply all levels of the trolley with the same air velocity. This indicates, that it is possible to achieve a homogenous drying in the whole chamber.

Conclusions

The air flow patterns in ripening chambers are investigated by measurement of the air velocity during regular production. A comparison of horizontal and vertical inlet flow in a new type of ripening chamber has shown higher velocities for horizontal inlet airflow. The differences of the airflow velocity between the several levels were higher. The problem of a inhomogeneous drying by not reaching the upper areas of the trolleys with dry air in vertical flow has demonstrable been improved by this new way of air flow guidance.

Acknowledgements

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