The foodtexture puff device used to monitor the effect of electrostimulation on rigor mortis development

F.R. BAMELIS, V. MOLENAAR and J.G. DE BAERDEMAEKER

Kasteelpark Arenberg 30, B-3001 Heverlee, Belgium
Tel ++32 16 328593 Fax: ++32 16 321994
*Corresponding author: flip.bamelis@biw.kuleuven.be

The introduction of industrial methods of meat production and marketing leads to a demand for an automated in-line quality monitoring system in order to keep up with consumer demands. To monitor rigor mortis development during the slaughter process of poultry, only an optical approach has been reported. Recently, a novel technique was developed to measure the stiffness of semi solid foodstuffs, called the Foodtexture Puff Device (FPD). This non destructive, non contact and fast technique generates a deformation of the material using an air puff and measures this deformation using a laser system.

In this research, the ability of the FPD to monitor the development of Rigor Mortis in poultry meat is tested. Therefore, 24 carcasses from 3 flocks were measured hourly during the first 8 hours post mortem. One measurement was repeated 24 hours post mortem. Half of the carcasses from each flock were electrostimulated.

From the results it can be seen that the measured deformation features decrease with developing rigor mortis. This decrease is faster in the group of electrostimulated carcasses. However, at 24 hours post mortem, no differences were found anymore between the two different treatments. Besides these major differences caused by the different treatment of the carcasses, minor differences were found between different flocks.

It can be concluded that the FPD is a useful tool for monitoring the rigor mortis development in poultry meat. It can be of use for inline application during the slaughter process as a grading tool for carcass quality and/or as a tool to estimate the process quality.

Keywords: Rigor Mortis Development, Foodtexture Puff Device, online monitoring

Introduction

With the introduction of industrial meat processing plants, the demand for automated quality measurement techniques to evaluate the different quality aspects of the processed meat has grown. For the pork industry, several devices exist like the spectroscopic techniques to measure pH (Anderson et al., 1999) or to predict drip loss (Forrest et al., 2000). Even measurements techniques for body composition (e.g. lean meat proportion and muscle/fat ratio) on pigs alive were developed (Romvari et al., 2005).

However for the poultry industry, the research that has been published on using non destructive quality aspects is a technique to monitor rigor mortis development by Cavitt et al. (2003). Digital images of slaughtered chickens were analyzed and relationships between wing movements and chemical indicators for rigor mortis development were investigated. Elbow distance was positively correlated with the pH of the pectoralis. This might be useful to estimate the development of rigor mortis, for differences caused by electrostimulation.
Recently, the Foodtexture Puff Device was introduced as an instrument to measure tenderness of agricultural processed products like cheese and coagulated milk (Bamelis and De Baerdemaeker, 2006). This device generates an air puff that is directed perpendicular to the surface of the tested sample. The deformation of the sample is registered by a laser system. Hence, this system is non-contact and hygienic. Moreover, the measurements can be done very fast. This device seems to be suitable for repeated laboratory measurements or even for in-line applications.

In the presented research, the possibility is investigated to monitor the rigor mortis development in poultry meat using the FPD. This was tested in an experiment with different post mortem sample treatments, like the application of electrostimulation.

**Material and methods**

**The Foodtexture Puff Device (FPD) measurements**

The FPD generates an air puff of 6 bar nozzle pressure during 50ms that is directed towards the surface of the chicken breast using an air nozzle. The end of the nozzle is placed 4cm above the skin (see figure 1). From the moment that the air puff is generated, the deformation of the surface is recorded by a laser distance sensor during a period of 190ms after the excitation of the surface. The deformation data are sent to a PC by a data acquisition board (E-6024, National Instruments®, Zaventem, Belgium). Here, four different characteristics were calculated from the registered signal, i.e. the downgoing slope, the total deformation, the upcoming slope and the rest value (see fig 2). This was four times repeated and the mean value of the last three measurements were stored on the hard disk for further analysis. The measurement head was constructed by LET nv (Deinze, Belgium). This equipment is described more in detail by Bamelis and De Baerdemaeker (2006).

![Figure 1: The measurement head as used in the here discussed texts.](image_url)
Figure 2: Deformation measured by the Foodtexture Puff Device. The calculated characteristics are indicated on the figure. The full line represents a measurement just after slaughtering (15 minutes), the dotted line 375 minutes post mortem.

Materials
From three different flocks, 8 carcasses were randomly selected in a commercial slaughterhouse giving a total of 24 tested carcasses. During slaughtering, four of these got an electrostimulation. The electrostimulation was done using a commercial electrostimulator provided by Stork PMT (Boxmeer, The Netherlands). Once eviscerated, the carcasses were picked off the automated slaughtering line and stored in a refrigerated room (+5°C). During the storage, each carcass was measured with the FPD 15 minutes after slaughter and then every hour until 375 minutes post mortem and at 8 hours post mortem.

Figure 3: Biplot of PC1 and PC2 for the Principal Component Analysis.
**Statistical analysis**

A principal component analysis was applied to the measured parameters. For this dataset, two principal components were able to explain 99% of the variance. The first component alone explained 77% of the total variance. The biplot of these two first principal components is presented in figure 3. It can be seen that the first principal component is mainly correlated with the total deformation and both slopes, and the second component with the rest value after relaxation of the breast meat. The Principal Component Analysis was carried out using the Matlab 6.1 software.

Differences of both principal components for the different subgroups in this experiment were tested using a General Linear Model approach. This analyse was done in the SAS 6.12 software.

**Results**

In figure 4, the post mortem evolution of the first principal component can be seen for each flock-treatment combination in this experiment until 375 minutes post mortem. In general, a decrease of this value was noticed. Moreover, differences between the stimulated and the non stimulated carcasses were significant. From the first measurement onwards, the PC1 value of the stimulated carcasses was smaller compared with the non stimulated ones. This difference remained significant until 315 minutes post mortem. At 375 minutes post mortem and 24h post mortem (the latter values are not in presented in the graph), no significant differences were found between the two different treatments. Also, for the second principal component, no meaningful differences were found for the different subgroups in this experiment.

![Figure 4: Evolution of the first principal component. Means for each flock and treatment are given. Full lines are non stimulated carcasses, dotted lines are stimulated carcasses. Significant effects of treatment fore each measurement time are indicated (** p<0.01 and *** p<0.001). ES: electrostimulated carcasses, NES: not stimulated carcasses.](image-url)
From figure 3, it can be seen that a decreasing PC1 value corresponds with a smaller maximal deformation. Hence, during the development of rigor mortis, the maximal deformation reduced. This reduction was found to be larger in electrostimulated chicken carcasses, compared to not electrostimulated carcasses.

Discussion

Just after death, rigor mortis will develop due to the depletion of energy and the breast muscles become stiff (Sams, 1999). As reviewed by Cross (1979), electro stimulation of the slaughtered chicken meat will accelerate the ATP depletion, enhancing the rigor mortis development. It will also tenderize the meat by physical disruption of the muscle fibres and enhancing the action of endogenous proteases. For poultry, two electro stimulation techniques are available. The first type will stimulate the muscles only moderately to enhance the formation of rigor mortis. By applying the second type, a more severe contraction of the muscles is realized inducing small tears in the muscles (Sams, 1999). The technique applied in the presented research induced moderate contractions of the muscles, resulting in an enhanced formation of the rigor mortis.

The Foodtexture Puff Device (FPD) detected a post mortem decrease of the maximal deformation after excitation the breast filet of a slaughtered chicken. A faster decrease was found in electrostimulated carcasses.

The rigor mortis developments just after slaughtering are reflected in the results of this experiment. The decreasing maximum deformation (or first principal component) might be an indicator for the state of rigor mortis. Since rigor mortis will develop faster in the stimulated carcasses and an enhanced decrease of the total deformation was registered by the FPD in these carcasses, this hypothesis is confirmed.

The FPD can be a suitable device to monitor the formation of rigor mortis in poultry filets. The advantage of the technology is its non destructive nature and contact less measurements. Hence, repeated recordings in the time on the same subject can be made which is of interest for laboratory use. Moreover, the measurement is fast. This opens the possibility to apply the technique inline in automated slaughter chains.

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References
