Automated pork belly firmness evaluation as affected by temperature and multiple bends

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Objectives: 1. To determine the effect of temperature on degree of belly bend on an automated conveyor belt system for industrial applications. 2. To determine the interactive effect of multiple bends and temperature on degree of belly bending from the research point of view.

Materials and Methods: A conveyor belt system consisting of three motorized conveyor belts (Intbuying Inc., China) was construct- ed. Maximum speed (approximately 22 m/min) was selected. Bellies were placed posterior end first on the feeder conveyor (A), and the inclined angle was 16°. When the belly passed conveyor A, firmer bellies would fall on conveyor B (pick-up conveyor, inclined angle: 2°; 28 cm from A), intermediately firm bellies were expected to bend before reaching B, and fall on conveyor C (pick- up conveyor, inclined angle: 5°, 13 cm below and 22 cm distant from A), and the softest bellies would fall into the gap between conveyor A and C. Over approximately 5 months, 94 rib-in, skin-on pork bellies were collected. In study 1, 70 bellies were divided into three temperature groups 4°C (n=23), 2°C (n=23), and -1.5° (n=24). Bellies in each group were well mixed based on the various firmness levels. Each belly was only bent once on the conveyor belt system. In study 2, 24 bellies were well mixed based on firmness level. Bellies were stored at 4°C for 24 h, bent 10 times on the conveyor system, further chilled at 2°C and -1.5°C for 24 h and bent 10 times following each cooling period. In total, bellies for the multi-bend study were bent 30 times. Three black pins were placed on the side of each belly, at the posterior end, anterior end, and at the bend site, 24 cm from the posterior end. Belly width was measured at posterior end, middle point, and bend site. The length, thickness, and total weight of each belly were re- corded. Deep lean temperature of the pectoralis profundus was measured. Videos of the belly movement were taken using a digital monochrome camera (Canon EOS Rebel T2i/550D. Canon Inc., Japan). By scaling the pixels to coordinates through PyCharm, the location of coordinates was converted into bending angle. The iodine value (IV) of subcutaneous fat sampled from the cranial end of the belly was calculated (AOCS, 1998). Proc Mixed by SAS 9.4 was used to determine the effect of three temperature settings and multiple bends on bend angles. For study 1, using IV, three width measurements, overall length, total weight, and thickness, stepwise regression, based on maximum R^2 was performed for indications of measurements that most strongly contributed to angle estimations, and when combined, the best achievable estimation.

Results and Discussion: For study 1, the mean separation results indicated temperature presented a significant effect ($P<0.0001$, SEM = 8.18) on average bending angles: 140.58°, 149.74°, and 173.96° at 4°C, 2°C, and -1.5°C, respectively. As temperature de- creased, the degree of belly bending tended to be reduced. For study 2, bending angles ranged from 138.27° to 127.30° at 4°C for ten bends (bend 1 to 10) in total. No significant angle change ($P<0.05$) was observed after the third bend (131.86°), compared to 138.27° at the first bend. Similarly, bending angles ranged from 146.78° to 135.64° at 2°C for bends 11 to 20. A significant change ($P<0.05$) was determined from the fourteenth bend (139.65°), compared to 146.78° at the eleventh bend. At -1.5 °C, the bending angles ranged from 179.43° to 171.09°, and there was no significant effect of multiple bends on bending angles ($P>0.05$). Stepwise regression analysis for study 1 indicated that IV significantly ($P<0.05$) contributed to the explanation of variation in bending angles at all three temperatures. For 4°C, addition of mid-point belly width increased model R^2 by 0.1 (R^2 = 0.77) from using IV alone (R^2 = 0.67) and the model fit C(p) improved from 6.84 to 0.51. At 2°C and -1.5°C, only IV significantly ($P<0.05$) contributed to the regression relationship with R^2 of 0.60 (C(p) =4 .59) and 0.18 (C(p) = 1.20), respectively.

Conclusion: The present study suggested the automated conveyor system may be able to classify bellies based on various firmness levels. At lower temperatures the degree of bending may be less, and multiple bends may not change bending angles. Additionally, IV may contribute to the belly bending angle.

Reference:

AOCS. (1998). Official Methods and Practices of AOCS (5th ed.). Champaign, IL, USA: American Oil Chemists' Society.

Key words: Pork, Belly, Firmness, Automation, Conveyor