Advances in Natural Science
Vol. **3**, No. **2**, **2010**, pp. 170-176
www.cscanada.net

ISSN 1715-7862 [PRINT]
ISSN 1715-7870 [ONLINE]
www.cscanada.org

The 3rd International Conference of Bionic Engineering

Study on the Application of Biological Tactile in Fast Meat Freshness Detection[1]

TONG Yue-ying[2]

CHEN Dong-hui[3]

SHI Zhi-biao[4]

LEI Li [5]

TONG Jin[6]

Abstract: The author aimed to explore the application of biological tactile in fast non-destructive meat freshness detection. Used WDW-20 electronic universal testing machine, surveyed chicken, pork and beef the pressure characteristic curves, analysed respectively the relationship between the pressure characteristic curve parameters and the meat freshness. The author also analysed the relationship between the shape of pressure characteristic curve and the meat freshness. The results indicated that in the meal pressure characteristic curve, the curve shape and a number of mechanical parameters could reflect its freshness. Also, different types meat had different structures led them to the different mechanical properties; different types of meat characteristic curves, the meat pressure characteristic curve shape and parameters reflected their fresh meat differently. Biological tactile can evaluate meat freshness in a few seconds. This is a promising, economic, simple and practicable way of fast meat freshness detection.

[1] **This project was supported by the National Hi-tech Project (863Project) (Grant no. 2009AA043603-4 and 2009AA043604-2), the Key Project of Science and Technology Research of Ministry of Education of China (Grant no. 106061), the National Key Technologies R&D Program (Grant no. 2006BAD11A08), the National Science Fund for Distinguished Young Scholars of China (Grant no. 50025516), and the "985 Project" of Jilin University.**

[2] Associate Professor, PHD, The Key Laboratory of Terrain-Machine Bionics Engineering, Ministry of Education, China; College of Biological and Agricultural Engineering, Jilin University, Nanling Campus, 5988 Renmin Street, Changchun 130025, P.R. China. Research Interests: Biological material mechanics and agricultural products quality technology.

[3] The Key Laboratory of Terrain-Machine Bionics Engineering, Ministry of Education, China; College of Biological and Agricultural Engineering, Jilin University, Nanling Campus, 5988 Renmin Street, Changchun 130025, P.R. China.

[4] School of Energy Resources and Mechanical Engineering, Northeast Dianli University, Jilin 132012,P.R.China.

[5] College of Biological and Agricultural Engineering, Jilin University, Nanling Campus, 5988 Renmin Street, Changchun 130025, P.R. China

[6] Corresponding author, Professor, doctoral supervisor, The Key Laboratory of Terrain-Machine Bionics Engineering, Ministry of Education, China; College of Biological and Agricultural Engineering, Jilin University, Nanling Campus, 5988 Renmin Street, Changchun 130025, P.R. China. Research Interests: Biological material and agricultural bionics engineering.

* Received 18 April 2010; accepted 7 July 2010

Key words: Biological tactile; TVBN; Pressure Characteristic curve

1. INTRODUCTION

Human demand for poultry meat is not only because the requirement for rich protein and fat (ZHAO, 2004), but also meat has a delicacy taste as well as it can provide more human nutrition and healthier body, has caused meat become an essential part of the everyday diet. The meats have high nutrition, the suitable microorganism grow and reproduce, thus very easy go bad. The freshness level of meat begins to drop right after the poultry being slaughtered. The meat freshness affects its nutritional value. People who eat un-fresh meat can cause the food poisoning, light vomit, diarrhea, even death (ZHAO, 2004). Along with living standard increasing, the people are more and more strict to the fresh meat health quality requirement, to ensure the meat safety, we must understand the freshness of meat, and the examination meat freshness has become an important issue. The content of TVBN is an important index to evaluate poultry freshness. The freshness decrease with TVBN increases. Chinese National Standard GB16869-2005 regulates that the value of TVBN must less than 15 mg/100g for all fresh meat.

The meat freshness detection methods are various. There are many ways to test the freshness of meat. Conventional testing method is divided intosensory testing, physical testing and microbiological testing. Sensory testing is mainly by observing the color of meat surface, touching the meat surface to determine the dryness, moisture and viscosity degree, pressing the muscles to determine the elasticity of meat, sniffing the smell to determine whether it has gone bad, observing the transparency and the fat drop size of broth after boiling, sniffing the smell, to finally make a comprehensive determination according to the test results. This method is easy generally, it can reflect the objective situation and also allow us to draw a conclusion in time. Sensory test indicator is one of the state regulation indicators which are used to test the freshness of meat, this is the most basic test method. However, the result of sensory test is hard to quantify and it has subjective one-sidedness, even if the inspectors have enough experience, in many cases it is hard to draw a precise conclusion, it still needs the laboratory test. Although physical examination (including volatile basic nitrogen test) and microbiological examination has many ways, they are all laboratory tests, the testing process is cumbersome and it needs specialized equipments and professionals to operate, moreover, the test needs a long time, it is difficult to achieve an on-site rapid test (TONG et al., 2010).

In the recent ten years, some domestic and foreign experts devoted to use electronic nose (Tiina, 2006; HUANG et al., 2004), electronic tongue (Bae & Cho, 2002), and other electrical instruments to examine the freshness of meat. The operation of electronic nose is simple and fast, the sample does not need pre-treatment and it does not need any organic solvent to carry on the extraction either, therefore the electronic nose is a green analysis technology (ZHANG, 2005) which can protect the environment and also is not harmful for the operator's health. At present the problem of sensor drift has not solved, so electronic nose cannot adapt to the long time continued operation in the industry (ZHANG &TONG, 2005). The greatest advantage of electronic tongue is having the target. It can get corresponding information from the different sensory attributes of the solution. However, electronic tongue also has some insufficiencies, for instance, the manufacture process is complex, the reproducibility of electrode is poor, the service time is short (LIN, 2008) and so on.

For many years, the people continuously have looking for a way which can be widely used and can examine the freshness of meat fast, accurately and conveniently.

The reported work in this article is the author's inspiration from sensory test (TONG et al., 2007). From using biomimetic tactile to quickly measure the elasticity and other mechanical parameters of livestock and poultry meat, it reveals the relation between the freshness and mechanical parameters of livestock and poultry meat, it also achieves to measure the elasticity of meat from qualitative to quantitative. This method opens a new to test the freshness of meat on the production line and in market for the food producers. But now this technology is still in the testing stage. In recent years, some experts start to study the relation between the freshness and elasticity of meat. They thought the elasticity of meat can reflect the freshness.

But this conclusion still remains at the qualitative research stage, and it bases on sensory analysis. (TONG et al., 2010; JIANG & ZHOU, 2002)

2. TESTING METHODS AND PROTOCOLS

2.1 Testing methods

Device: Using electron universal testing machine WDW-20-type, testing machine measuring range 0 ~ 50N, resolution 0.001N, test pace 0.1 ~ 500m/min, Indication accuracy ± 0.1%, the pace accuracy ± 0.1%, deformation measurement accuracy ± 0.5%, displacement measurement accuracy ± 0.5%.

Material: Testing fresh meats(d) are bought from the Changchun farmers market which size are 60 mm × 40 mm × 20 mm, 100 mm × 100 mm × 100 mm, 100 mm × 100 mm × 100 mm respectively, The samples were cut according to their texture, and chose the test points by their texture too.

Testing meats came from the commercial poultry breasts which are produced by Jilin Deda Company, fresh storaged in the refrigerator, the environment temperature is 2℃. The samples were cut according to their texture, and chose the test points by their texture too.

2.2 Test Protocols

Testing meats are fresh storaged in the refrigerator at 4℃ environment temperature. And measure the pressure characteristic curve under room temperature 20℃ and relative humidity is 50%.

We tested 40 chickens, pork and beef samples respectively every day in consecutive nine days, the totally tested samples were 360, and found the average value of the testing data.

The process of the pressure characteristic curve was, taking a piece of poultry samples, putting on the lower disk of the test machine, the pressure head was fixed, the disk moved upward in a even speed (120mm/min) to 4 mm depth then moved downward to the original position each time. The testing machine is shown as figure 1, and result of the pressure Characteristic curve and parameters are shown as figure 2.

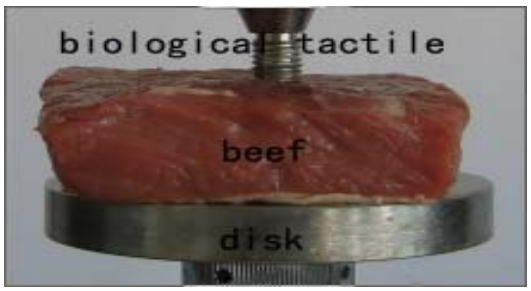

Fig. 1: The mechanical structure of testing beef pressure characteristic curves

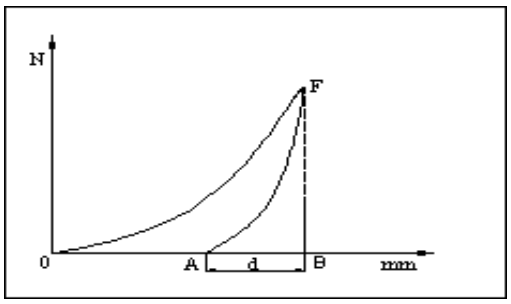

Fig. 2: Poultry pressure characteristic curves

d stands for the rebounded amount. Shows how much the poultry sample has rebound during the lower disc moves downward, unit: mm, one of the key indexes of meat flexibility.

FA is known as the rebound curve
S_1: F0B area, unit: J
S_2: FAB area, unit: J

S_1/S_2 expressed the ability of energy consumption and restore in the process, and it is called the ratio of work and its consumption.

To ensure comparability of testing environment, as soon as finished test of pressure characteristic curve on one poultry sample, detect its TVBN immediately, to evaluate the freshness of the poultry. In this way, the correlation between poultry tactile information and its freshness has been found. TVBN detected by semi-micro Kjeldahl method.

3. TEST RESULTS

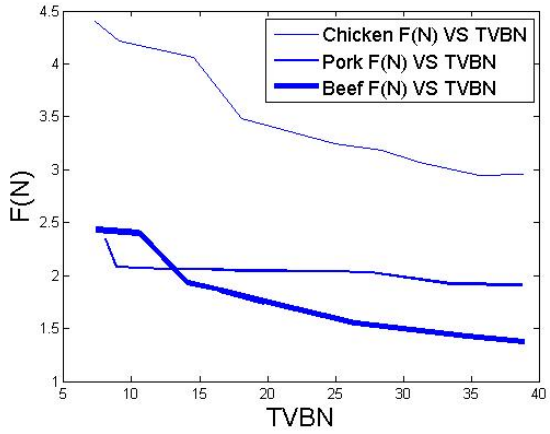

Fig. 3: The relation between value F of chicken, pork, beef and the amount of TVBN respectively

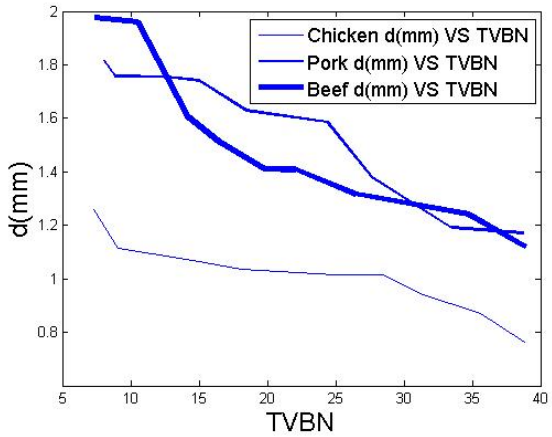

Fig. 4: The relation between value d of chicken, pork, beef and the amount of TVBN respectively

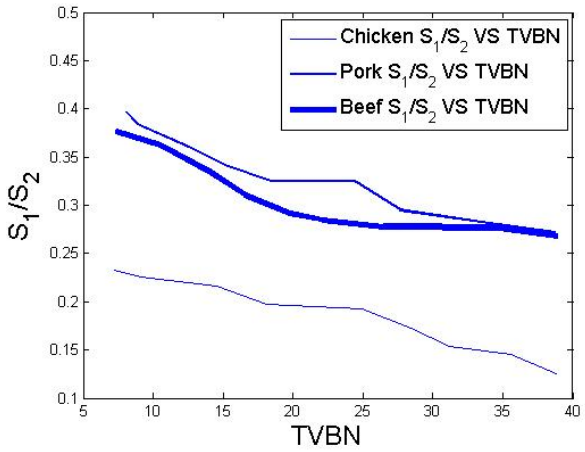

Fig. 5: The relation between value S_1/S_2 of chicken, pork, beef and the amount of TVBN respectively

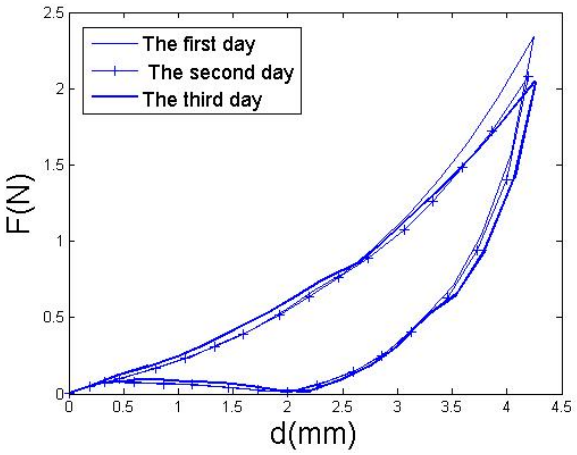

Fig. 6: The comparison of pressure characteristic curves of pork from first day to third day.

4. DISCUSSION

Table 1: The TVBN values of chicken, pork and beef at the first day

	chicken	pork	beef
TVBN （mm/100g）	7.26	8.04	7.34

The TVBN values of chicken, pork and beef were different at the first day, and this was due to different animal species and individual diversity.

In Figure 3, the F of chicken, pork and beef decrease when TVBN increase. After being slaughtered, the protease in animal body starts to Fig. 3 Shows the relation between value F of chicken, pork, beef and the amount of TVBN respectively decompose the protein and lipase starts to decompose the fat, in addition to the growth and reproduction of bacteria, all these elements lead to the damage of organizational structure of meat carcasses, the decrease of strength of muscle fibers, the reduction of ability to resist external force. Because of the difference of species, the value of F is increasing as the amount of TVBN increases.

The organizational structure of live animal is complete, the water holding capacity is good, thus the elasticity of meat is good. After animal being slaughtered, the damage of cell and tissue structure by bacteria is serious, (TONG et al., 2007) the water holding capacity, the strength of muscle fibers and the elasticity of meat will decrease. The quantity of TVBN in meat is proportional to the amount of bacteria (LI & LIU, 2003). Figure 4 shows that the d value of chicken, pork and beef decrease when amount of TVBN increases. Because of the difference of species, the value of d is increasing as the amount of TVBN increases.

S_2 is the work which produces by the pressure head acted on the poultry sample when the head moves upwards. S_1 is the energy that release from the meat when the head moves upwards. The amount of TVBN in meat is proportional to the degree that the organizational structure of meat has been destroyed, as the amount of TVBN increases, the less meat elasticity, as well as S_1 that we could get. From the perspective of ability, S_1 can reflect the elasticity of meat, but F and d have a great impact on the S_1. Because F and d decrease when the amount of TVBN increases, S_1 and S_2 decreases when the amount of TVBN increases, it is more precisely to use S_1/S_2 to reflect the elasticity of meat. Figure 5 shows that the S_1/S_2 value of chicken, pork and beef decreases when the amount of TVBN increases, Because of the difference of species, the value of S_1/S_2 changes differently as the same amount of TVBN changes.

Figure 6 is pressure characteristic curve of the same piece of pork from several consecutive days testing. From the figure we can see that whether the tray move upward or downward, the curves are all concave, this indicated the inhomogeneity of mechanical properties along the thickness of the meat, and the thickness of meat decreases with the depth increase (TONG et al., 2006). From three curves in figure 6 we can see that when the rebound curve begins to drop, the slope of curve increase when the amount of TVBN increases, which means the concave degree of rebound curve increase when the amount of TVBN increases.

5. CONCLUSION

The value of F, d and S_1/S_2 of the Chicken, pork and beef decrease when the amount of TVBN increases. Because of the difference of species, the value of F d and S_1/S_2 changes differently as the same amount of TVBN changes, the value of F, d and S_1/S_2 can reflect the amount of TVBN.

Indicated the inhomogeneity of mechanical, properties along the thickness of the meat, and the thickness of meat decreases with the depth increase.

The concave degree of rebound curve increases when the amount of TVBN increases. The concave degree of rebound curve can reflect the amount of TVBN.

To build a mathematic model basic on the relationship between the value of F, d, S_1/S_2 and pressure Characteristic with the amount of TVBN, we find a rapid detection way of testing meat freshness.

Pressure characteristic curve can reflect the freshness of meat, the advantage of this method is fast, non-destructive, affordable, convenient, and it can also be widely used.

REFERENCES

Bae, Y. M., Cho, S. I.. (2002). Response of polymer membranes as sensing elements for an electronic tongue [J]. *Transactions of ASAE, American Society of Agricultural Engineers.45 (5)*: 1511–1518.

China Meat Research Center. (2008). *Q & A: the Safety of Meat Products [J]*. BEIJING: China Textile & Apparel Press. 6:84.

HUANG Yan-bo, LAN Yubin, R.E. Lacey. (2004). Artificial senses for characterization of food quality. *Journal of Bionics Engineering Vol.1 No.3*, 159–173

LIN Ke. (2008). The Development and Application Research of the Electronic Tongue in Food Analysis. *Journal of Anhui Agricultural Sciences, 36(15)*:6602-6604

LI Zhen-xing, LIU Zhong-dong. (2003). A Correlative Study on the Elasticity and Freshness of meat, *JOURNAL OF ZHENGZHOU INSTITUTE OF TECHNOLOGY, 12*,Vol 24.4:37～39. (in chinese)

JIANG Zi-jian, ZHOU Yan. (2002). Study on Assaying Methods of Meat Elasticity[J]. *Food Science, 23(4)*: 99～102. (in chinese)

Tiina Rajamaki. (2006). Application of an electronic nose for quality assessment of modified atmosphere packaged poultry meat [J]. *Food Control , 17*: 5–13.

TONG Jin, LU Tie-biao, MA Yun-hai, WANG Heng-kun, Ren Lu-quan, Arnell A.R. (2007). Two-body abrasive wear features of surfaces of pangolin scales. *Journal of Bionic Engineering, 4(2)*: 77-84. (EI)

TONG Jin, ZHAO Yan-ru, SUN Jiyu, CHEN Dong-hui. (2007). Nanomechanical properties of the stigma of dragonfly Anax parthenope julius Brauer. *Journal of Materials Science, 42*: 2894–2898.(SCI、EI)

TONG Yue-ying, CHEN Dong-hui, SHI Zhi-biao, TONG Jin. (2010). A mathematical Model of Relationship of Mechanics Parameter and Its Freshness of Chicken[J]. *Journal of Agricultural Mechanization Research, 32(3)*:174-176.(in chinese).

TONG Yue-ying, CHEN Dong-hui, SHI Zhi-biao, TONG Jin. (2010). Relationship between the Poultry Pressure Characteristic Curve and Its Freshness [J]. *Journal of University Engineering and Technology Editing, 40(2)*:491-495.(in chinese)

TONG Jin, ZHANG Fu, ZHOU Jiang, MA Yun-hai, LIU Cai-yong, Yamaguchi Tomoharu. (2006). Microstructure features of the Elytra of beetle Protaetia orentalis and biomimetic design of composites. *Biosystem Studies, 9(1)*: 83-90.

ZHAO Ji-fu. (2004). *Food Technology[M]*. BEIJING:China light industry press, 38 .(in chinese)

ZHANG Nan, WENG Jiang-lai, MA Chang-wei. (2005). Research on Electronic Nose and Its Application in Meat Inspection. *MEAT RESEARCH*: *8*:29~31. (in chinese).

ZHANG Zhe, TONG Jin. (2005). Research and Application of Electronic Nose and Electronic Tongue in Food Inspection. *Journal of Huazhong Agricultural, (10)*:25~29.