QUALITY OF MEAT FROM PIGS RAISED IN ENVIRONMENT TREATED WITH TITANIUM DIOXIDE

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Abstract

Experiments involving nanotechnology (walls and ceiling coated with titanium dioxide - TiO_2) in pig farming culminated in an assessment of meat quality following the slaughter. This was done by technological and sensory evaluation of meat properties and by analyses of the basic nutrients. The tests performed did not show any negative effects of the applied coating on meat quality. In color evaluation, meat samples a* from the experimental group of pigs showed a greater proportion of red color (p=0.0146). The color shift may be considered positive.

Key Words: pig farming, nanotechnology, technological evaluation, sensory evaluation, titanium dioxide.

Agriculture, like other industries, is looking into some practices rooted in nanotechnology. This paper discusses the use of titanium dioxide (TiO_2) in eliminating ammonia emissions from buildings holding livestock. The approach relies on the role of metal oxides as catalysts in chemical processes. Chemical reactions take place on the surfaces of oxide molecules. The reaction starts with an exposure of TiO_2 to sunlight, which TiO_2 absorbs and produces two types of carriers: electrons (e-) and holes (h+). An important TiO_2 property is the oxidizing ability of its holes, stronger than the reducing ability of excited electrons, as explained by Fujishima et al. (1999). This property helps reduce atmospheric emissions of harmful substances in industrial applications. In further research, photo-catalytic properties of TiO_2 have been utilized for sterilization purposes as well as hygienic and anti-emissive measures, as documented by Li et al. (2004).

Material and Methods

Pig Housing and Experimental Environment

Bred pigs were the animals chosen to verify the environmental effect on livestock. Two identical halls with a nominal capacity of 100 animals each were available, operated continuously. The pigs were housed on vacuum-ventilated grates. The halls have a wet feeding system. Both halls are used for the final fattening of pigs. The experimental hall was treated as follows: First, the walls and ceiling received a coat of penetrative paint. After about one week of drying, the surface was coated with Detoxy Color paint containing nanoparticles of TiO_2. Due to the continuous operation, different combinations of pig counts and weights were obtained when measuring the emissions. Two experiments were carried out:

Experiment 1: Illumination by Natural Light

It took about 12 months to verify this phase. Gas emissions were measured 20 times during the experiment. The corresponding average temperatures were 17.4°C for the control group of pigs and 17.2°C for the experimental group. The average pig weight was 57.3 kg/pc and 71.8 kg/pc respectively. Comparing the emission factors, the control group registered 2.73 kg/pc/yr of NH_3 emissions and the experimental group 2.75, or 0.8% more. However, when stated per 100/kg/yr of pig weight, the production of NH_3 was 5.04 kg in the control group and 3.92 kg in the experimental group, or 22.3% less (P<0.001). The environment had a positive influence on weight increase as well, which was 0.686 kg/pc/day in the control group and 0.715 kg/pc/day in the experimental group, or 4.1% more.

Experiment 2: Illumination by Daylight Spectrum with 4% of UVB

Fluorescent lamps with light of a specific wavelength were installed along the perimeter of the stable. The lamp operation was controlled by a programmable switch. The verification took about 160 days. The gas was measured 4 times in the course of the experiment. During the measurements, the pigs weighed 84.5 kg/pc in the control group and 77.5 kg/pc in the experimental group, with the temperatures being 22.4°C and 21.9°C respectively. Gas generation was 2.86 and 2.26 kg/pc/yr respectively, that is 20.1% lower (P<0.001). Converted to NH_3 per 100 kg of weight, it was 4.26 in the control group and 3.26/100kg/yr in the experimental group, or 23.4% lower (P<0.05). There has been no weight gain assessment since the experiment continues until March 2011.

Meat Evaluation Methodology

With respect to the main objective, the studied applications proved to be effective. In these types of experiments, it is desirable to monitor also the fattening indicators, carcass value and meat quality in consumer-friendly parameters.

Not knowing any negative consequences of the monitored applications on the analytical values of the meat after slaughter, we focused on technological and sensory indicators of meat quality as the signs that could signal potential changes.

Technological Evaluation

Among the technological criteria, we monitored the meat color values with L* being the lightness of color on a scale of 0 (black) to 100 (white), a* on a scale of -60 (red) to +60 (green), and b* on a scale of -60 (yellow) to +60 (blue). This three-dimensional matrix common in other fields provides the most accurate definition of meat color. Along with the pH values, it allows to classify possible deviations as meat defects in standard categories. However, this was not the intention, since there was no assumption of ETW causing or otherwise influencing the appearance of meat deficiencies. An important culinary parameter, although largely overlooked in consumer education, is a spontaneous loss of moisture, or drippage for short, in two 24 hour periods after the slaughter, on a 100 g sample of pure muscle tissue stored in a PE wrapper at 4-7°C. The pH values were measured at the same time.

Sensory Evaluation

For a test of consumer significance, we chose sensory evaluation. We heat-treated pure muscle tissue m.l.d., or boneless roast, by grilling it on a glass-ceramic contact grill. The grilling, without salt or spices, was on a surface heated to 250°C until the temperature inside the slice of meat 2 cm thick reached 90°C. The slice was then cut into cubes with about 2 cm long edges, then temperature-equalized in a closed container at 50°C until served to the evaluators. The presentation occurred in approximately one hour's time.

Working individually, the evaluators considered a number of criteria per Table 1. To avoid the influence of subconscious decision-making, the samples were marked with graphic symbols rather than numbers. The samples (cubes) of the control and experimental groups were always served together. A total of 10 samples/pigs per group was evaluated, always by 10 evaluators. A nine-grade rating scale was used, with 9 being the best and 1 being the worst. There was no inedible category, nor was there such a case. The overall rating reflected the evaluator's fundamental priority independent of the other ratings.

Chemical Analysis – Basic Nutrients

The samples of meat were first analyzed for added water and dry matter. Then the amount of fat, protein, ash and hydroxyproline in the dry matter was determined and the energy value (MJ/kg) calculated. The determination of basic nutrients was done only for the second experiment.

Results

Results of Meat Quality Evaluation

Experiment 1: Illumination by Natural Light

The results of a 2010 experiment on 2x6 pigs in the interior coated with paint containing TiO_2 and natural lighting were comparable to the control conditions. The differences in some criteria cannot be attributed to the application because of a large inherent variability in the data. Only the color values a* (-red to +green) in the experimental group showed a greater proportion of red color at P=0.05 (p=0.0146) level. This shift may be viewed rather positively. The resultant data is in Table 1 and 2.

Table 1. Experiment 1 – Technological Evaluation of Meat

Parameter>	pH 1st day	pH 2nd day	L* 1st day	a* (+red to –green, from -60 to +60)	b* (+blue to – yellow, from -60 to +60)	Loss by drippage (%)	Loss by freezing (%)	Loss by grilling frozen (%)
Control Group								
Average	5.57	5.50	56.41	1.59	12.00	-4.7	-10.3	-37
S=	0.13	0.06	4.41	0.82	1.05	1.7	2.3	8
Experimental Group								
Average	5.45	5.53	58.12	3.51	13.48	-5.0	-12.8	-41
S=	0.03	0.12	7.76	1.37	1.73	3.2	2.4	4
P =				0.0146				
P <	NS	NS	NS	0.05	NS	NS	NS	NS

Table 2. Experiment 1 - Sensory Evaluation of Meat

Parameter>	Smell intensity	Smell appeal	Crispness	Texture	Juiciness	Chewability	Flavor intensity	Overall rating
Control Group								
Average	5.81	5.17	5.34	5.15	4.78	5.24	5.25	5.10
S=	1.82	2.01	2.00	1.68	1.80	1.92	1.54	2.08
Experimental Group								
Average	5.73	5.35	5.03	4.70	4.13	4.43	4.48	4.55
S=	1.89	1.91	1.75	1.69	1.42	1.88	1.65	2.02
P <	NS	NS	NS	NS	NS	NS	NS	NS

Experiment 2: Illumination by Light of a Specific Wavelength (UVB Spectrum)

Results of the experiment with TiO_2 application combined with the addition of artificial light in the UVB spectrum.

The results obtained were similar to those in the preceding experiment. The red color proportion in this experiment was the same in both groups. The resultant data are in Table 3 and 4. Both experiments were done in the operational facility and experimental abattoir of Institute of Animal Science in Uhříněves.

Chemical Analysis – Basic Nutrients

Applying a layer of TiO_2 to the walls and ceiling of the piggery had practically no effect on the nutrient content of the pig meat, under both natural and artificial lighting.

Table 3. Experiment 2 – Technological Evaluation of Meat

Parameter>	pH 1st day	pH 2nd day	L* 1st day	a* (+red to -green, from -60 to +60)	b* (+blue to –yellow, from -60 to +60)	Loss by drippage (%)	Loss by freezing (%)	Loss by grilling frozen (%)
Control Group								
Average	5.31	5.30	58.28	0.95	11,87	5,68	9,09	25,48
s=	0.01	0.03	1.69	1.10	1.04	1.84	2.44	3.86
Experimental Group								
Average	5.35	5.34	59.83	0.95	12.24	5.73	9.68	26.78
S=	0.09	0.04	2.76	1.60	1.11	1.84	1.74	6.75
P <	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Experiment 2 - Sensory Evaluation of Meat

Parameter>	Smell intensity	Smell appeal	Crispness	Texture	Juiciness	Chewability	Flavor intensity	Overall rating
Control Group								
Average	5.90	5.47	5.98	5.42	5.07	4.78	5.27	5.23
S=	1.68	1.63	1.80	1.49	1.68	1.74	1.85	1.68
Experimental Group								
Average	6.13	4.93	5.22	5.25	4.87	4.67	4.75	4.80
S=	1.73	1.7	2.03	1.63	1.74	1.79	2.00	1.81
P <	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Experiment 2 – Indicators of Basic Nutrients

	Dry matter g/kg	Fat g/kg	Proteins g/kg	Ash g/kg	Hydroxyproline g/kg	Energy value (calculation) MJ/kg	Added water%
Control Group							
Average	256.34	13.02	226.25	11.39	0.54	4.28	35.93
S=	6.26	3.96	4.86	0.23	0.03	0.18	4.50
Experimental Group							
Average	257.36	18.56	222.59	10.99	0.52	4.43	27.53
S=	4.17	4.71	3.73	0.40	0.06	0.13	3.92
P <	NS	NS	NS	NS	NS	NS	NS

Conclusion

Nanotechnology applications have been tested also on other species of farm animals, with similar results. Mono-gastric broiler chicken operations, comparable to pig farming, yielded similar data on meat quality, the differences in some criteria being insignificant.

In conclusion, it may be said that nanotechnologies have a positive effect on atmospheric emissions without an indication of a negative impact on meat quality per selected criteria. In that sense, the applications proved to be beneficial.

References

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