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EFFECTS OF DIFFERENT NATURAL FOOD COLORING ADDITIONS ON THE QUALITY OF CHICKEN SAUSAGE

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Abstract

Sausage is one of the most popular foods in the world. As human beings pay more and more attention to health, the research of mixed meat as raw materials for sausages, plant raw materials (mushrooms, fruits and vegetables, dietary fiber) as ingredients, and the substitution of nitrite have become hot topics in the field of sausage research. In this study, chicken, pork, wheat bran were used as the main raw materials to prepare sausages, adding different contents of red yeast red and beet powder to improve the color and increase product acceptance of wheat bran chicken sausages. Through the analysis of sausage color, cooking loss, texture properties, moisture distribution and sensory evaluation and other parameter changes, the effect of natural pigments on sausage quality was studied. The results of the study showed that the red value a* of red yeast rice and beet red in chicken sausage was significantly increased (P < 0.05), and the a* values of the control group, L1, L2, L3, and L4 were 5.5, 11.29, 13.27, 19.51, 22.30, and the sensory scores of the L1-L4 treatment group were also significantly increased compared with the control. Cooking loss, fat loss and water loss were significantly reduced (P < 0.05). Compared with the control treatment group, the cooking loss rate of chicken sausages (1.5 g of red yeast rice powder and 1 g of beet red) in the L3 treatment group was the smallest and the emulsion stability was the highest. The addition of natural pigments had no significant effect on sausage texture and pH value (P > 0.05). In summary, the wheat bran in chicken sausages of the L3 treatment group had better results in color, cooking weight loss, emulsification stability, pH, moisture content, texture, and sensory evaluation. The research results provide technical support and data support for the application of natural pigments in chicken sausages.

Keywords: Chicken Sausage; Food coloring; Red yeast rice; Beet red; Quality characteristics.

ВПЛИВ РІЗНИХ ДОБАВОК НАТУРАЛЬНИХ ХАРЧОВИХ БАРВНИКІВ НА ЯКІСТЬ КУРЯЧОЇ КОВБАСИ

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Анотація

Ковбаса є одним з найпопулярніших продуктів харчування в світі. Дослідження в якості сировини для неї змішаного м'яса з інгрідієнтами рослинної природи, а також питання заміни нітритів є актуальною темою досліджень. У даному дослідженні в якості основної сировини для виготовлення ковбас використовували куряче м'ясо, свинину, пшеничні висівки, змінна кількість червоних дріжджей та бурякового порошку для поліпшення кольору і підвищення споживчих властивостей курячих ковбас. Результати дослідження показали, що червона цінність a* червоного дріжджового рису і бурякового червоного в курячої ковбасі була значно збільшена (P < 0.05), а значення a* контрольної групи, L1, L2, L3 і L4 склали 5.5, 11.29, 13.27, 19.51, 22.30 і сенсорні оцінки групи обробки L1-L4 були значно збільшені в порівнянні з контрольним зразком. Втрата варіння, втрата жиру і втрата води були значно знижені (P < 0.05). У порівнянні з контрольною групою втрати при варінні курячих сосисок (1.5 г порошку червоного дріжджового рису і 1 г червоного буряка) в групі обробки L3 були найменшими, а стабільність емульсії – найбільшої. Додавання натуральних пігментів не зробило істотного впливу на текстуру ковбаси і значення pH (P > 0.05). Пшеничні висівки в курячих ковбасах групи обробки L3 мали кращі результати за кольором, втратою маси при варінні, стабільності емульгування, pH, вмісту вологи, текстурі і сенсорній оцінці. Результати дослідження забезпечують технічну підтримку і дані для застосування натуральних пігментів в курячих ковбасах.

Ключові слова: Куряча ковбаса; харчовий барвник; червоний харчовий рис; буряковий червоний; якісні характеристики.

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Introduction

Food safety is important to human health. Nitrite is usually used additives in meat products to play multiple roles in color enhancement, flavor and bacteriostasis et al. [1; 2]. It can improve the quality of processed meat products and extend the shelf life. However, high intake of nitrate or nitrate meat products may induce carcinogenic N-nitroso compounds (NOCs) and increase the prevalence of colorectal cancer [3; 4]. Nitrite is becoming unpopular as a hair coloring agent. It is a trend to replace nitrite with natural pigments [5].

Red yeast rice is a traditional Chinese fermented product with a history of more than 1,000 years [6]. It is rich in the aroma of wine, not only for wine making, but also an excellent red pigment [7]. It has the functions of invigorating the spleen, harmonizing the stomach, eliminating food, and removing swelling. Medical research has shown that the effective ingredient of red yeast rice is lovastatin, which can lower cholesterol and triglycerides, increase high-density lipoprotein, and lower blood pressure and blood lipids [6; 8]. Red yeast rice is often used in food supplements, and the European Union Food Safety Agency has approved its health claims to control cholesterol. Traditional Chinese food often uses red yeast rice, such as braised pork, fermented bean curd, red rice wine, red steamed bread, red rice sausage, etc [9; 10].

Indica rice, japonica rice, glutinous rice, etc. are used as raw materials for making red rice. The rice is cleaned and soaked in clean water for about 60 minutes, and then put into a wooden barrel for steam cooking, the temperature is reduced (55–58 °C), the monascus is sprinkled in, stirred evenly, and the fermentation is carried out. The fermentation temperature is 55 °C, and the fermentation needs 3–4 days, then the red rice is sun-dried or dried. When it is necessary to use red yeast rice powder, it can be crushed [11; 12].

Ukraine and China have abundant sugar beet resources. Beet red pigment is a natural pigment made from edible red beets through extraction, separation, concentration, and drying. The main ingredients are beet anthocyanins and betaxanthin. The product is a red-purple to dark purple liquid, block or powder, easily soluble in water, the aqueous solution presents red to purple-red, bright color. The beet powder used in this study was prepared by slicing, vacuum microwave drying, crushing, and sieving (60 mesh). It is a natural red pigment.

Compared with synthetic pigments, the biggest feature of monascus pigment is that it is a natural edible pigment, and it has the advantages of safety, non-toxicity, nutrition and health; compared with other natural pigments, it can be used in many aspects, such as hair color Agent use etc [13]. Fabre. C. E et al. also mentioned that adding monascus pigment to meat and meat products has better dyeing ability than synthetic pigments. Beet red pigment, like monascus pigment, is also a kind of natural edible pigment. It has the characteristics of safety and non-toxicity, good coloring ability, and high nutritional value. It is one of the natural pigments that are allowed to be used universally and safely in the world [14; 15].

In order to study the effect of nitrite substitutes on the color of minced meat, Yang Huijuan et al. set up three groups of experiments: adding 100 $mg \cdot kg^{-1}$ nitrite, adding 0.5 % beet powder and 50 $mg \cdot kg^{-1}$ nitrite, adding 0.1 % beet powder and 0.06 % glycosylated acylhemoglobin. Comprehensive color, total myoglobin and other indicators, the results showed that the meat emulsion with 0.1 % beet powder and 0.06 % glycosylated acyl hemoglobin has the best color and can replace part of sodium nitrite in meat emulsion products [16]. Xiao Chaogeng and others added glycosylated acyl hemoglobin (0.04 %, 0.06 %, 0.08 %) compound beet powder (0.1 %, 0.3 %, 0.5 %) to Chinese sausages, and determined the nitrite content and color difference of each group of sausages , Nitroso pigment and total pigment, TBARS value, pH value, acidity and texture analysis and other indicators on the quality of sausage, the results show that 0.06% glycosylated acyl hemoglobin and 0.1 % sugar beet powder composite replace 100 mg/kg sub Sodium nitrate is very effective when added to Chinese sausages [17]. Previous studies have shown the possibility of beet powder as a sausage coloring agent.

At present, the research on beet powder mostly focuses on the stability and extraction conditions of beet red pigment, while the research on adding beet red to meat emulsion to replace sodium nitrite is relatively rare. In this paper, red yeast red and beet red are used as the research objects. By setting different addition amounts, the changes in parameters such as color, cooking loss, texture characteristics, etc. are analyzed, and the best plan is selected to add favorite colors to chicken sausages.

Research goals and objectives. The purpose of this study is to use natural Chinese red yeast rice pigment and beet powder to add to chicken sausages to give the chicken sausages a bright and safe red color and avoid potential safety hazards caused by nitrite.

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(1) The effect of adding red yeast red and beet red natural pigments on the color of sausages;

(2) The effect of adding red yeast red and beet red pigment on the physical and chemical properties and texture properties of chicken sausage;

(3) The development of meat products can be used to replace nitrite.

Modification (3): (3) The application of natural pigments in chicken sausages is made possible and supported by data.

Materials and Methods

Materials. Chicken breast, fatty pork, wheat bran, tapioca starch, modified tapioca starch, potato starch, ice water, salt, five-spice powder, pepper, rice wine, red yeast rice powder, beet red (the beets are crushed after vacuum microwave drying treatment and sieved (particle diameter less than 250 micron, 60 mesh), Hezhou University Laboratory, China), Phosphate (Sodium pyrophosphate 60 %, sodium tripolyphosphate 39 %, sodium hexametaphosphate 1 %), casings (commercially salt-cured fresh Pig small intestine), beet red.

Instruments and equipment. Colorimeter (CR-400, Shoufeng Instrument Technology Co., Ltd, Changzhou, China; Calibrated with a white plate, L* = +97.83, a* = −0.43, b* = +1.98). Water distribution analysis with low field nuclear magnetic resonance instrument, nuclear magnetic resonance imaging analyzer (NMI20, Shanghai Newmai Electronic Technology Co., Ltd, Shang Hai, China). Texture profile analysis was measured at room temperature with a texture analyzer (TA.XT PLUS, Stable Micro System, UK).

Processing of chicken sausage. Defrosting chicken breast → Casing cleaning → Soaking the casing for 30min → Minced the chicken breast (including the fat) → Adding ingredients according to the ingredient list (Table 1) → Adding ice water and mixing→ The casing is put into the sausage machine → The casing is knotted at one end → Enema → Air in a ventilated place until the skin is dry → 80 °C water bath for 30 minutes → Dry the sausage skin moisture → Cool to room temperature (about 20 °C) → Refrigerate.

Table 1

Recipes of bran chicken sausages with different food coloring

Ingredient (g)	**Control group**	**L1**	**L2**	**L3**	**L4**
Pig skin	100.0	100.0	100.0	100.0	100.0
Chicken breast	400.0	400.0	400.0	400.0	400.0
Fat(pig)	50.0	50.0	50.0	50.0	50.0
Wheat bran (part below 80mesh)	6.0	6.0	6.0	6.0	6.0
Cassava starch	35.0	35.0	35.0	35.0	35.0
Cassava denaturant starch	20.0	20.0	20.0	20.0	20.0
Potato starch	20.0	20.0	20.0	20.0	20.0
Ice water	100.0	100.0	100.0	100.0	100.0
Salt	7.0	7.0	7.0	7.0	7.0
Phosphate	1.5	1.5	1.5	1.5	1.5
Spices	4.5	4.5	4.5	4.5	4.5
Pepper	0.5	0.5	0.5	0.5	0.5
Rice wine	25.0	25.0	25.0	25.0	25.0
Red rice powder	0.0	1.5	0.0	1.5	1.5
Beet red	0.0	0.0	1.0	1.0	2.0

Color. Place the chicken sausages stored at 4 °C at room temperature to equilibrate for 1 hour. Used the colorimeter and O/D test head to determine the brightness value (L*), redness value (a*) and yellowness value (b*).

Cooking loss. Refer to the method of Jiang Shuai [18]. Weigh 35 g of minced meat into a 50 ml centrifuge tube and centrifuge (3000 rpm, 5 min) to remove air bubbles in the tube. Then, heat it in a water bath (75 °C, 30 min), cool the heated sample at room temperature for 1 hour, weigh it after cooling, and record its mass.

The calculation of cooking loss is shown in formula:

$$CookingLoss(\%) = \frac{w_{0(g)} - w_{1(g)}}{w_{0(g)}} \times 100 \qquad (1)$$

where *CL*-cooking loss; *W0*-weight of raw meat batters; *W1*-weight of cooked meat batters.

Emulsion stability. Pour the liquid lost during cooking (centrifuge tube upside down for 40 minutes) into a glass dish. Moisture loss is the weight of the liquid lost by cooking and drying after heating at 105 °C for 16 hours, while fat loss is the mass of the sample remaining after the drying of the liquid lost by cooking [19; 20]. The calculation of water loss and fat loss is shown in formulas:

$$MoistureLoss(\%) = \frac{w_2 - w_3}{w_0} \times 100 \quad (2)$$

$$FatLoss(\%) = \frac{w_3}{w_0} \times 100 \quad (3)$$

where W2-weight of cooking liquid; W3-remaining weight after heating.

TPA. The chicken intestines stored at 4°C were placed at room temperature to equilibrate the temperature, and the sample was cut into 40 mm×20 mm (height×diameter) cylinders to determine the texture. The experiment uses the TPA puncture method to measure chicken sausages. The probe model is P/5. Set the measured parameters, 5 mm/s before the test rate, 1 mm/s test rate, 1 mm/s after the test rate, 50 % The compression ratio, 5 g trigger force [18; 21]. The measurement indicators include hardness, elasticity, cohesiveness, chewiness, adhesiveness and recovery.

Moisture distribution. In this experiment, low-field nuclear magnetic resonance (LF-NMR) technology was used to determine the dynamic distribution of internal water content of chicken intestines and raw meat paste in different experimental groups [20; 22]. Wrap the raw meat mince with plastic wrap into spherical samples with a diameter of about 1cm, cut the chicken intestines into 1cm×1cm×4cm, and wrap the sample with plastic wrap into cylindrical samples and place them in a nuclear magnetic test tube (test tube diameter is 1.8 cm, height 18 cm), use the analysis application software to determine the sample relaxation time. Inversely perform the lateral relaxation (T2) through the CONTIN software, and display the corresponding relaxation time (T2B, T21 and T22) and amplitude (A2B, A21 and A22). And use the imaging software that comes with the system to scan the sample into an MRI picture, and use the pseudo-color IPT.2014 software to make the MRI picture pseudo-color processing.

Sensory evaluation. Invite 10 food majors with sensory evaluation experience to form an evaluation team. Cut off both ends of the heated sausage, cut the middle part into a 1cm-long cylinder, and distribute the chicken sausages of different experimental groups to the group members for evaluation. Mainly evaluate the color, hardness, flavor, viscosity and overall acceptability of bran chicken sausage [20]. The scoring table is shown in Table 2.

Table 2

Sensory Evaluation Standard

Evaluation index	**Evaluation score**		
	1~3 Score	**4~6 Score**	**7~9 Score**
Color	No appetite, poor color	average appetite, normal color,	appetite, attractive color
Texture	The taste is rough and hard	The taste is slightly rough and hard	The taste is fine and elastic
Flavor	No sausage taste	average sausage taste	suitable sausage taste
Viscosity	Sticky teeth	Slightly sticky teeth	Non-sticky teeth
Overall acceptability	Not accept	accept	like

Statistical analysis. The measurement index is repeated 3 times, and the data results are all expressed as mean ± standard deviation ($\overline{X}$ ± S). All data used the one-way analysis of variance (ANOVA) post-multiple comparison method in the IBM SPSS Statistics 22 data editor, set the significance level to P=0.05, and used the LSD program to analyze the significant differences (P<0.05 is significant). Use Microsoft Excel 2017 software to draw charts.

Results and discussion

Color

Table 3

The effect of two different food colorings on the color difference of raw meat emulsion and sausage

Treatment	L*		a*		b*	
	Mashed meat	Sausage	Mashed meat	Sausage	Mashed meat	Sausage
Control group	73.65±1.15[a]	73.04±0.89[b]	6.90±0.45[d]	5.50±0.48[d]	14.90±1.04[a]	13.88±0.18[a]
L1	71.12±0.53[b]	69.57±2.01[c]	12.27±0.27[c]	11.29±0.06[c]	14.76±0.32[a]	13.34±0.66[a]
L2	65.57±0.29[c]	67.32±1.32[c]	18.54±1.12[b]	13.27±0.23[c]	12.56±0.98[bc]	12.06±0.49[b]
L3	61.96±1.48[d]	61.89±2.87[d]	19.51±1.70[b]	19.40±2.58[b]	11.13±1.03[b]	11.60±0.84[c]
L4	59.37±0.23[e]	63.59±0.22[d]	24.21±1.17[a]	22.30±0.21[a]	8.95±0.61[c]	11.39±0.18[c]

*Note: Means within a column with different letters are significantly different (p<0.05).

Adding edible red pigment can improve the color of sausages and obtain a joyful color. The test results in Table 3 show that the redness a* value of meat emulsion and sausage with pigment increased significantly ($P<0.05$), while the L* value and b* value showed a decreasing trend ($P<0.05$). The L2 treatment group with 1.0g beet red was more red than the L1 treatment group with 1.5g of red yeast rice, indicating that beet red can provide a higher red value than red yeast rice. Compared with the L2 treatment group, there was no significant difference in the a* value of raw meat emulsion, but the a* value of L3 sausage was significantly higher than that of L2 ($P < 0.05$). The L4 treatment group continued to increase the amount of beet red, and the a* value of raw meat emulsion and sausage a* values are significantly higher than the other treatment groups, and the red color is better. Liu Guoqing et al. used red yeast powder and ketchup to replace part of the sodium nitrite in frankfurter sausages. Red yeast powder and ketchup, the optimal amount of sodium nitrite is 0.001 %, 10 % and 0.0005 %, which can be substituted 70 % nitrite [23]. The Kultmfach Federal Institute of Meat Products in Germany has added natural edible red pigments to sausages, and proved that this red pigment can play a very good role in the color and color stability of sausages. This shows that the addition of natural red pigments to sausages is allowed, and the effect is considerable.

Cooking Loss and Emulsification Stability

Table 4

The effect of two different food colorings on the cooking loss and emulsification stability of raw meat emulsion

Treatment	Cooking loss	Moisture loss	Fat loss
Control treatment	11.99 ± 1.86[a]	11.70 ± 1.73[a]	0.29 ± 0.13[a]
L1	10.24 ± 1.55[ab]	10.01 ± 1.51[ab]	0.23 ± 0.04[a]
L2	10.56 ± 0.77[ab]	10.33 ± 0.81[ab]	0.23 ± 0.04[a]
L3	8.52 ± 0.54[b]	8.26 ± 0.57[b]	0.26 ± 0.08[a]
L4	9.57 ± 0.58[b]	9.36 ± 0.55[b]	0.21 ± 0.04[ab]

*Note: Means within a column with different letters are significantly different (p<0.05).

As shown in Table 4, compared with the control group, the cooking loss, water loss, and fat loss of the treatment groups with different addition amounts of red yeast rice and beet red were significantly reduced ($P < 0.05$), this phenomenon indicates that different amounts of red yeast rice powder and beet red can reduce cooking loss, water loss and fat loss during the heating process of chicken sausage. Yang Huijuan et al. found in their studied that the mixed water-soluble protein of 0.1 % beet red and 0.06 % glycated acyl hemoglobin was helpful to improve the overall emulsification function of meat emulsion, which is beneficial to the water retention and water retention of meat emulsion products [16]. Gelability has a positive effect. This may be due to the fact that dried beet powder contains a lot of cellulose that can retain moisture, and red yeast rice powder contains amylopectin that helps to form a gel to retain moisture, although they are added in small amounts. In summary, the L3 group had the lowest cooking loss, water loss and fat loss ($P < 0.05$), that was, when the amount of red yeast rice powder was 1.5g and beet red was 1g, the cooking loss rate of chicken sausage was the lowest, and the emulsification stability of chicken sausage was the highest.

TPA

Table 5-1

The effect of two different food colorings on texture of raw meat emulsion

Treatment	Hardness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
Control group	90.18±38.91[ab]	0.57±0.31[ab]	0.45±0.21[ab]	44.70±37.74[a]	33.33±41.37[a]	0.04±0.01[a]
L1	73.92±14.07[b]	0.91±0.01[a]	0.59±0.03[a]	44.09±9.71[a]	40.00±9.16[a]	0.05±0.00[a]
L2	98.43±11.77[ab]	0.64±0.25[ab]	0.41±0.07[ab]	40.96±11.56[a]	27.76±18.34[a]	0.06±0.02[a]
L3	116.45±14.12[a]	0.64±0.11[ab]	0.45±0.05[ab]	53.20±11.65[a]	34.61±12.65[a]	0.05±0.00[a]
L4	60.47±5.00[b]	0.44±0.09[b]	0.35±0.07[b]	21.50±5.92[a]	19.90±4.79[a]	0.06±0.01[a]

*Note: Means within a column with different letters are significantly different (p<0.05).

Table 5-2

The effect of two different food colorings on texture of chicken sausage

Treatment	Hardness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
Control group	206.83±106.43[a]	0.79±0.33[a]	0.47±0.17[a]	108.32±77.49[a]	101.07±83.17[a]	0.13±0.07[a]
L1	103.00±5.92[ab]	0.16±0.03[a]	0.15±0.01[a]	105.64±0.26[a]	20.52±0.45[a]	0.03±0.00[b]
L2	256.31±46.32[a]	0.28±0.14[a]	0.27±0.14[a]	84.22±10.05[a]	27.99±36.63[a]	0.06±0.05[ab]
L3	115.78±7.29[ab]	0.54±0.43[a]	0.43±0.33[a]	51.30±31.04[a]	12.16±7.33[a]	0.04±0.00[b]
L4	83.89±26.33[b]	0.71±0.43[a]	0.52±0.26[a]	38.75±11.46[a]	30.83±21.99[a]	0.06±0.03[ab]

*Note: Means within a column with different letters are significantly different (p<0.05).

Through the texture analyzer to measure the hardness, elasticity, cohesiveness and chewiness of sausages and other indicators, objectively evaluate the edible quality of the product, which is a key feature for evaluating the quality and acceptability of meat products [21]. The results from Table 5-1 and 5-2 were shown that the addition of red yeast red and beet red two natural pigments can change the texture characteristics of raw meat emulsion and chicken sausages. The hardness, viscosity, and chewiness of the chicken sausages change significantly. The L4 treated chicken sausages the hardness, chewiness and gumminess of the chicken sausage were significantly reduced, but the springiness did not change much, and the difference was not significant ($P > 0.05$). The hardness, springiness and cohesiveness of the chicken sausage in the L3 treatment group were moderate, but the chewiness value was the lowest. It can be seen that adding a small amount of natural plant pigments has a greater impact on the texture properties of chicken sausages. On the one hand, it can be seen from the data that there are some errors in the instrument, and texture parameters are only used as scientific data for sausage research. The optimal results need to be combined with sensory evaluation and color parameter comprehensive evaluation.

Dynamic distribution of moisture in chicken sausage. The T_2 distribution after inversion and fitting shows 3 peaks according to the relaxation time. According to the different degrees of free movement of water molecules, from left to right, it indicates bound water (T_{2b}), non-flowing water (T_{21}) and free water (T_{22}) [24].

It can be seen from Figure 1 that compared with the control group, the relaxation time of bound water and non-flowing water in the treatment group added with red yeast rice powder and beet red all shifted to a shorter relaxation time, while the relaxation time of free water Move in the direction of the long relaxation time. The relaxation time of free water has no obvious migration trend ($P > 0.05$), but the relaxation time of bound water and non-flowing water has a very obvious migration trend ($P < 0.05$), which shows that natural pigments are added and the pigments are mixed. In the chicken sausage meat emulsion, the flow capacity of the non-flowing water can be reduced, so that it is more closely combined with the meat chyme protein, and it is obvious in the figure that the free water is shifting to the non-flowing water (L4 treatment Group exception). Research by Chen Yichun et al. showed that the relaxation time of the three kinds of water in Frankfurt sausages with vegetable oil pre-emulsion all moved to the direction of short relaxation time ($P < 0.05$). It also shows that the non-flowing water in the sausage is more tightly bound to the protein in the meat [20].

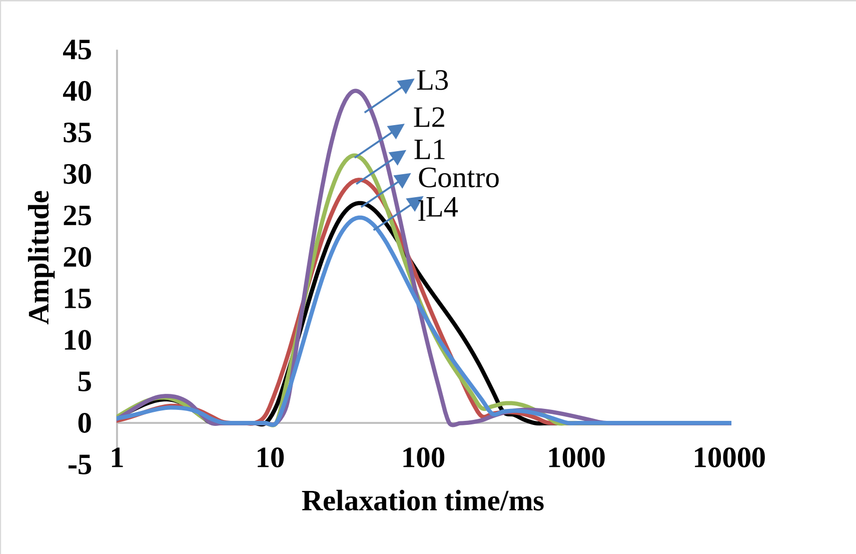

Fig. 1. Effects of nature food coloring Additions on Water Distribution in Chicken Sausage

Table 6

Effects of nature food coloring Additions on Water Distribution value in Chicken Sausage

Treatment	T_{2b}/ms	T_{21}/ms	T_{22}/ms	A_{2b}	A_{21}	A_{22}
Control group	2.17±0.35^{a}	40.73±6.61^{a}	338.13±54.87^{a}	2.74±0.15^{b}	26.18±0.37^{d}	2.10±1.57^{a}
L1	2.56±0.42^{a}	40.73±6.61^{a}	338.13±54.87^{a}	2.00±0.11^{c}	28.87±0.49^{c}	1.24±0.09^{a}
L2	1.85±0.30^{a}	34.61±5.62^{a}	397.91±64.57^{a}	2.91±0.21^{ab}	31.62±0.70^{b}	2.27±0.17^{a}
L3	2.17±0.35^{a}	34.61±5.62^{a}	468.27±75.99^{a}	3.16±0.11^{a}	39.10±1.14^{a}	1.57±0.05^{a}
L4	2.17±0.35^{a}	40.73±6.61^{a}	397.91±64.57^{a}	1.78±0.10^{c}	33.52±0.65^{b}	1.42±0.05^{a}

The results of water distribution in Table 6 show that as the amount of red yeast red and beet red added to the chicken sausage increases gradually, the A_{2b} and A_{21} values both increase significantly, while the A_{22} value decreases significantly. This may be due to the two natural When food pigments are added to chicken sausages and act on the meat emulsion system, there will be a tendency for free water to change to bound water and difficult-to-flow water, so the free water is reduced.

Nuclear magnetic imaging analysis

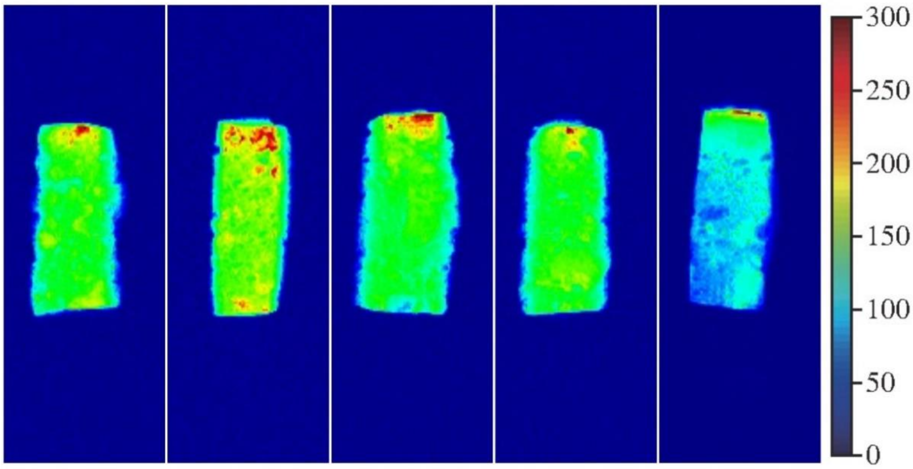

Fig. 2. Pseudo-color map of chicken sausage with different Nature food coloring content

Figure 2 shows a pseudo-color picture obtained by nuclear magnetic resonance by adding different amounts of red yeast rice powder and beet red to chicken sausage, which visually shows the distribution of moisture. With the increase of the amount of pigment added, the red and yellow areas in the pseudo-color picture gradually become less, and the water molecules in the sausage gradually decrease, and L4 is significantly reduced. This may be because excessive pigment is added to the sausage, which makes the chicken sausage protein cross-linked. The capacity is weakened, which reduces the water holding capacity of the sausage, so that the free water distribution of the chicken sausage is reduced.

Sensory evaluation

Table 7

Effects of nature food coloring Additions on sensory evaluation in Chicken Sausage

Treatment	Color	Texture	Flavor	Viscosity	Overall acceptability
Control group	2.80±0.79[b]	3.10±0.99[bc]	4.10±1.85[a]	4.00±1.76[a]	5.30±1.06[ab]
L1	4.30±1.42[a]	4.50±1.08[a]	5.10±1.29[a]	5.00±1.56[a]	4.50±1.43[b]
L2	4.50±1.08[a]	4.00±1.05[ab]	4.80±1.55[a]	3.90±1.52[a]	5.30±1.20[ab]
L3	5.00±1.49[a]	4.50±1.35[a]	4.50±0.85[a]	4.60±1.51[a]	5.90±0.88[a]
L4	5.20±1.48[a]	2.70±1.25[c]	4.20±1.55[a]	4.10±1.20[a]	4.10±1.37[b]

As shown in Table 7, The color score of the treatment group with added pigment was significantly higher than that of the control group. The texture scores of the L1 and L3 treatment groups were significantly higher than those of the control group. The L1 flavor score was the highest, followed by the L2 and L3 treatment groups. The L3 treatment group had the highest overall acceptable score and was significantly different from the control group. In addition, the color score and texture score of the L3 treatment group were significantly higher than those of the control group. Tang Hong-gang et al. [25] found that beet powder and sodium nitrite complex, beet powder and modified hemoglobin complex have similar effects to sodium nitrite, making Chinese sausages show uniform bright red, rich aroma, toughness and chewy, effective to improve the sensory score, especially the effect of beet powder and modified hemoglobin complex was more prominent. This proves that adding red yeast rice powder and beet red to sausages can make its color value more and more accepted by people, and the addition of red yeast rice powder and beet red has no effect on the flavor and viscosity of sausages, except to help increase appetite, and it is safe and has a suitable taste. The sensory scores of the L3 treatment group in all aspects are ideal.

Conclusion

Chicken sausage with 400 g of chicken, 50 g of pig back dart, 80 g of pig skin, 6 g of wheat bran as the main raw materials, adding 1.5g of red yeast rice and 1g of beet red, can provide the popular red color of wheat chicken sausages, and provide the cooking loss value of sausages. At the lowest, it helps to improve the hardness, stickiness and chewiness of sausages. Low-field

NMR technology can be used to visually observe the moisture content in chicken sausages. The addition of natural colorants had no negative effect on bran chicken sausage quality. In the industrial application stage, it will be possible to reduce the amount of nitrite used when natural colorants are mixed with nitrite. This study provides data support for the application of natural pigments in chicken sausages.

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