APPLICATION OF WATER EXTRACT FROM HONEYSUCKLE (*Lonicera japonica Thunb*) LEAVES AND ITS EFFECT ON THE QUALITY OF FRESH CHICKEN MEAT*

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The preservation of meat and meat products has been widely concerned, the development of natural food preservatives is currently one of the hot spots of food preservation research. The objective of this study was to explore the feasibility of Honeysuckle（*Lonicera japonica Thunb*）leaf extract as a preservative for meat products.The fresh-keeping effect of honeysuckle leaf water extract (WE-HL) was studied in fresh chickens, pH value, colour, thiobarbituric acid reactive substances (TBARS), volatile basic nitrogen (VBN), texture profile of fresh chickens containing WE-HL, butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT), respectively, were determined during 7-day storage at 4°C. WE-HL can inhibit the oxidation of protein and fat in fresh chicken and has not significantly changed the colour and texture of fresh chicken during storage ($P > 0.05$). Its ability to inhibit lipid oxidation was higher than that of BHA and BHT. WE-HL is noted to be a promising fresh chicken preservative.

honeysuckle leaves; water extract; chicken meat; natural food preservatives; meat quality; antioxidant; meat texture

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INTRODUCTION

Chicken is a popular food in people's daily life because it can provide rich nutrients including protein, vitamins and minerals to maintain human health (Kartikasari et al., 2021). With the rapid socio-economic development, consumers have much higher requirements in food quality and safety (Pathmanathan et al., 2021). As one of the most important quality attributes, freshness of chicken products has attracted the attention of both producers and consumers and has a close relationship with the marketing and consumption of the products. It can be affected by many factors, such as handling and storage conditions (Chowdhury et al., 2023).

The quality of chicken will deteriorate rapidly in the process of processing, transportation, storage and sales after slaughtering, which limits the shelf-life of fresh chicken (Nychas et al., 2008; Pellissery et al., 2020). The preservation of meat and meat products has been widely concerned.

The evaluation of chicken quality included sensory indexes, chemical indexes, physical indexes and microbial indexes (Chacha et al., 2022). Sensory evaluation had a direct impact on consumers' purchasing behavior, it was a subjective method that cannot provide objective quantifiable results (Çapan B. and Bağdatli A., 2023). During storage, fat oxidation rancidity and protein decomposition would change the color, texture and odor of chicken and decrease its quality. Volatile

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basic nitrogen (TVB-N) content and thiobarbituric acid (TBARS) value could measure the degree of protein and fat oxidation, thus reflecting the quality of chicken meat. Meat color, tenderness, water retention, pH value, texture and so on were commonly used as physical indexes to judge meat quality (Fallah et al., 2023; Purwandoko et al., 2023).

In the meat products can use the BHA (butylated hydroxyanisole) and BHT (butylated hydroxytoluene) as food preservatives. Therewith, there are data on limiting the use of these synthetic additives. BHA and BHT can induce allergic reactions in the skin and may contribute to the exacerbation of cutaneous anaphylaxis and the development of asthma and allergic rhinitis (Yamaki et al., 2007).

Nowadays it is growing the consumer demand for clean-label and natural ingredients. It is used some plant extracts used as antioxidants, that exhibit similar or better properties compared to synthetic antioxidants (Shah et al., 2014). Such raw materials have an antioxidant power without affecting the consumers' perceptions and the quality of the final products.

Honeysuckle（*Lonicera japonica Thunb*）is a kind of medicinal and edible plant. Honeysuckle flower is often used to prepare honeysuckle tea (Fang et al., 2022), and its leaves have good antibacterial activity. Shevchuk (2023) found that the extract obtained by extracting honeysuckle leaves with polar solvents contained leucocyanidins, glycosides and flavonoids. The presence of compounds containing P - vitamin activity in the leaves of honeysuckle determines its antioxidant and anti-inflammatory properties. The aqueous extract of honeysuckle leaves contains isoflavones; xanthones; flavones, the presence of which determines its antioxidant and anti-inflammatory properties (Shevchuk et al., 2023). These facts make the extract of honeysuckle leaf most valuable additives for the fresh-keeping of foods. The use of natural food additives is one of the future trends in food preservation (Carocho et al., 2014; Zanetti et al., 2018). This is promising for use for meat prods ucts thanks to their unique antimicrobial properties defend against several harmful bacteria associated with *S. aureus*, *Strep. faecium*, *E. coli*, *Salmonella* (Palíková et al., 2008).

To the best of our knowledge, there have been no studies on the use of Honeysuckle leaf extract as a meat preservative.

In this study, honeysuckle leaves were washed, dried, ground, passed through 80 mesh sieves, extracted with water, filtered under vacuum, concentrated by rotary evaporation, dried under vacuum, and ground in turn to obtain the water extracts of honeysuckle leaves (WE-HL). The objective of the study was to explore the feasibility of aqueous extract of Honeysuckle leaves as a natural preservative for meat. This study can develop a kind of natural preservative for fresh chicken and has important significance for fresh chicken processing and comprehensive utilization of honeysuckle leaves (Katiyo et al., 2020).

MATERIALS AND METHODS

The chicken breast with a core temperature of 2 ± 2 °C (Arbor Acres, females, 49-day-old, after 24–48 h of slaughtering, 72.58% moisture content, 2.34% fat, 22.60% crude protein, and pH 5.89) was purchased from Hualian supermarket in Xinxiang City, China. BHA and BHT are food grade. Honeysuckle *Lonicera japonica Thunb*） leaves were picked from the honeysuckle base in Fengqiu County, Xinxiang City, Henan Province, China.

Process of making honeysuckle leaf powder

Fresh honeysuckle leaves were washed under running water to eliminate surface dust before being dried for five hours at 100°C. The 7% moisture dried honeysuckle leaves were then ground and sieved through an 80-mesh filter. The sieved material was honeysuckle leaf powder.

Preparation of WE-HL

6g of honeysuckle leaf powder and 300mL of distilled water were added to the distillation flask and extracted at 60 ℃ for three times, each time 3h. The leach liquor was vacuum filtered and then concentrated by rotary evaporation at 60 ℃. The concentrated solution was frozen at -20℃ for 12 hours and then put into the vacuum desiccator for 24h. Next, the dried honeysuckle leaf powder were grinded well and placed in a sterile bag for upcoming studies.

Samples preparation

Before the experiment, the auxiliary tools to be used, such as knives and cutting boards, were wiped and disinfected with 75% alcohol, and sterilized under ultraviolet lamp for 30min. After removing the fat and fascia from the surface of the chicken sample, the chicken was cut into 2 × 1 × 1 cm^3 cubes. 0.1% WE-HL aqueous solution, 0.1% BHA aqueous solution, and 0.1% BHT aqueous solution were sprayed evenly over the surface of the fresh chicken according to the liquid-solid ratio of 1:10, respectively. It is then stored in a sterile PE plastic ziplock bag, labeled and refrigerated at 4 °C. By measuring the pH value, color, TBARS, volatile basic nitrogen（VBN) and textural profile of fresh chicken during 7-day storage at 4 ℃, the fresh-keeping effect of 0.1% WE-HL, 0.1% antioxidant BHA, and 0.1% BHT on fresh chicken was studied for the first time, the control check（CK） was without preservative.

Table 1. Changes in pH of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	5.713 ± 0.075^{de}	5.897 ± 0.064^{abcd}	5.737 ± 0.032^{cde}	5.757 ± 0.070^{cd}
3	6.057 ± 0.064^{abcd}	6.170 ± 0.017^{ab}	5.196 ± 0.007^{abcd}	6.090 ± 0.010^{abc}
5	5.410 ± 0.020^{e}	6.170 ± 0.020^{ab}	5.990 ± 0.014^{abcd}	6.153 ± 0.102^{ab}
7		6.427 ± 0.006^{bcd}	6.390 ± 0.030^{abc}	6.247 ± 0.031^{a}

Different lowercase letters mean significant differences ($P<0.05$).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf; BHT: chicken with 0.1% BHA.

pH determination

The pH value was determined carried out as described by (Choe et al., 2018; Nan et al., 2023a) with some modification. 10 g of sample were mixed with 100 g of 0.1 mol/L potassium chloride solution, the mixture was homogenized (speed, 8000 rpm) for 1 minute in homogenizer (T25, IKA, Germany). The homogenates were filtered through Whatman No. 4 filter paper (Whatman, Maidstone, England), the pH value of the filtrate was measured with pH meter (Model320, Metler-Toledo Ltd, Essex, UK). Each treatment was tested three times.

Color determination

As previously reported (Nan et al., 2022c), the color measurement was carried out in five replicates for each formulation using a Minolta chromameter (CR-400, Minolta Camera Co., Japan). The standard white colorimetric plate was L* = 93.56, *a** = 0.01, *b** = 3.45. The probe of the chromameter was placed close to the surface of the chicken to avoid light leakage. The Hunter's colour values (*L** (lightness), *a** (redness), and *b** (yellowness)) of three chicken from each treatment were determined, and the averages were reported. Each treatment was tested five times.

TBARS determination

According to Xu's method with some modification (Xu et al., 2021), 5 g of the ground sample and 20 mL of distilled water were homogenized with a homogenizer (IKA-T25, IKA Instruments Ltd, Staufen, Germany) for 3 minutes. 25 mL of trichloroacetic acid (TCA) aqueous solution was incorporated. The mixture stayed at room temperature for 1 h and then centrifuged at 2000 r/min for 10 min. The supernatant was diluted to 50 ml with distilled water. The diluent (5 mL) was mixed with 0.02mol/L 2-thiobarbituric acid (TBA) aqueous solution (5mL). The mixture was incubated at 95 °C for 20 min before being cooled for 5 min at 0 °C in sequence. Then 10mL chloroform was added in. The mixture was centrifuged at 2000 r/min for 10 min. The absorbance of the supernatant was measured at 532 nm by the spectrophotometer against a distilled water blank. Each treatment was tested five times. The TBARS value was expressed as mg/100 g sausage according to the following formula:

$$\text{TBARSvalue (mg/100g)} = A532 \times 7.8 \quad (1)$$

VBN determination

The value of VBN was determined by semi-micro Kjeldahl method (National Food Safety Standard, GB 5009.228-2016). The sample was dispersed well in 100 mL distilled water and extracted for 30 minutes before filtration. Take 10 ml 20 g /L boric acid solution, 5 drops of mixed indicator solution (1 g /L methyl red mixed with 1 g /L hypomethyl blue mixed by volume ratio of 2:1), 10.0mL filtrate, and 5ml 10g /L magnesium oxide suspension, distill for 6 min, and take out the receiving bottle of the distillate. The sample solution was titrated to the reaction end point with 0.0100 mol/L hydrochloric acid standard titration solution. The value of VBN (mg/100 g) was calculated from the volume of hydrochloric acid consumed. Each treatment was tested three times.

Texture profile analysis (TPA)

Based on a previously reported method (Cerón-Guevara et al., 2021; Nan et al., 2022b) with some modifications. The fresh chicken were cut into $2 \times 1 \times 1$ cm^3 cubes. Texture profile were measured using a TA-XT Plus texture analyzer (Stable Micro Systems, London, UK). Two compression cycle tests were performed, compressing the samples to 40%. The calibration probe consisted of a P36R aluminum cylinder with a 1 kg load cell and a calibration distance of 30 mm. The settings used for texture analysis were as follows: pre-test speed, 2 mm/s; test speed, 1 mm /s; post-test speed, 1 mm/s; and interval time was 5 s. The measured parameters were adhesiveness (mNs), springiness (mm), cohesiveness, and resilience. Each treatment was tested five times.

Table 2. Changes in L* value of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	55.483±5.675	55.027±4.618	57.010±2.077	52.963±0.685
3	54.650±0.910	52.833±7.320	50.913±4.498	56.513±8.372
5	58.423±8.878	54.927±3.506	56.800±3.069	60.020±1.757
7		57.073±0.774	57.203±4.447	56.143±1.121

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BH.

Table 3. Changes in *a** value of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	-0.833±1.136^{b}	-0.413±1.078^{ab}	-0.973±0.266^{b}	0.557±2.467^{ab}
3	-0.467±0.595^{ab}	0.253±1.111^{ab}	-0.330±0.981^{ab}	0.603±1.821^{ab}
5	1.097±0.952^{ab}	1.960±1.642^{a}	0.055±0.375^{ab}	0.305±2.155^{ab}
7		0.417±0.958^{ab}	-0.293±0.700^{ab}	-0.880±0.922^{b}

Different lowercase letters mean significant differences (P <.0.05).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BHA.

Table 4. Changes in *b** value of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	15.567±3.208^{abc}	15.197±1.940^{abc}	18.293±1.381^{abc}	19.690±3.758^{a}
3	12.460±0.500^{c}	19.137±4.312^{a}	12.860±2.296^{bc}	18.957±3.239^{ab}
5	20.257±5.750^{a}	19.690±1.350^{a}	14.693±5.386^{abc}	14.707±0.761^{abc}
7		20.627±0.630^{a}	19.293±1.945^{a}	14.453±4.682^{abc}

Different lowercase letters mean significant differences (P < 0.05).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BHA.

Statistical analysis

SPSS software (v.20.0, IBM Corp., Armonk, NY, USA) was used to statistically analyze the data. Duncan's multiple range tests were applied to determine whether there were significant (P < 0.05) differences between the treatments. The results are expressed as the mean± standard deviation.

RESULTS AND DISCUSSION

pH

The spoilage microorganisms in fresh chicken could cause the decomposition of proteins and nitrogenous substances during its growth and reproduction, metabolites such as amines were produced that change the pH of the chicken. Therefore, pH can reflect the freshness of meat (Adam et al., 2021; Zheng et al., 2022). During storage, the pH value of the experimental group increased continuously (Table 1), while that of the control group increased first and then decreased. On day 5 of storage, the pH values of the three treatment groups were higher than that of CK, but the pH values were no more than 6.17. There was no significant difference among the BHA, WE-HL, and BHT (P > 0.05). However, they are all significantly higher than CK (P < 0.05). It is generally considered spoiled when the pH of meat is higher than 6.17. On day 7 of storage, the pH of all samples was higher than 6.17, so all samples had deteriorated by day 7. On the 5th day of storage, the pH value of CK decreased because the carbohydrates in the chicken

Table 5. Changes in TBARS value of chicken during storage (mg/100g)

Storage time(day)	CK	BHA	WE-HL	BHT
1	2.459±0.044^{f}	1.715±0.028^{j}	1.866±0.056^{i}	1.759±0.013^{j}
3	2.779±0.073^{d}	1.976±0.067^{h}	2.035±0.065^{gh}	2.087±0.067^{g}
5	4.293±0.088^{a}	2.856±0.022^{d}	2.647±0.033^{e}	2.952±0.061^{c}
7		3.759±0.017^{b}	3.737±0.028^{b}	3.737±0.023^{b}

Different lowercase letters mean significant differences ($P < 0.05$).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BHA.

were broken out and fermented by enzymes, which lowered the pH value of chicken. We also observed that the CK group had the smell of spoilage on the 5th day of storage. Therefore, the indexes of the CK were not determined on the 7th day of storage in the experiment.

Color

The meat color of chicken meat was one of the most intuitive factors affecting consumers' desire to buy. Generally speaking, the higher the L* value, the better the color brightness of the meat, the meat was not white, and the meat quality was better; the higher the *a** value, the lower the *b** value, the better the meat color (Tomasevic et al., 2021).

During storage, there was no significant difference in L*, *a**, *b** values between the control group and the three experimental groups. The results (Tables 2, 3, 4) showed that the three preservatives had no significant effect on the color of fresh chicken.

As can be seen from Table 2 and Table 3, although there were differences in L* and *a** values among the control group, BHA, WE-HL and BHT, the differences were not significant ($P > 0.05$). L* value represented brightness, *a** value represents redness, the research results indicated that WE-HL did not significantly change the brightness and redness of chicken meat during storage ($P > 0.05$).

As can be seen from Table 4, on the third day of storage, there was no significant difference between the *b** value of WE-HL group and CK ($P > 0.05$), while the *b** value of BHA and BHT in sample group was significantly higher than CK and WE-HL ($P < 0.05$). During the whole storage period, there was no significant difference between the yellowness values of WE-HL group and CK group ($P > 0.05$), indicating that the protective effect of water extract of honeysuckle leaf on the yellowness of chicken was better than that of BHA and BHT.

In short, water extract of honeysuckle leaf did not significantly change the color of chicken meat during storage ($P > 0.05$).

TBARS

The amount of secondary oxidation products of fat in chicken can be expressed by the value of thiobarbituric acid (TBARS). The higher the content of thiobarbituric acid products, the more serious the decline of chicken quality (Pu et al., 2023). As can be seen from Table 5, with the increase of storage time, the TBARS value of chicken samples increased continuously, indicating that the fat oxidation of chicken samples and the production of a small amount of malondialdehyde and the freshness of chicken samples decreased (Kang et al., 2022). In the same storage time, the TBARS values of the samples with three preservatives were all less than CK significantly ($P < 0.05$), indicating that the three preservatives could delay the fat oxidation of fresh chicken (Rupasinghe et al., 2022; Song et al., 2022) (Table 5). On the 5th day, the TBARS value of WE-HL was lower than that of the other three groups significantly ($P < 0.05$). On the 7th day, there was no significant difference between the experimental groups ($P > 0.05$). In conclusion, the water extract can significantly inhibit the rate of lipid oxidation ($P < 0.05$).

VBN

Chicken was rich in protein. Protein would decompose under the action of enzymes and microorganisms to produce ammonia and amines and other basic nitrogenous substances. By measuring the content of volatile basic nitrogen (TVB-N), the quality of chicken can be determined. The higher the content, the lower the freshness (Kademi et al., 2019).

As can be seen from Table 6, during the storage, the value of VBN in the experimental group and the control group increased continuously. In the same storage time, the values of VBN in the samples with three preservatives were less than control group, which indicated that the three preservatives could delay the protein oxidation rate of fresh chicken (Rakasivi et al., 2022). On the 5th day, the values of VBN in the three treatment groups were lower than those in

Table 6. Changes in VBN value of chicken during storage (mg/100g)

Storage time(day)	CK	BHA	WE-HL	BHT
1	4.900±0.700^{fgh}	2.800±0.700^{i}	4.200±0.700^{h}	4.433±0.404^{gh}
3	5.833±0.404^{def}	4.433±0.404^{gh}	5.367±0.404^{efg}	5.133±0.404^{fgh}
5	7.700±0.400^{b}	6.533±0.404^{cd}	6.733±0.404^{c}	6.300±0.700^{cde}
7		10.500±0.700^{a}	10.033±0.404^{a}	9.800±0.700^{a}

Different lowercase letters mean significant differences (P.<.0.05).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BHA.

Table 7. Changes in adhesiveness of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	-59.686±11.417^{ab}	-58.611±11.712a^{b}	-57.420±12.119^{a}	-57.920±9.499^{ab}
3	-78.550±18.302^{b}	-66.850±17.558^{ab}	-66.490±6.656^{ab}	-67.139±13.074^{ab}
5	-85.543±16.012^{c}	-73.066± 9.295^{ab}	-71.743±17.193^{ab}	-75.550±6.935^{ab}
7		-83.586±10.535^{bc}	-82.300±30.070^{bc}	-82.300±10.981^{bc}

Different lowercase letters mean significant differences (P < 0.05)

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BHA.

Table 8. Changes in springiness of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	0.919±0.200^{ab}	0.920±0.136^{ab}	0.933±0.100^{a}	0.927±0.209^{ab}
3	0.859±0.192^{ab}	0.870±0.154^{ab}	0.860±0.124^{ab}	0.867±0.208^{ab}
5	0.723±0.115^{b}	0.825±0.160^{ab}	0.806±0.155^{ab}	0.796±0.165^{ab}
7		0.740±0.172^{b}	0.721±0.144^{b}	0.710±0.128^{b}

Different lowercase letters mean significant differences (P < 0.05).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BHA.

the control group significantly (P＜0.05), indicating that the three treatment groups produced less nitrogen-containing compounds such as ammonia (NH_3) and low-molecular-weight amines, and had better freshness (K i m et al., 2022).

However, there was no significant difference among the three treatment groups (P＞0.05), indicating that BHA, WE-HL, and BHT all have the ability of anti-oxidation to protein, while there is no difference in their anti-oxidation ability to protein (P＞0.05) (Table 6).

TPA

The tissue status of meat products is closely related to the freshness of meat, and TPA is useful for quickly evaluating the texture of food (A d a m , 2021). During storage, the adhesiveness of all the samples increased gradually, but the adhesiveness of BHA, WE-HL and BHT was lower than that of CK, and WE-HL was less than the experimental group with BHA and BHT. On the 5th day of storage, the adhesiveness of BHA, WE-HL, and BHT was significantly lower than CK (P < 0.05), but there was no significant difference between them (P > 0.05) (Table 7).

The springiness value (Table 8), cohesiveness value (Table 9) and resilience value (Table 10) of chicken samples decreased continuously during the storage period of 1 to 7 days. In the same storage period, the springiness, cohesiveness and resilience of the samples with three kinds of preservative solutions were

Table 9. Changes in cohesiveness of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	0.586±0.115^{ab}	0.587±0.200^{ab}	0.599±0.145^{a}	0.592±0.132^{ab}
3	0.467±0.135^{bc}	0.527±0.058^{b}	0.507±0.253^{b}	0.530±0.486^{b}
5	0.450±0.154^{c}	0.483±0.122^{bc}	0.470±0.125^{bc}	0.491±0.159^{b}
7		0.467 ± 0.064^{bc}	0.467 ±0.280^{bc}	0.489 ± 0.141^{bc}

Different lowercase letters mean significant differences ($P < 0.05$).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf ; BHT: chicken with 0.1% BHA.

Table 10. Changes in resilience of chicken during storage

Storage time(day)	CK	BHA	WE-HL	BHT
1	0.322±0.105^{ab}	0.340±0.186^{a}	0.327±0.177^{ab}	0.330±0.198^{ab}
3	0.297±0.231^{ab}	0.308±0.356^{ab}	0.303±0.113^{ab}	0.304±0.136^{ab}
5	0.268±0.125^{c}	0.297±0.568^{b}	0.287±0.568^{b}	0.296±0.126^{b}
7		0.270±0.201^{bc}	0.273±0.196^{bc}	0.276±0.110^{bc}

Different lowercase letters mean significant differences ($P < 0.05$).

Note: CK: chicken with no preservative; BHA: chicken with 0.1% BHA; WE-HL: chicken with 0.1% water extract of honeysuckle leaf; BHT: chicken with 0.1% BHA.

higher than those of CK, and there was no significant difference among the three preservatives ($P > 0.05$). According to the results of VBN in this study, it can be inferred that this may be because BHA, WE-HL and BHT reduced the degree of protein degradation and actomyosin decomposition of chicken meat, so that the muscle binding force was greater than CK. However, on the 5th day, the cohesiveness of BHT and the resilience of BHA, WE-HL, and BHT was greater significantly than those of CK ($P < 0.05$).

All the obtained results of the study of the use of WE-HL as a preservative for raw chicken meat are significant. Previous studies of scientists were devoted to fermented meat (Jurcaga et al., 2022), but the results of the research presented in this article are unique, since raw chicken meat was taken as the object of research.

CONCLUSIONS

WE-HL could significantly inhibit the growth and reproduction of spoilage microorganisms in fresh chicken and delay the lipid and protein oxidation of fresh chicken, and its antioxidant capacity to fat was significantly stronger than BHA and BHT ($P < 0.05$).

The pH values for the samples using the WE-HL did not increase as rapidly as for the samples than BHA and BHT.

WE-HL could keep the color and texture characteristics of fresh chicken and had the same protection effect as BHA and BHT. There was no significant difference between the yellowness values of WE-HL group and CK group ($P > 0.05$), indicating that the protective effect of water extract of honeysuckle leaf on the yellowness of chicken was better than that of BHA and BHT.

The results of the study showed that there was no significant difference between the three treatment groups ($P > 0.05$), indicating that all BHA, WE-HL and BHT have protein antioxidant capacity, while there is no difference in their protein antioxidant capacity.

WE-HL can be used as a natural preservative for fresh chicken. The shelf-life of fresh chicken can be extended from 3 days to 5 days. This study provided new ideas for the further processing and utilization of honeysuckle leaves.

AUTHOR CONTRIBUTIONS

Conceptualization, Haijuan Nan, Stepanova Tetiana and Bo Li; methodology, Stepanova Tetiana; software, Stepanova Tetiana; validation, Haijuan Nan and Stepanova Tetiana; formal analysis, Haijuan Nan; investigation, Haijuan Nan and Bo Li; resources, Bo Li; data curation, Haijuan Nan; writing—original draft preparation, Haijuan Nan; writing—review and editing,

Stepanova Tetiana and Bo Li; visualization, Bo Li; supervision, Stepanova Tetiana; project administration, Stepanova Tetiana; funding acquisition, Haijuan Nan and Bo Li. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Adam SSM (2021): Sensory and Instrumental Methods of Meat Evaluation: A review. International Journal of Food Science and Agriculture, 5(4), 627–638. doi: https://doi.org/10.26855/ijfsa.2021.12.010

Çapan B, Bağdatli A (2023). Investigation of organic chicken breeding and meat quality. Animal Health, Production and Hygiene, 12(1), 52–59. doi: https://doi.org/10.53913/aduveterinary.1263469

Carocho M, Barreiro MF, Morales P, Ferreira IC (2014): Adding Molecules to Food, Pros and Cons: A review on synthetic and natural food additives. Comprehensive Reviews in Food Science and Food Safety, 13(4), 377–399. doi: https://doi.org/10.1111/1541-4337.12065

Cerón-Guevara MI, Santos EM, Lorenzo JM, Pateiro M, Bermúdez-Piedra R, Rodríguez JA, Castro-Rosas J, Rangel-Vargas E (2021): Partial replacement of fat and salt in liver pâté by addition of Agaricus bisporus and Pleurotus ostreatus flour. International Journal of Food Science & Technology, 56(12), 6171–6181. doi: https://doi.org/10.1111/ijfs.15076

Chacha JS, Ofoedu CE, Xiao K (2022): Essential oil-based active polymer-based packaging system: A review of its effect on the antimicrobial, antioxidant, and sensory properties of beef and chicken meat. Journal of Food Processing and Preservation, 46(11). doi: https://doi.org/10.1111/jfpp.16933

Choe J, Lee J, Jo K, Jo C, Song M, Jung S (2018): Application of winter mushroom powder as an alternative to phosphates in emulsion-type sausages. Meat Science, 143, 114–118. doi: https://doi.org/10.1016/j.meatsci.2018.04.038

Chowdhury MAH, Ashrafudoulla M, Mevo SIU, Mizan MFR, Park SH, Ha SD (2023): Current and future interventions for improving poultry health and poultry food safety and security: A comprehensive review. Comprehensive Reviews in Food Science and Food Safety, 22(3), 1555-1596. doi: https://doi.org/10.1111/1541-4337.13121

Determination of volatile base nitrogen in food. CNS. GB 5009.228 (2016).

Fallah AA, Sarmast E, Jafari T, Mousavi Khaneghah A (2023): Vegetable oil-based nanoemulsions for the preservation of muscle foods: A systematic review and meta-analysis. Critical Reviews in Food Science and Nutrition, 63(27), 8554-8567. doi: https://doi.org/10.1080/10408398.2022.2057415

Fang L, Long N, Li Y, Liao X, Shi L, Zhao H, Zhou L, Kong W (2022): Transfer behavior of pesticides from honeysuckle into tea infusions: establishment of an empirical model for transfer rate prediction. Ecotoxicology and Environmental Safety, 234, 113377. doi: https://doi.org/10.1016/j.ecoenv.2022.113377

Jurcaga L, Bobko M, Haščík P, Bobková A, Demianová A, Belej L, Kročko M, Mendelova A, Čech M, Herc P, Mesárošová A. (2022): Effect of Blackcurrant and Kamchatka Honeysuckle Extracts on Quality Properties of Raw-Cooked Meat Product. Journal of Microbiology Biotechnology and Food Sciences, 12(3), e5349. doi: https://doi.org/10.55251/jmbfs.5349

Kademi HI, Ulusoy BH, Hecer C (2019): Applications of miniaturized and portable near infrared spectroscopy (NIRS) for inspection and control of meat and meat products. Food Reviews International, 35(3), 201-220. doi: https://doi.org/10.1080/87559129.2018.1514624

Kang T, Kang T, Yim D, Yim D, Kim SS, Kim SS, Baek KH, Kim HJ (2022): Effect of plasma-activated acetic acid on inactivation of salmonella typhimurium and quality traits on chicken meats. Poultry Science, 101(5), 101793. doi: https://doi.org/10.1016/j.psj.2022.101793

Kartikasari LR, Hertanto BS, Nuhriawangsa AMP (2021): Nutritional Value of Chicken Meat Fed Diet Supplemented with Purslane Rich in Omega-3 Fats. IOP Conference Series: Earth and Environmental Science, 828(1), 012039. doi: https://doi.org/10.1088/1755-1315/828/1/012039

Katiyo W, de Kock HL, Coorey R (2020): Sensory implications of chicken meat spoilage in relation to microbial and physicochemical characteristics during refrigerated storage. Lwt, 128, 109468. doi: https://doi.org/10.1016/j.lwt.2020.109468

Kim YY, Park SJ, Kim JS, Shin HS (2022): Development of freshness indicator for monitoring chicken breast quality and freshness during storage. Food Science and Biotechnology. doi: https://doi.org/10.1007/s10068-022-01034-x

Nan H, Stepanova TM, Li B (2023): Effects of button mushroom Agaricus bisporus (Agaricomycetes) and soybean oil on storage characteristics of chicken sausage. International Journal of Medicinal Mushrooms, 25(9), 73–83. doi: https://doi.org/10.1615/IntJMedMushrooms.2023049470

Nan H, Stepanova TM, Kondratiuk NV, Nie Y, Li B (2022): Effects of Agaricus bisporus on gel properties of chicken myofibrillar protein. International Journal of Food Science and Technology, 57, 5532–5541. doi: https://doi.org/10.1111/ijfs.15898

Nan H, Zhou H, Li B, Stepanova T, Kondratiuk N (2022): Effects of Agaricus bisporus alone or in combination with soybean oil or water as fat substitutes on gel properties, rheology, water distribution, and microstructure of chicken batters. Food Science and Technology, 42, e116121. doi: https://doi.org/10.1590/fst.116121

Nychas GJ, Skandamis PN, Tassou CC (2008): Meat spoilage during distribution. Meat Science, 78(1/2), 77-89. doi: https://doi.org/10.1016/j.meatsci.2007.06.020

Palíková I, Heinrich J, Bednář P, Marhol P, Křen V, Cvak L, Valentová K, Růžička F, Holá V, Kolář M (2008): Constituents and antimicrobial properties of blue honeysuckle: A novel source for phenolic antioxidants. *Journal of Agricultural* and *Food Chemistry*. 56, 11883–11889. doi: https://doi.org/10.1021/jf8026233

Pathmananathan PR, Aseh K, Kenny K (2021): Consumer Behavior and Purchase Intention of Organic Meat: An Overview. Archives of Business Research. doi: https://doi.org/10.14738/abr.96.10347

Pellissery AJ, Vinayamohan PG, Amalaradjou MAR (2020): Spoilage bacteria and meat quality. Meat quality analysis. Academic Press, 307-334. doi: https://doi.org/10.1016/B978-0-12-819233-7.00017-3

Pu H, Wei Q, Sun DW (2023): Recent advances in muscle food safety evaluation: Hyperspectral imaging analyses and applications. Critical Reviews in Food Science and Nutrition, 63(10), 1297-1313. doi: https://doi.org/10.1080/10408398.2022.2121805

Purwandoko PB., Kuala SI, Susanti ND, Apriyanto IF, Novianti F, Tribowo RI (2023): Current Technological Approach for Chicken Meat Freshness Evaluation: A Review. In BIO Web of Conferences 69, e 03018. EDP Sciences. doi: https://doi.org/10.1051/bioconf/20236903018

Rakasivi KGJ, Chin KB (2022): Evaluation of product quality of chicken sausages with addedcinnamon (cinnamomum cassia) and mushroom (pleurotus sajur-caju) powders at various concentrations. Journal of Food Processing and Preservation, 46, e16958. doi: https://doi.org/10.1111/jfpp.16958

Rupasinghe R, Alahakoon A, Alakolanga A, Jayasena D, Jo C (2021): Oxidative stability of vacuum-packed chicken wings marinated with fruit juices during frozen storage. Korean Society for Food Science of Animal Resources, 42, 61-72. doi: https://doi.org/10.5851/KOSFA.2021.E62

Shah M.A., Bosco S.J.D., Mir S.A. Plant extracts as natural antioxidants in meat and meat products. Meat Sci. 2014;98:21–33. doi: 10.1016/j.meatsci.2014.03.020.

Sheikha AFE, Allam AY, ElObeid T, Basiouny EA, Abdelaal AA, Amarowicz R, Oz E, Proestos C, Karrar E, Oz F (2022): Impact of a Carboxymethyl Cellulose Coating Incorporated with an Ethanolic Propolis Extract on the Quality Criteria of Chicken Breast Meat. Antioxidants, 11(6), 1191. doi: https://doi.org/10.3390/antiox11061191

Shevchuk L, Vintskovska Y, Babenko S, Hrynyk R, Levchuk L (2023): Sensory and bioactive quality indicators of fresh and dried blue honeysuckle fruits (Lonícera caeruléa L.). Roslinnictvo ta Ġruntoznavstvo, 14(4), 98–110. doi: https://doi.org/10.31548/plant4.2023.98

Song J, Jiang L, Qi M, Suo W, Deng Y, Ma C, Li H, Zhang D (2022): Microencapsulated procyanidins by extruding starch improved physicochemical properties, inhibited the protein and lipid oxidant of chicken sausages. Journal of Food Science, 3, 1184-1196. doi: https://doi.org/87. 10.1111/1750-3841.16057

Tomasevic I, Djekic I, Furnol MFI, Terjung N, Lorenzo JM (2021): Recent advances in meat color research. Current Opinion in Food Science, 41. doi: https://doi.org/10.1016/j.cofs.2021.02.012

Xu D, Zhang H, Zhang L, Huang T, Jia R, Lu J (2021): Effects of electron beam irradiation on quality of weever fillets during refrigerated storage. Food Frontiers, 2, 519-26. doi: https://doi.org/10.1002/fft2.80

Yamaki K, Taneda S, Yanagisawa R, Inoue KI, Takano H, Yoshino S (2007): Enhancement of allergic responses in vivo and in vitro by butylated hydroxytoluene. Toxicol. Appl. Pharmacol, 223,164–172. doi: https://doi.org/10.1016/j.taap.2007.05.007

Zanetti M, Carniel TK, Dalcanton F, dos Anjos RS, Gracher Riella H, de Araújo PHH, de Oliveira D, Antônio Fiori M (2018): Use of encapsulated natural compounds as antimicrobial additives in food packaging: A brief review. Trends in Food Science & Technology 81, 51-60. doi: https://doi.org/10.1016/j.tifs.2018.09.003

Zheng L, Liu L, Yu J, Shao P (2022): Novel trends and applications of natural pH-responsive indicator film in food packaging for improved quality monitoring. Food Control, 134, 108769. doi: https://doi.org/10.1016/j.foodcont.2021.108769

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