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EFFECTS OF AGARICUS BISPORUS AND FLAMMULINA VELUTIPES MUSHROOMS ON QUALITY OF CHICKEN BATTERS

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ABSTRACT *It was noted the modern tendencies of the cultivated mushrooms using as a fat substitutes in the technology of low-fat meat products. It was states that variety of low-calorie, low-fat foods have come to the fore, and quickly become the mainstream of the future development of food. The mushrooms are worldwide cultivated and rich in protein, vitamins, dietary fiber, amino acids, polysaccharides, minerals, but low in fat and calories In order to develop low-fat meat products, the compound of Agaricus bisporus and Flammulina velutipes mushrooms were used as fat substitute to replace the pork-back fat in chicken batters. The amino acids content of these mushrooms allows receiving a nice flavor and can be use in the minced meat. It was use a chicken meat as a well-liked raw material for emulsified products. For preparation of meat batters was used chicken breast, salt and sodium tripolyphosphate. The chicken meatballs were prepared with the cultivated mushrooms as fat-substitutes.The mushrooms were compounded to replace fat in chicken batters, and the effect of compounding these mushrooms on the quality of chicken mince was investigated to find the optimal ratio of fat replacement. The cooking loss, water holding capacity, color, texture and rheological properties of chicken batters were studied. The results showed that the compound of Agaricus bisporus and Flammulina velutipes improved the texture, increased the water holding capacity, redness and yellowness, and reduced the cooking loss and brightness of chicken batters. When the ratio of Agaricus bisporus and Flammulina velutipes was 2:1 to replace 30% pork-back fat, chicken batters showed the best quality. In conclusion, the combination of Agaricus bisporus and Flammulina velutipes is a promising fat substitute in the development of low-fat meat products.*

Keywords: *cultivated mushrooms; Agaricus Bisporus; Flammulina velutipes; chicken meat; fat*

ВПЛИВ ГРИБІВ AGARICUS BISPORUS І FLAMMULINA VELUTIPES НА ЯКІСТЬ КУРЯЧОГО ФАРШУ

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АНОТАЦІЯ *Розглянуто сучасні тенденції використання культивованих грибів як жирозамінників у технології м'ясних продуктів зі зниженим вмістом жиру. Встановлено, що різноманітність низькокалорійної їжі з низьким вмістом жиру вийшла на перший план і швидко стала основним напрямком майбутнього розвитку харчової продукції. Гриби, які використовувалися під час дослідження, культивуються в усьому світі та багаті білком, вітамінами, харчовими волокнами, амінокислотами, полісахаридами, мінералами, проте мають низький вміст жиру та невисоку калорійність. Для розробки м'ясних продуктів за зниженим вмістом жиру суміш грибів Agaricus bisporus та Flammulina velutipes використовувалася для заміни свинячого жиру в курячому фарші. Вміст амінокислот у грибах дозволяє отримати приємний смак і використовувати їх у фарші. Було використано куряче м'ясо, як популярну сировину для емульгованих продуктів. Для приготування м'ясного фаршу використовували курячу грудку, сіль і триполіфосфат натрію. З використанням культивованих грибів, як жирозамінника, були виготовлені курячі фрикадельки. Гриби були використані для заміни жиру в курячому фарші, було досліджено вплив суміші грибів на якість курячого фаршу, з метою визначення оптимального співвідношення такої заміни. Було вивчено теплові втрати, водоутримувальну здатність, колір, консистенцію та реологічні властивості курячого фаршу. Результати показали, що суміш Agaricus bisporus і Flammulina velutipes покращила текстуру, збільшила водоутримувальну здатність, колірні характеристики, а також зменшила втрати при тепловій обробці та яскравість курячого фаршу. Встановлено співвідношення Agaricus bisporus і Flammulina velutipes, що становило 2:1 для заміни 30% свинячого жиру, коли курячий фарш виявив найвищі показники якості. Таким чином, поєднання Agaricus bisporus і Flammulina velutipes є перспективним для заміни жиру при розробці м'ясних продуктів зі зниженим вмістом жиру.*

Ключові слова: *культивовані гриби; Agaricus Bisporus; Flammulina velutipes; м'ясо курки; жир*

Introduction

Health issues become particularly important with the development of society. As one of the three major nutrients in food, fat provides human body with the nutrients they need, but excessive intake of fat can lead to hypertension, myocardial infarction, stroke and other serious diseases and also easily lead to metabolic syndrome, neuropsychiatric disorders and other diseases in obese people. Therefore, a variety of low-calorie, low-fat foods have come to the fore, and quickly become the mainstream of the future development of food [1]. However, fat has important influence on the physical properties of food, such as appearance, flavor, texture and rheology during food processing, the reduction or removal of fat will result in significant decrease in food quality. In view of this, the use of fat substitutes to develop and produce low-fat products that are as consistent as possible with the taste of traditional full-fat products has become a major development trend in the production of low-fat food products, showing great challenges and development potential [2].

Agaricus Bisporus (Ab) and *Flammulina velutipes* (Fv) mushrooms are cultivated worldwide and rich in protein, vitamins, dietary fiber, amino acids, polysaccharides, minerals, but low in fat and calories [3,4].

One of the most well-liked emulsified meat items around the world is chicken products. Typically, a chicken sausage comprises 20–35% fat, which is crucial for the water holding capacity, cooking loss, flavor, colour and textural qualities of emulsified products [1]. In this study, for the first time, Ab and Fv mushrooms were compounded to replace fat in chicken batters, and the effect of compounding Ab and Fv mushrooms on the quality of chicken mince was investigated to find the optimal ratio of fat replacement. Many studies have demonstrated that proteins and dietary fibers contribute to the formation of the gel system of minced meat[5,6]. The abundance of amino acids in Ab and Fv mushroom also adds flavor to minced meat. Therefore, Ab and Fv mushroom should be ideal fat substitutes. The results of this study can be used as a reference for the development of low-fat meat products.

The purpose of the work

The goal of the work is investigation of Agaricus bisporus and Flammulina velutipes as a valuable raw materials for fat substitutes in meat products.

Materials and Methods

Materials. Fresh chicken breast meat, pork-back fat, *Agaricus bisporus* (*Ab*) mushroom, *Flammulina velutipes (Fv)* mushroom, sugar, white pepper powder, sodium polyphosphate were obtained from Silpo Supermarket, Sumy, Ukraine. Methyl silicone oil was analytically pure grade.

Raw material treatment. *Ab and Fv* mushrooms were washed, dried (45°C for 12 h) and ground. *Ab* powder sieved through a 200 mesh sieve and *Fv* powder sieved through a 40 mesh sieve. The excess fat and connective tissue of the fresh chicken breasts and the excess connective tissue of pork-back fat were removed, and then chicken breasts meat and pork-back fat were placed into vacuum bags respectively after being ground separately using a grinder with a 6 mm perforated plate, (MM-12, Guangdong, China).Then they were stored at -40°C.

Chicken batters preparation. The chicken meat and pork-back fat were thawed. The preparation of meat batters was carried out in an ice water bath as follows: chicken breast, salt and sodium tripolyphosphate were mixed in a cutter bowl (Joyoung S2-A808, Jinan, China) for 30 seconds. After a 3-minute break, the One-third of the ice water was added, and the mixture was then chopped for 30 seconds. Pork-back fat, *Ab and Fv* mushroom powder, white pepper powder, sugar, one-third of the ice water were added, and the mixture was then chopped for 2 minutes after a 3-minutes pause. Finally, the remaining one-third of the ice water was added, and the mixture was then chopped for 1 minute after a 3-minutes pause. The meat batters was placed into a 50 ml centrifuge tube and centrifuged at 500 × g for 5 minutes to remove the residual air. The rheology was determined for the raw meat batters after the above treatments. The rest of the meat batters was boiled at 80 ℃ in a constant-temperature water bath for 30 minutes, and then cooled in the ice-water bath for 20 minutes. The cooked chicken batters were taken out for the determination of cooking loss, water holding capacity, color and texture.

Determination of cooking loss (CL). According to Choe et al. [7] with a slight modification, m_1 gram of raw chicken batters wad placed into a 50ml centrifuge tube and cooked at 80°C. Next, the cooked chicken batters were weighed to obtain m_2 after absorbing the surface moisture with absorbent paper. Finally, the CL was calculated according to the following formula. For each formulation, the measurement was performed three times.

$$CL\,(\%) = \frac{m1 - m2}{m1} \times 100 \qquad (1)$$

Determination of water holding capacity (WHC). According to the method of Wang et al.[8] with a slight modification, about 10 g (m1) of cooked chicken batters was wrapped in absorbent paper and placed into a 50 mL centrifuge tube and then centrifuged at 8000 r/min for 10 minutes. Next, cooked chicken batters was weighted after removing the absorbent paper to obtain m_2. For each formulation, the measurement was performed three times.

Determination of color. According to the method of Zahari et al.[9] with a slight modification, the cooked chicken batters was cut into 2 cm cylinders. The colour of its center part was measured with CR-400 color meter, and the L* value, b* value and a* value were recorded. Where L* represented the brightness, a* represented the redness, and b* represented the yellowness. The colour of the Standard white colorimetric plate was L*=96.15,

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a*=0.70, b*=1.83. For each formulation, the measurement was performed five times.

Determination of texture profile analysis (TPA). According to the method of Li et al. [10] with a slight modification, the cooked chicken batters was cut into 2 cm small cylinders, and the hardness, springiness, cohesiveness and chewiness of chicken batters were measured by a texture analyzer with a P36R probe at 20℃. The texture properties of the sample were determined according to the following parameters: compression ratio, 50%; pre-test rate, 2.0mm/s; test rate, 2.0mm/s; post-test rate, 5 mm/s; test time, 5 s; trigger force, 5.0g. For each formulation, the measurement was performed three times.

Determination of rheological properties. According to the method of Xu et al.[11] with some modification, an appropriate amount of raw chicken batters was placed on the sample table of rheometer with a probe of p35TiL and a gap of 1 mm and sealed with silicone oil. Dynamic temperature scanning was carried out in the linear viscoelastic region of oscillation mode and 1% strain. Dynamic temperature scanning conditions as follows: the sample was held at 20 ℃ for 2 min; Heating procedure, 20~80 ℃; heating rate, 2 ℃/min. During the heating process, the sample was continuously shear in an oscillating mode and at a fixed frequency of 0.1 Hz, and the change of the storage modulus (G') during the dynamic scan was recorded. For each formulation, the measurement was performed three times.

Statistical analysis. The one-way ANOVA and means comparison test (Duncan) were used to examine the impact of the various formulations using SPSS 20.0 (IBM) statistical software, and the significance threshold was set at 5%. The data was expressed as mean ± standard deviation.

Results and analysis

Effect of *Ab and Fv* mushrooms on the CL of chicken batters. Table 1 shows the effects of different proportions of *Ab and Fv* mushrooms on the CL of chicken batters. As can be seen from Table 2, compared to CK, the CL of chicken batters decreased significantly when adding *Ab and Fv* mushrooms ($P < 0.05$). There was no significant difference between the CLs of T_1, T_2, T_3 ($P > 0.05$). Meanwhile, T_4 had a significantly lower CL ($P < 0.05$). The low CL were attribute to the rich dietary fiber in the mushrooms, which has the ability to absorb water, showing high water retention [12].

Effect of *Ab and Fv* mushrooms on the WHC of chicken batters. Table 2 shows the effects of different proportions of *Ab and Fv* mushrooms on the WHC of chicken batters. As can be seen from Table 3 that WHC increases gradually with the increase of the amount of Ab and Fv mushroom. WHC of T_1 group was significantly lower than that of CK group ($P < 0.05$), i.e., the WHC of batters with only the addition of *Ab* decreased. WHC of T_2 and T_3 groups was not significantly different from that of CK ($P > 0.05$), WHC of T_4 group was significantly higher than that of CK($P < 0.05$). Ab and Fv mushrooms are rich in dietary fibers and carbohydrates. Dietary fiber dispersed in water can form a spherical gel solution, which can effectively enhance the water retention of chicken batters; carbohydrates combined with water molecules to form a reticulated gel that can retain a large amount of water[10]. This study showed that the addition of Ab and Fv compound effectively enhanced the WHC of chicken batters.

Effect of *Ab and Fv* mushrooms on colour of chicken batters. Table 3 shows the effects of different proportions of *Ab and Fv* mushrooms on the colour of chicken batters. From Table 4, it can be seen that the addition of *Ab and Fv* mushrooms complex decreased the brightness (L*) and increased the yellowness (b*) and redness (a*) of chicken batters. As the amount of Ab and Fv mushrooms increased, the brightness decreased significantly ($P < 0.05$), and the yellowness and redness did not change significantly($P > 0.05$). The main reason for this was the browning of *Ab and Fv* mushrooms during drying, which deepened their color and accordingly gave them a low brightness and high redness and yellowness [13].

Effect of *Ab and Fv* mushrooms on the TPA of chicken batters. Table 3 shows the effects of different proportions of *Ab and Fv* mushrooms on the TPA of chicken batters. From Table 4, it can be seen that *Ab* and *Fv* mushrooms changed the TPA of the chicken batters. The hardness and chewiness of the chicken batters increased significantly ($P < 0.05$) with the increase in the amount of *Ab* and *Fv* mushrooms, but there was no significant difference in chewiness between the T3 and T4 groups ($P > 0.05$). Springiness was significantly increased in T_2 group compared to CK ($P < 0.05$). The increase in hardness, chewiness and elasticity should be relative to the increased WHC and decreased cooking loss of the chicken batters due to the dietary fiber in the mushrooms [14]. The significant decrease in the cohesiveness of T_3 and T_4 groups compared to CK attribute to the ash contained in the mushrooms [6]. Taken together, the T_2 group showed improved firmness, chewiness and springiness without decreasing the cohesiveness of the chicken batters, and the T2 group was the most effective in improving the TPA of the chicken batters.

Table 1 – Cooking loss of chicken batters

Treatments	CK	T1	T2	T3	T4
Cooking loss /%	2.98±0.25a	2.45±0.22b	2.23±0.11b	2.09±0.21b	1.61±0.20c

a–c Means within a line with different letters are significantly different ($p < 0.05$)

Table 2 – WHC of chicken batters

Treatments	CK	T_1	T_2	T_3	T_4
WHC/%	93.10±0.25bc	90.63±0.09d	92.77±0.20c	93.63±0.45b	94.55±0.37a

a–d Means within a line with different letters are significantly different ($p < 0.05$).

Table 3 – Colour of chicken batters

Treatments	L^*	a^*	b^*
CK	87.89±0.30a	0.13±0.10b	12.63±0.47b
T_1	69.01±0.58b	2.77±0.19a	16.46±0.41a
T_2	68.34±0.59b	2.58±0.14a	16.21±0.26a
T_3	64.63±1.14c	2.39±0.26a	16.69±0.25a
T_4	61.76±0.38d	2.75±0.10a	16.25±0.21a

Effect of *Ab and Fv* mushrooms on the G' of chicken batters

Myofibrillar proteins and protein-protein interactions, particularly those involving the myosin protein, are constantly changing processes that are reflected in dynamic rheological properties. These processes are strongly related to the intramolecular and intermolecular binding in protein molecules. The matrix strength and elastic characteristics of the meat gel network are indicated by variations in the storage modulus (G') [15]. As can be seen from Fig. 1, the changes of G' of chicken batters with different amount of *Ab and Fv* mushrooms had a similar trend, which was roughly divided into five stages. G' increased slightly (21~25 ℃); G' slowly decreased (26~53 ℃); G' continued to increase (54~59 ℃) , the myosin head polymerization in chicken batters made the reaction between proteins to form a weak gel in this stage[16]. G' appeared to fall sharply to reach the bottom (60~63 ℃) due to the denaturation of the myosin tail in chicken batters, resulting in the formation of the structure of the protein gel damage [5,17]. G' increased sharply (64~80 ℃), the proteins

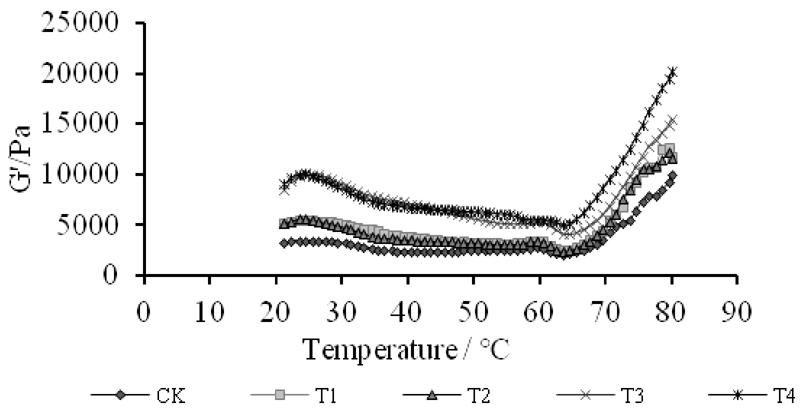

Fig. 1 – G' of chicken batters

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aggregated and formed a gel, and the semi-soluble gel formed an elastic gel after being heated, and then the chicken batters was transformed from a viscous-elastic sol-gel state to an elastic gel network structure in this stage[6,18]. Throughout the temperature rise, the G' of chicken batters with *Ab* and *Fv* mushrooms compound were greater than that of CK and increased with increasing mushroom amount. Higher G' values indicated a more compact meat gel structure, which was similar to the change in hardness values [19]. The addition of dietary fiber could effectively improve the solubility of proteins, thus increasing the G' value of the system, and the pattern of the change of its G' value is related to the gel denaturation temperature [10,20].

Conclusion

Partial replacement of pork-back fat in chicken batters with *Ab* and *Fv* mushrooms compound reduced cooking loss, increased redness and yellowness, decreased brightness and improved rheological properties of chicken batters. Water holding capacity, chewiness, hardness and springiness of chicken batters were increased, and the cohesiveness decreased significantly when fat substitution exceeded 30%. In conclusion: all the qualities of chicken batters were improved when *Ab* and *Fv* mushrooms were compounded at 2:1 to replace 30% of pork-back fat in chicken batters. *Ab* and *Fv* mushrooms compound is a promising fat substitute for producing low-fat meat products.

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