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# Influence of some edible coatings on physicochemical and sensory properties of low-fat fried mushroom (*Agaricus bisporus*)

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**ABSTRACT**

White button mushroom (*Agaricus bisporus*) is widely used in cooking and has good nutritional value. Today, the demand for fried edible mushrooms is increasing. Edible coatings can reduce oil uptake and improve the quality characteristics of fried products. In this study, the effect of wheat flour (0, 1, 2 and 3% w/v), corn flour (0, 1, 2 and 3% w/v) and Aloe vera gel (0, 10, 20 and 30% w/v) on the quality attributes of mushroom during deep fat frying were investigated. The results showed that different coating materials decreased oil absorption in the final product ($p<0.05$). The lowest amount of oil uptake was observed for samples coated with 3% of wheat flour and 1% corn flour and 10% Aloe vera gel. Also, the used coatings agents improved frying efficiency, moisture content and sensorial properties of fried mushroom ($p<0.05$). Colorimetric results showed that the Aloe vera and wheat flour coatings, increased L (brightness) and ΔE (color difference). The highest a value (redness) was observed in samples coated with 3% wheat flour and the lowest a value was related to the samples coated with 3% corn flour. The highest amount of b value (yellowness) was observed in the control sample. The results showed that the use of the aloe vera gel, wheat and corn flour coatings improved the quality properties of fried mushrooms. Therefore, the use of edible coatings seems necessary in production of low-fat fried mushroom.

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## 1- Introduction

White button mushroom (*Agaricus bisporus*) is widely used in cooking and has good nutritional value. Today, due to cultural and social changes, the consumption of ready to-eat foods, including fried foods and breadcrumbs becoming increasingly popular [1, 2]. Frying is a quick and cheap process that is widely used to prepare delicious foods. In this process, oil is both a heating medium and a factor that produces high calorie products [3]. Many factors such as oil quality, nutrient composition, initial moisture content, frying temperature and time can influence oil absorption [1, 2, 4]. However, consumption of fried foods due to high fat levels has always been a challenge to human health [5, 6]. One of the best ways to reduce oil absorption in, fried products is using edible coatings before frying of the product to trap water and form barrier films to reduce moisture loss and subsequently reduce oil absorption [7, 8]. Coating the surfaces of products prior to deep-fat frying is a popular practice that helps to control moisture loss and oil uptake during frying. It also helps to modify textural and color properties of fried products [3, 6]. There is a linear correlation between products surface and fat content [9]. It is generally found that oils are absorbed during frying by water evaporation as well as water vapor condensation. The reduction of surface tension increases the contact between the oil and the food, consequently contributing to increased oil uptake [10]. The surface properties of fried products play an important role in the quality and acceptability of the product, as the oil absorbed into the fried product mainly tends to be absorbed into the product pores [11]. Several researches have recently been done to reduce oil absorption during deep fat frying. Daraei et al. (2011) showed that application of hydrocolloids as edible coatings leads to produce of low-fat French fries with the same or better quality attributes, compared to the control samples [1, 5, 12]. Lalam et al. (2013), investigated the mechanism of mass transfer during deep frying of chicken nuggets and showed that edible coatings reduced oil absorption in these products and so reduced the disadvantages of high oil content in fried products [13]. By Considering the importance of hydrocolloid coatings for improving the quality of fried products and increasing demand for consumption of fried mushrooms in the society, this study was performed to investigate the effect of different edible coatings (Aloe Vera gel, wheat and corn flour) on the quality properties of low-fat fried mushrooms.

## 2. Materials and methods

### 2.1 Materials

In this study, edible mushrooms, aloe vera gel, wheat and corn flour were purchased from the local market in the Hamedan city of Iran.

### 2.2 Methods

#### 2.2.1 Preparation of coating solutions

Batter and gum formulation containing different concentrations of aloe vera gel (10, 20 and 30% w/v) wheat flour (1 and 2% w/v) and corn flour (1 and 2% w/v) were prepared by adding of these compounds in distilled water at room temperature.

#### 2.2.2 Sample preparation, mushroom coating and frying

For each treatment, 100 g of washed mushroom was immersed in the coating solution for 1 minute. Then the samples were placed and rinsed on a sieve at room temperature for one minute and then weighed. Frying process were done in sunflower oil at 180 ᵒC for 4 minutes. Coating percentage was calculated by equation (1):

$$\text{Coating percentage} = [(C-I)/I)] \times 100 \quad (1)$$

C: the weight of the coated raw mushroom, I: is the initial weight of the uncoated mushroom [5, 12].

#### 2.2.3 Dry matter and moisture content

Dry matter and moisture content were determined by weighing a certain weight (5g) of the mushroom and incubating at 105 ℃ for 6 hours to reach a constant weight [14].

**2.2.4 Fat content**

The fat content of the samples was measured by a cold extraction method using N-hexane solvent for 24 hours [14].

**2.2.5 Oil reduction due to coating**

The rate of decrease in oil uptake (oil reduction due to coating) was calculated from the equation (3):

$$\text{Oil reduction (\%)} = \frac{[\text{OC (coated samples)} - \text{OC (uncoated samples)}]}{\text{OC (uncoated samples)}]} \times 100 \qquad (3)$$

OC; oil content of samples

The water retention rate due to coating, was calculated from the equation (4):

WR = [Wc (coated samples) - Wc (uncoated samples)/ Wc (uncoated samples)] × 100 (4)

WR is moisture holding capacity or water retention rate due to coating and WC is the moisture content of the samples [5, 6].

**2.2.6 Frying efficiency**

Frying efficiency was calculated by considering the weight of fried (g) and non-fried mushrooms after the coating process using the equation (2):

Frying efficiency =[(C-W)/C)] × 100 (2)

Where, C and W are the weight of the samples before and after frying [5, 15].

**2.2.7 Sensory evaluation of the product**

To investigate the organoleptic properties of fried mushrooms, five-point hedonic scale method (including; 1: very good, 2: good, 3: not good not bad, 4: bad and 5: very bad) were used. The panelists were trained and evaluated the texture, color, taste and appearance of the product [6, 16, 17].

**2.2.8 Colorimetric**

To investigate the effect of different treatments on the color indices (L, a, b and ΔE), The samples were placed in the dark room and then photographed by a digital camera (Samsung company with magnification of 4128 × 3096) and processed using Adobe Photoshop CS6 software. The L, a and b indices were measured by image processing methods. The ΔE was calculated by the equation (5) [18, 19].

$$\Delta E = \left[\left(L_S - L_B{}^2\right) + \left(a_S - a_B{}^2\right) + \left(b_S - b_B{}^2\right)\right]^{1/2} \qquad (5)$$

**2.2.9 Statistical analysis**

This study was conducted based on a completely randomized design (CRD) and data analysis was done by SAS (9.1.3) software. Excel (2010) was used to draw the charts. For means comparison, Duncan multiple range test (P<0.05) was used. All experiments were performed in three replications.

## 3. Result and Discussion

**3.1 Moisture and dry matter content**

As shown in figure 1, the moisture content of the coated mushrooms was higher than the control sample due to the moisture barrier properties of the hydrocolloid material.

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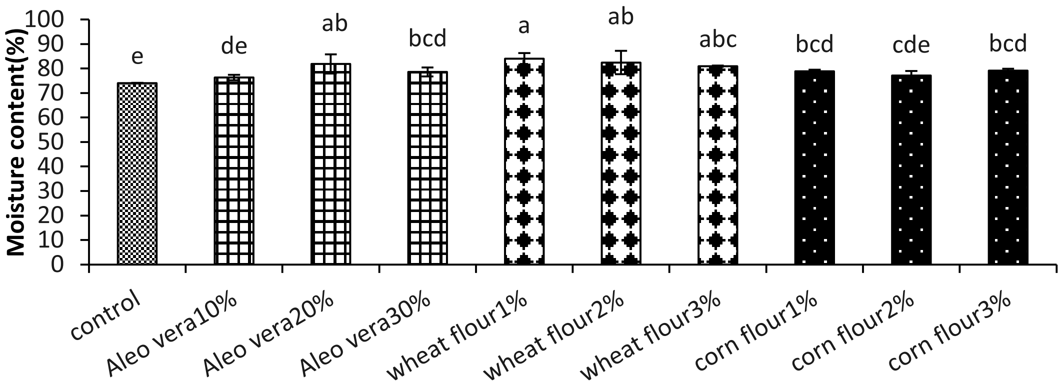


**Figure 1:** Effect of coating with corn and wheat flour and Aloe Vera on the moisture content of fried mushroom

Sample coated with wheat flour 1% had the highest amount of moisture content, while the lowest amount of moisture content was observed in the control sample ($p<0.05$). These results are consistent with other researches [7].

The dry matter content of the fried mushroom samples showed in the figure 2. As can be seen the highest amount of dry matter content were found in both control and samples coated with 10% Aloe Vera and the lowest dry matter content was related to the coated samples with wheat flour 1%. Coating materials, due to their barrier properties, prevent moisture loss during frying, resulting in lower dry matter content of the coated samples than the control sample.

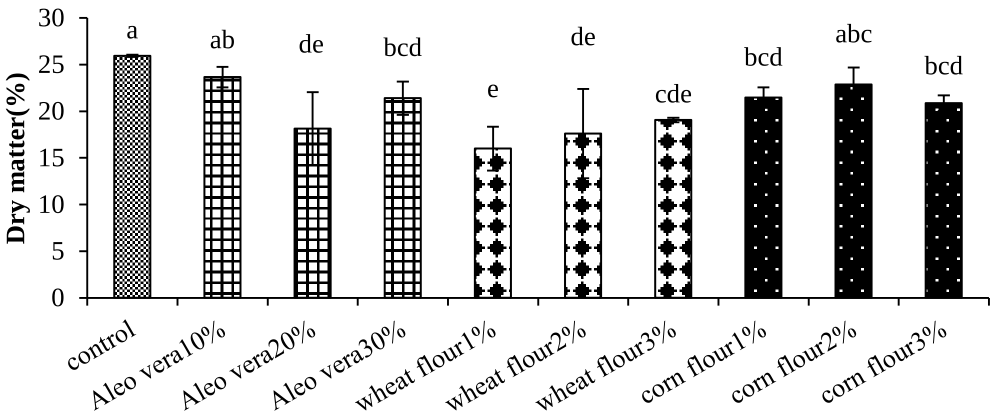


**Figure. 2:** Effect of coating with corn and wheat flour and Aloe Vera on the dry matter content of fried mushroom

Figure 3 illustrated that, as the concentration of the coating materials increased, the amount of dry matter decreased that is due to the higher moisture retention ability of the higher concentrations of the coating agents ($p<0.05$). Deep fat frying of food causes heat transfer from oil to food texture and moisture content evaporation. This process causes a difference in pressure and drying of the surface of the product. The difference in pressure at the surface of the food lead to the water movement from the center to the surface of the food through the cavities in the cell structure. In the following process, the oil enters at the damaged areas and the pores created in the tissue of the food texture and replace the water [20]. In products with higher moisture content, the resulting water vapor leads to an excessive pressure inside the pores of food that prevents oil absorption. This inhibitory property of water vapor probably continues until moments after removing food from the oil, and as the product cools, the vapor becomes condensed into the pores of the food texture [10] The condensed vapor creates a vacuum and suction of oil into the tissue of the food [20]. The increase in moisture content in coated foods is due to the barrier properties of hydrocolloid materials that prevent moisture loss from the product, and then it is expected that the oil absorption in the food will be reduced. Different researchers investigated the effect of hydrocolloid coatings on the quality properties of fried products and concluded that hydrocolloid coatings reduce oil uptake during deep frying process by preventing moisture loss. The results of this study were in agreement with the results of other researchers. [4, 12]. Gohari Ardabili et al. (2021) observed that coating of Zuchini slices with ballango seed gum resulted in a decrease in moisture loss in deep fat fried slices compared to the control sample [2]. Also, Aghajani et al. (2018) reported the positive effect of Aloe vera gel coating on preventing moisture loss in the deep-frying process of carrot slices [4].

### 3.2 Fat content

The fat content of fried samples is shown in figure 3. As can be seen, the fat content of all coated samples was lower than the control treatment (16.53). The highest and lowest amount of fat content were observed in control and coated sample with 3% wheat flour, respectively ($p<0.05$).

Coatings can reduce oil absorption during the frying process.

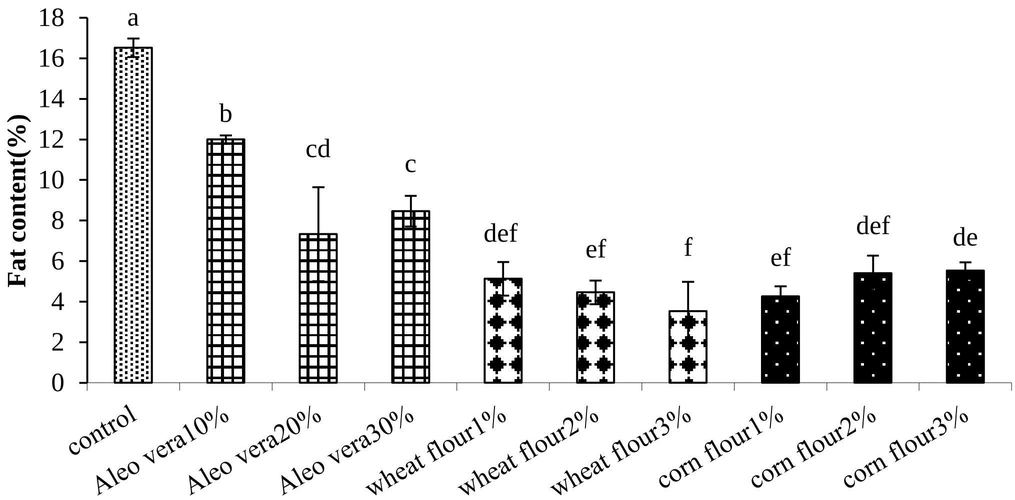


**Figure 3:** Effect of coating with corn and wheat flour and Aloe Vera gel coating on fat content of fried mushroom

Applying the coating before frying creates a uniform layer around the food, keeping fried products crisp by preventing moisture transferring from the food into the crust or absorbing moisture transferred from the environment into the crust [12, 21, 22]. Oil uptake reduction in coated samples is due to the inhibitory effect of the coating agents and preventing the reciprocal flow of water vapor and oil at the surface of the product [13, 23]. The results of this study were consistent with the results obtained by other researchers [5, 24, 25]. Porosity is a physical attribute affecting the mass transfer during deep frying process [26].

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Coating as a surface pretreatment, by reducing water loss and surface porosity acts as a barrier against oil absorption. In addition, surface coating reduces the pores on the shell surface and roughness of the product surface, which is associated with a reduction in oil absorption [27]. Also, oil uptake reduction is due to hydrophilic properties of polysaccharide coatings which reduces the solubility of oil in the product. Sari et al. (2017) investigated the effect of different concentration of aloe vera gel (0, 3 and 5% W/V) on the amount of oil uptake and quality properties (oil uptake, moisture content, frying efficiency, flavor and color) of fried chicken meat and reported that with increasing the aloe vera gel concentration the amounts of water loss and oil uptake during frying were reduced [17]. Yadegari et al. (2017) stated that coating potato slices with *lepidium sativum* seed, *alyssum homolocarpum* and methyl cellulose gums and their combinations, prevented moisture loss of slices and oil absorption during frying compared to the control (without coating) samples which is consistent with the results of the present study. These researchers attributed the reduction in oil absorption and moisture retention of fried potatoes to the barrier properties of these gums [23].

**3.3 Coating percentage:**

As can be seen in the figure 4, the highest percentage of coating (81.38%) was related to the coated mushroom with 3% corn flour and the lowest amount (5.23%) was observed in the mushroom coated with aloe vera 10%. It can be concluded that as the concentration of the coating materials increased, the coating percentage increased, but this increase was different in the coating with wheat flour ($p>0.05$).

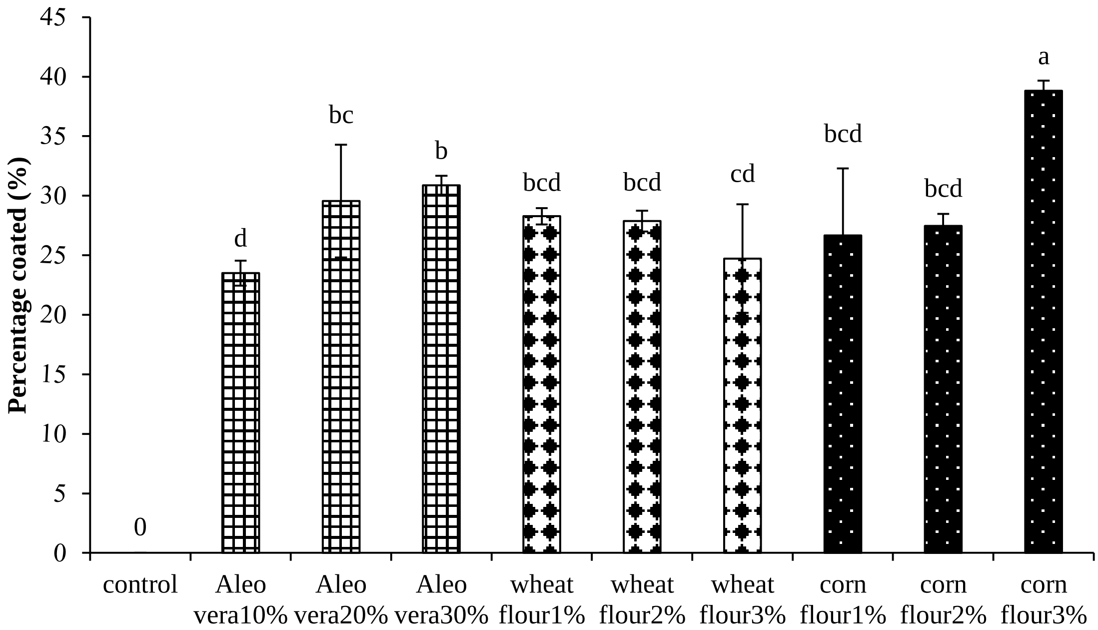


**Figure 4:** Effect of coating with corn and wheat flour and Aloe Vera gel coating on the coating percentage of fried mushroom

**3.4 Frying efficiency**

Since frying efficiency represents the weight of the finished product, therefore, according to the results of the figure 5 the highest frying efficiency (74.25) was observed in the samples coated with wheat flour 3% and the lowest frying efficiency (64.40) was observed in control samples.

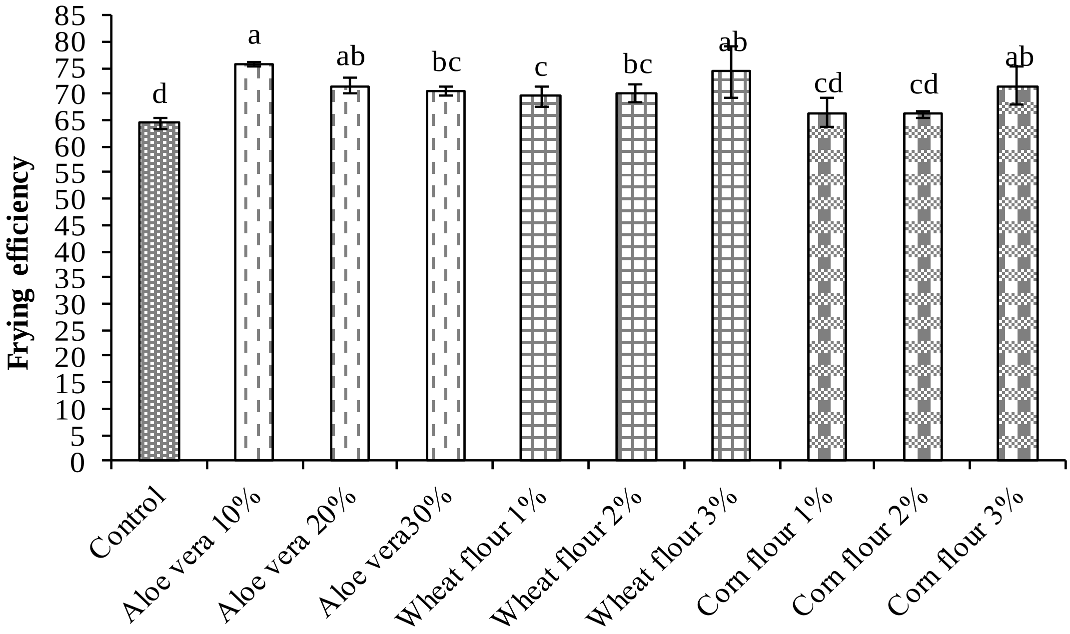


**Figure. 5:** Effect of coating with corn and wheat flour and Aloe Vera coating on the frying efficiency

These results were in agreement with the results of other studies ($p<0.05$). The increase in frying efficiency by increased concentration of the applied coatings indicates the ability of these materials to prevent water loss during frying process. The frying efficiency is obtained from the weight ratio of coated slices after frying to the weight of coated slices before frying. By Considering the ability of damping and moisture retention in the used hydrocolloid coatings, moisture loss during frying process of the product is reduced and as a result, more weight of the product is obtained after frying, which increases the frying efficiency. The lowest frying efficiency was related to control samples (without coating) which, confirmed the effect of coatings on increasing frying efficiency. These results were consistent with the findings of other researchers [2, 4, 23]. The researchers also stated that coating the products before the frying process by preventing the loss of moisture and reducing the absorption of oil during frying increases the frying efficiency, which is attributed to the barrier properties of the coatings.

**3.5 Decrease of oil uptake due to coatings:**

According to the figure 6, coating agents have different performance in oil absorption rate. The highest fat reduction (78.62%) was observed in the sample coated with 3% wheat flour while the lowest fat reduction (27.4%) was observed in coated samples with 10% Aloe Vera gel. The results were in agreement with the results of Daraei Garmakhany et al. (2021), Garcia et al. (2002) [1, 28].

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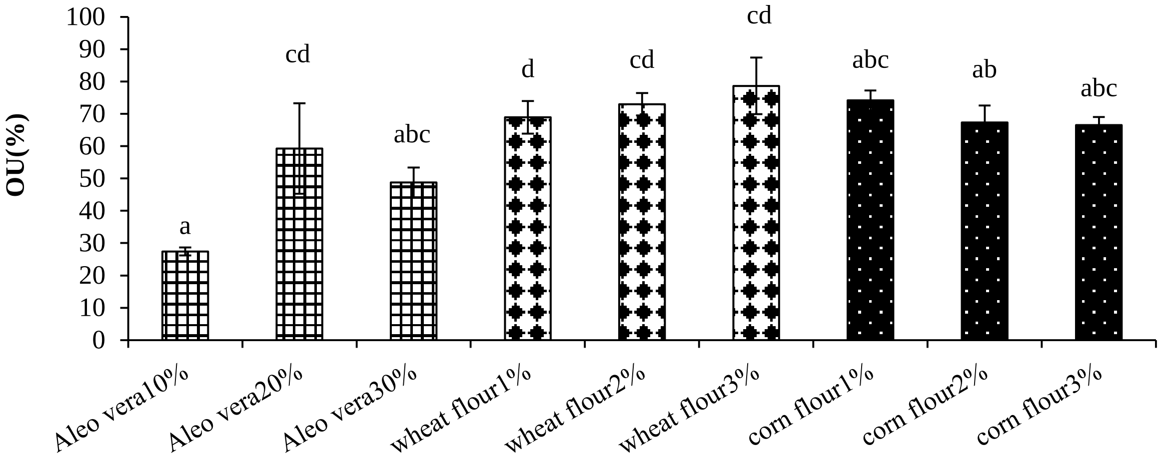


**Figure. 6:** Effect of coating with corn and wheat flour and Aloe Vera gel coating on the oil reduction of fried mushroom

### 3.6 Reduction of water loss during frying:

According to figure 7, the highest decrease in moisture loss during frying was observed in samples coated with 2 % corn flour (17.22%) and the lowest moisture loss reduction was observed in coated samples with 1% of wheat flour (9.86%).

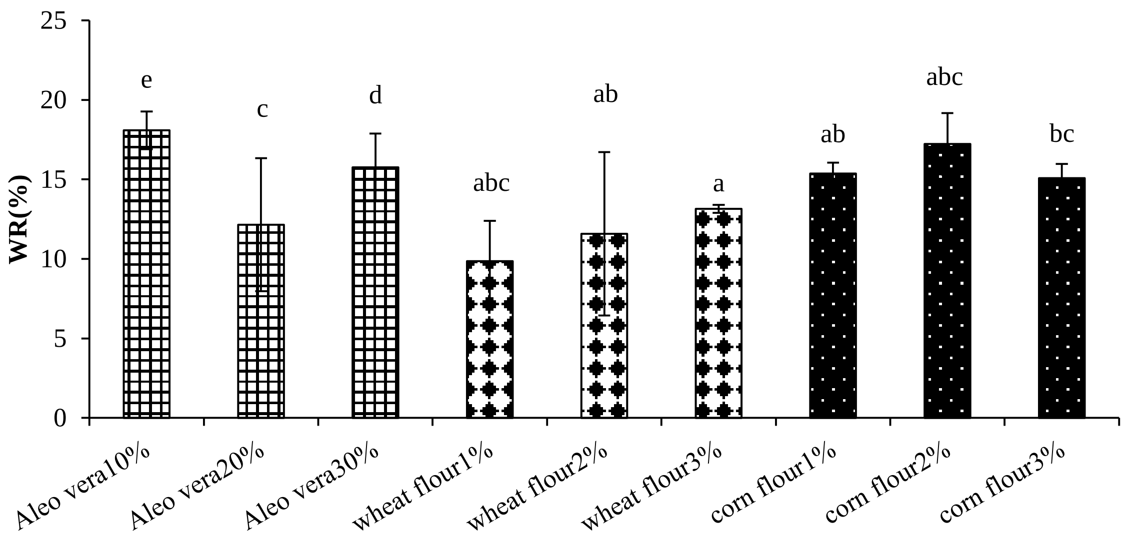


**Figure. 7:** Effect of coating with corn and wheat flour and Aloe Vera gel coating on the water retention of fried mushroom

The reason for the decrease in moisture loss during frying is the barrier properties of the coating agents, which prevents the moisture outflow on the outer surface of the mushrooms. The results are in line with the results reported by other researchers [1].

### 3.7 Sensory evaluation

Examination of sensory attributes shows differences in the color, acceptability and blistering of fried mushrooms (Figure 8).

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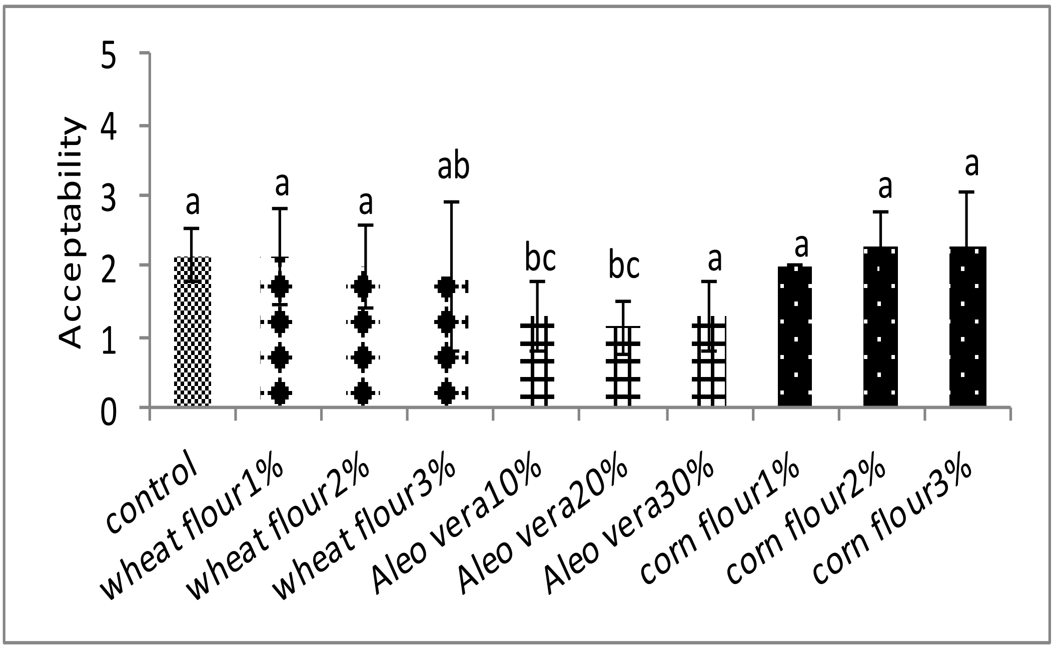
The highest and lowest overall acceptability of fried product were related to the coated samples with 20% for aloe vera and 2% for corn flour coated samples, respectively ($p>0.05$). Also, the lowest and the highest color acceptance of fried mushrooms was related to the coated samples with 20% aloe vera and 2% corn flour, respectively ($p<0.05$). In the case of blistering of fried mushrooms, the highest and lowest acceptance were observed in fried mushrooms with aloe vera 10% and wheat flour 2% respectively ($p<0.05$).

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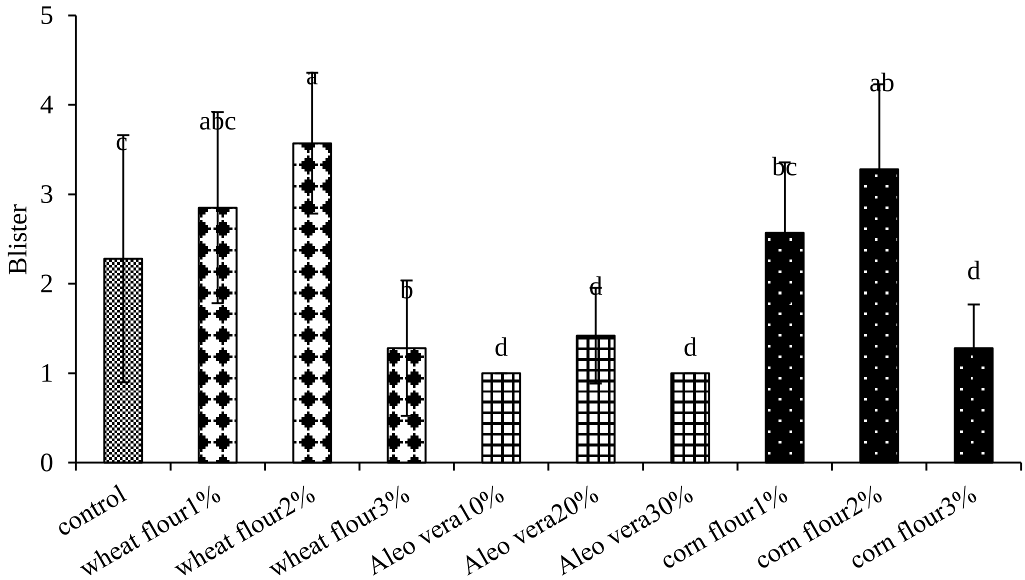


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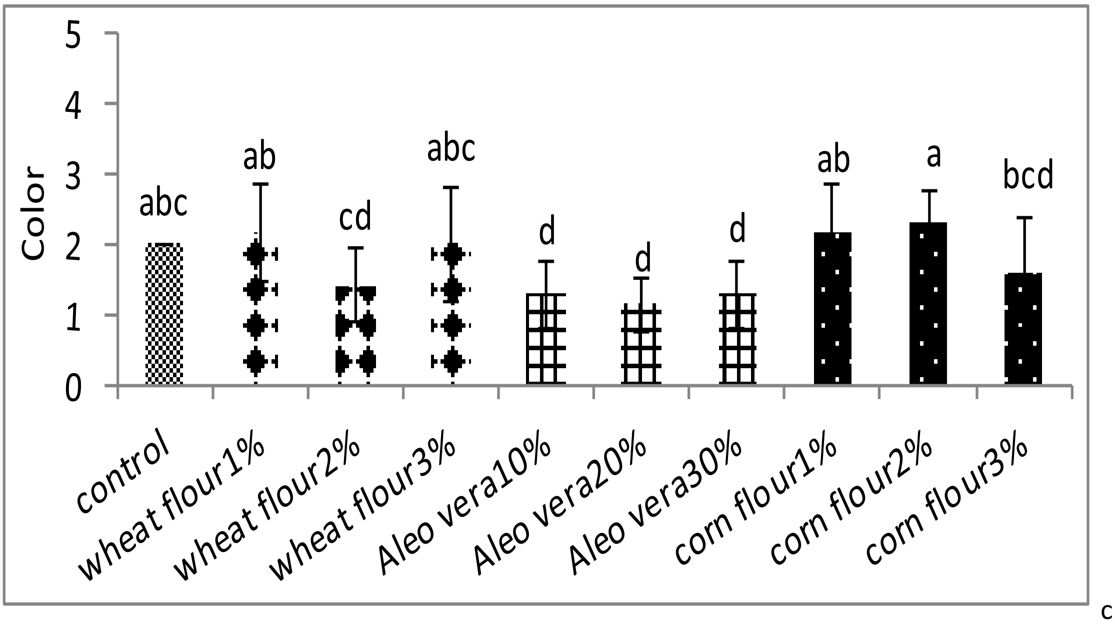


**Figure. 8:** Effect of coating with corn and wheat flour and aloe vera coating on the; (a) acceptability, (b) blistering and (c) color of fried mushroom.

Organoleptical evaluation showed some differences in texture, color and blistering properties of the final product. As can be seen in figure 8c the best color score which is the best color in mushroom was found in samples coated with aloe vera gel. According to the organoleptical results, the best and worst sensory properties were related to aloe vera and corn flour coated samples, respectively but there was no significant difference with control samples. The results were consistent with the findings of other researchers [28, 29].

**3.8. Taste, Texture and flavor**

As can be seen from the figure 9.a, the highest and lowest taste scores were found in fried mushrooms coated with aloe vera 30% and corn flour 3% respectively ($p>0.05$). The figure 9.b, was related to the texture score of the fried mushroom, also showed that the highest and lowest texture were observed in the samples coated with aloe vera gel 30% and wheat flour 1% respectively ($P>0.05$). It also showed that different coating agents had no adverse effect on fried mushroom compared to the control treatment ($p>0.05$). The highest flavor scores (figure 9.c) were found in samples coated with Aloe Vera 30% and corn flour 2%, respectively. The lowest flavor scores were related to the control group and samples coated with 1% and 2% wheat flour, respectively ($P>0.05$).

a


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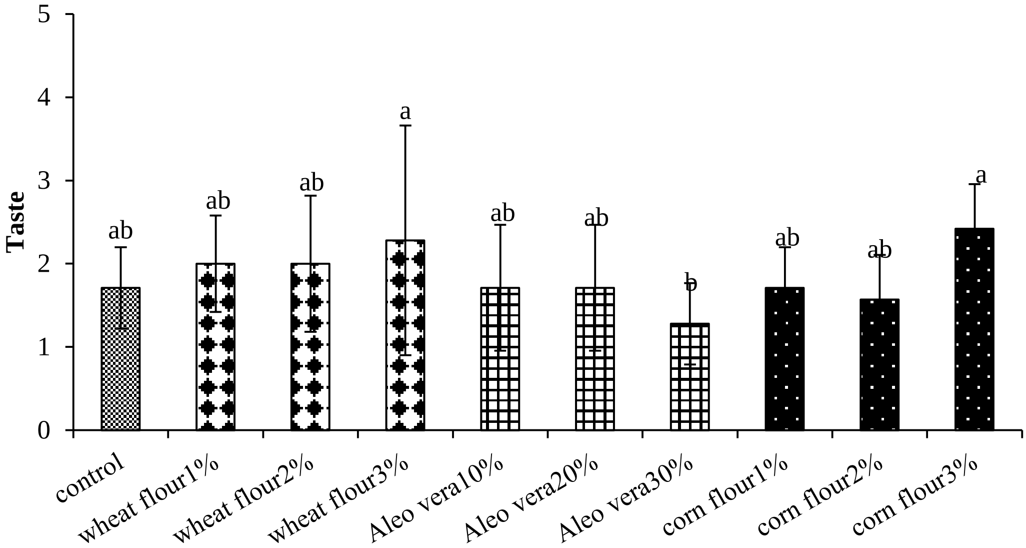
Taste
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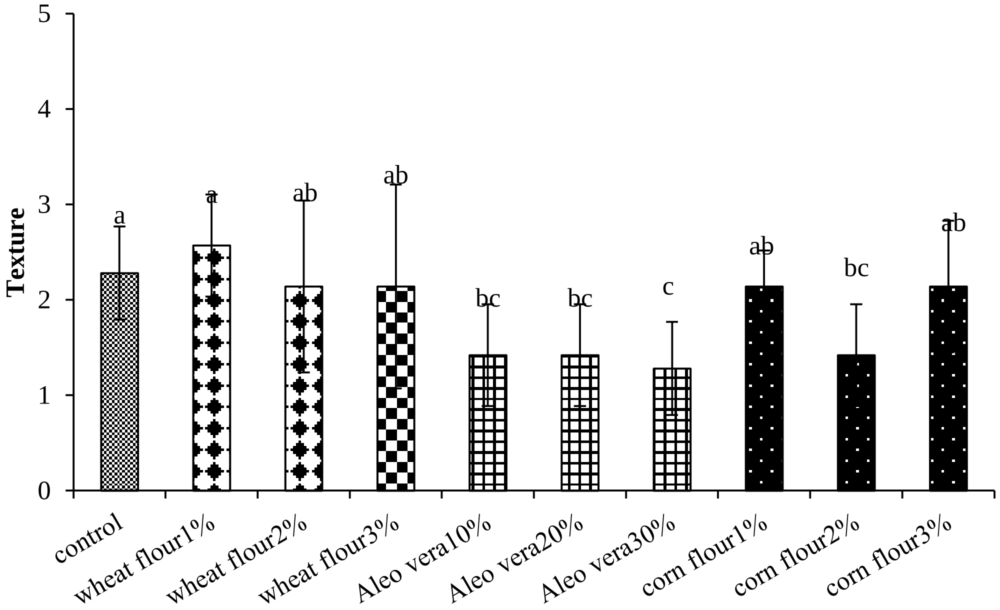
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Aleo vera30%
corn flour1%
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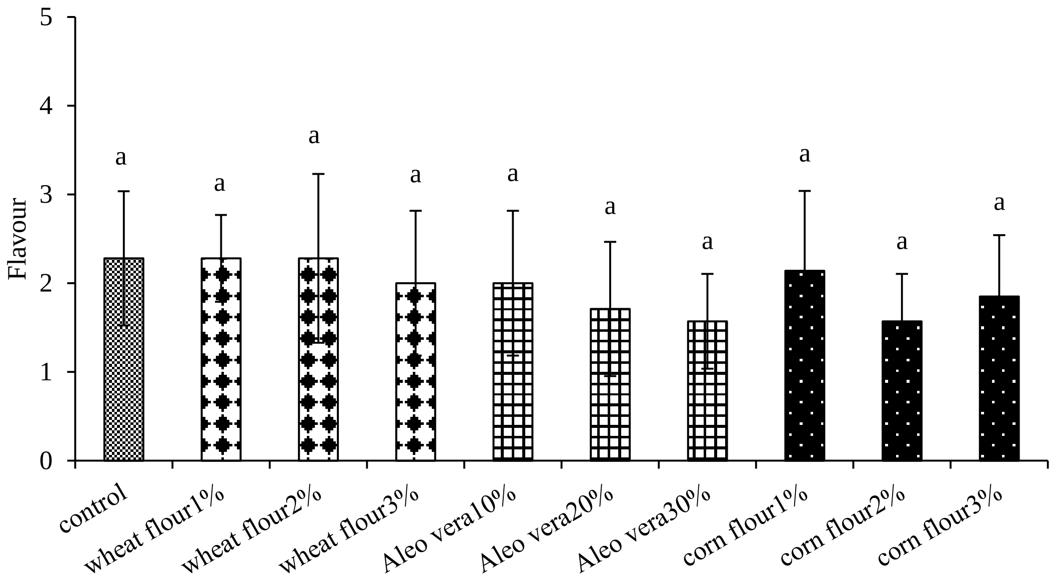


c

**Figure 9:** Effect of coating with corn and wheat flour and aloe vera gel coating on the: (a) taste; (b) texture; (c) flavor of fried mushroom

### 3.9. Color image processing

The results of image processing of all treatments are shown in Table 1. As can be seen, the highest amount of L (lightness) value was observed in samples coated with 1, 2 and 3% wheat flour, while the lowest amount of L value was observed in samples coated with 1% corn flour. The difference between the treatments with the highest and lowest L values were not significant ($P>0.05$). The lowest a (redness) value was related to the samples coated with 3% corn flour and the highest a value was observed in samples coated with 3% wheat flour. The highest amount of b (yellowness) value was observed in the control sample and the lowest amount of b value was related to the coated samples with 2% corn flour. Coated samples with corn and wheat flour were statistically significant difference from control samples in term of b value ($P<0.05$), while samples coated with Aloe Vera gel were not significantly different from the control samples ($P>0.05$). In terms of $\Delta E$, there was a difference between all treatments, although this difference was not statistically significant in many samples ($P>0.05$). The highest amount of $\Delta E$ was observed in samples coated with 2 and 3% wheat flour and samples coated with 10 and 20% Aloe Vera gel, while the lowest amount of $\Delta E$ was related to both control and coated samples with 2% corn flour.

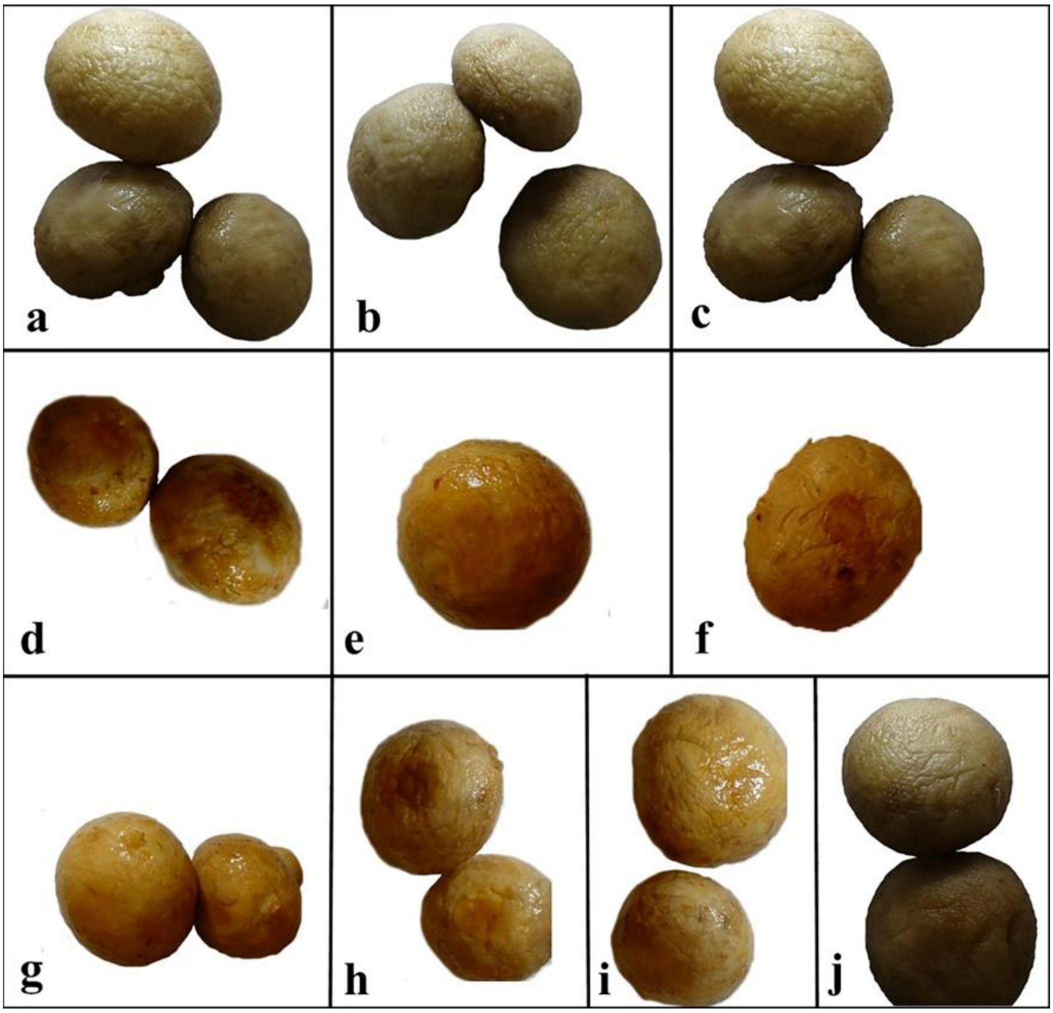


**Figure 10:** Effect of used edible coatings on color changes of fried mushroom, a; Corn flour 1%, b; Corn flour 2%; c; Corn flour 3%, d; wheat flour 1%, e; wheat flour 2%, f; wheat flour 3%, g; Aloe vera 10%, h; Aloe vera 20%, I; Aloe vera 30% and j; Control treatment

**Table1**. Changes in color parameters of fried mushroom samples

| Treatment | color parameters | | | |
|---|---|---|---|---|
| | L | a | b | ΔE |
| Control | 38$^{bc}$ | 6.77$^{b}$ | 39.11$^{a}$ | 7.13$^{bc}$ |
| Aloe Vera 10% | 40.33$^{b}$ | 4.88$^{bcd}$ | 37.77$^{a}$ | 12.15$^{ab}$ |
| Aloe Vera 20% | 39.88$^{b}$ | 4.22$^{cd}$ | 34.44$^{a}$ | 11.67$^{ab}$ |
| Aloe Vera 30% | 38.77$^{bc}$ | 5.22$^{bc}$ | 34.66$^{a}$ | 9.63$^{abc}$ |
| Wheat flour 1% | 50.5$^{a}$ | 9.83$^{a}$ | 27$^{b}$ | 8.48$^{abc}$ |
| Wheat flour 2% | 46.5$^{ab}$ | 10$^{a}$ | 27.66$^{b}$ | 15.93$^{a}$ |
| Wheat flour 3% | 46.66$^{b}$ | 10.5$^{a}$ | 33.16$^{a}$ | 13.45$^{ab}$ |
| Corn flour 1% | 31$^{c}$ | 3.5$^{cd}$ | 21.16$^{c}$ | 10.73$^{abc}$ |
| Corn flour 2% | 37.66$^{bc}$ | 2.66$^{cd}$ | 20.16$^{c}$ | 3.45$^{c}$ |
| Corn flour 3% | 46.66$^{ab}$ | 2.5$^{d}$ | 23.66$^{bc}$ | 9.04$^{abc}$ |

In each column, the numbers with same letters have no significant difference (p>0.05).

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## 4.Conclusion

The results showed that using coating agents, due to form a protective layer on the surface of the mushroom, decreased moisture loss of mushroom during frying and the amount of oil uptake in all coated treatments is lower than the control sample. Because of the increasing consumption of fried products and the importance of reducing oil consumption in the diets, the use of edible coatings in production of different fried foods and nuggets is recommended.

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مقاله علمی_پژوهشی

# بررسی تأثیر برخی پوشش های خوراکی بر خواص فیزیکوشیمیایی و حسی قارچ سرخ شده کم چرب (*Agaricus bisporus*)

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**چکیده**

قارچ دکمه ای سفید (*Agaricus bisporus*) در آشپزی کاربرد زیادی داشته و ارزش غذایی خوبی دارد. امروزه تقاضا برای قارچ خوراکی سرخ شده در حال افزایش است. پوشش های خوراکی می توانند جذب روغن را کاهش داده و ویژگی های کیفی محصولات سرخ شده را بهبود بخشند. در این تحقیق تأثیر آرد گندم (۰، ۱، ۲ و ۳ درصد وزنی)، آرد ذرت (۰، ۱، ۲ و ۳ درصد) و ژل آلوئه ورا (۰، ۱۰، ۲۰ و ۳۰ درصد) بر کیفیت قارچ در طی فرایند سرخ کردن عمیق مورد بررسی قرار گرفت. نتایج نشان داد که پوشش های مختلف سبب کاهش جذب روغن در محصول نهایی شدند ($p<0.05$). کمترین میزان جذب روغن برای نمونه های پوشش داده شده با ۳ درصد آرد گندم و ۱ درصد آرد ذرت و ۱۰ درصد ژل آلوئه ورا مشاهده شد. همچنین، پوشش‌های مورد استفاده باعث بهبود راندمان سرخ‌کردن، رطوبت و ویژگی‌های حسی قارچ سرخ‌شده شد ($p<0.05$). نتایج رنگ سنجی نشان داد که پوشش های آلوئه ورا و آرد گندم، L (روشنایی) و $\Delta E$ (اختلاف رنگ) را افزایش دادند. بیشترین مقدار a در نمونه های پوشش داده شده با ۳ درصد آرد گندم و کمترین مقدار a (قرمزی) مربوط به نمونه های پوشش داده شده با ۳ درصد آرد ذرت بود. بیشترین مقدار b (زردی) در نمونه شاهد مشاهده شد. نتایج نشان داد که استفاده از پوشش‌های ژل آلوئه ورا، آرد گندم و آرد ذرت باعث بهبود خواص کیفی قارچ سرخ‌شده می‌شود. بنابراین استفاده از پوشش های خوراکی در تولید قارچ سرخ شده کم چرب ضروری به نظر می رسد.