



Journal of Food Science and Technology (Iran)

Homepage: www.fsct.modares.ir

Scientific Research

Feasibility study of producing functional oil cake using Shiitake and Ganoderma mushroom powders and investigating their quality characteristics

Yasamin Bakhtiari Bidkorpe ¹, Maryam Gharachorloo ^{2*}, Masoud Honarvar ²

- 1- MSc Student of the Department of Food Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran.
- 2- Associate Professor of the Department of Food Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran.

ARTICLE INFO

Article History:

Received: 2023/01/25

Review: 2025/10/22

Accepted: 2025/10/26

Keywords:

oil cake,

enrichment,

shiitake mushroom powder,

ganoderma mushroom powder

DOI: 10.48311/fsct.2026.83362.0

*Corresponding Author E-

Gharachorloo.m@gmail.com,
maryam.gharachorloo@iau.ac.ir

ABSTRACT

Cake is one of the products that is widely used due to its good taste, high nutritional value, and ease of use. It has been used commonly for centuries and is being consumed today regularly by most people in the society. Many modifications and changes have been made on cake ingredients in order to improve its quality and increase its nutritional value and shelf life. Enrichment of the cake formulation is one of these modifications. In this research, we enriched oil cakes with shiitake mushroom powder (*Lentinula edoes*) and *Ganoderma Lucidum* mushroom powder. Shiitake and *Ganoderma* mushroom powder were used at 4 levels of 0, 5, 10, 15% as a substitute for wheat flour in the oil cake formulation. The characteristics of the cake, including percentage of compounds, volume, peroxide index (by standard method), color (by image processing method), degree of hardness (by Texture profile analysis) and sensory characteristics were evaluated. By increasing the percentage of Shiitake mushroom and *Ganoderma* powder in the cake formulation (10 and 15%), the viscosity of the dough increased in such a way that the characteristics of the dough were more similar to solid materials than viscoelastic materials, and the device was not able to read the viscosity of doughs in these cases. The volume decreased by increasing the substitution of mushroom powder with wheat flour, but the amount of protein, fiber and hardness of the samples increased. The amount of fat increased in the samples containing Shiitake mushroom but decreased in the samples containing *Ganoderma* mushroom compared to the control samples. The color indices increased with the increase in the percentage of added mushroom powder. Components L* (lightness) and b* (yellowness) decreased and component a* (redness) increased in comparison to the control samples. The amount of aw in the samples after 2 hours of cooking did not differ significantly, but after weeks, the amount of aw of the enriched samples decreased in comparison to the control sample. Increasing the percentage of both shiitake mushrooms and *Ganoderma* powders in the oil cake formulation decreased the peroxide index.

1- INTRODUCTION

In Now Present Cake part Snacks is that To One Between Promise Food Conversion Done and Value Food it Also in Basket Food Family I see Important Perception It will be. Many From Reforms and Changes On Compositions Cake Done is Up to In addition On Increase Value Nutrition Hey, Also Quality it particle for direct object Improvement Data and Also Time Durability The product Increase Give (Food and Drug Administration, 2012). Correction Feature Hi This Products and use From Components With Features Bioactivity May Can In Preserve Security Society Effective (Dalandar Kouhi, 2019).

The use of mushrooms in many types of products such as soups, sauces, pickles, etc. is common in many countries, but there is very little information about the use of mushroom powder in bakery products such as cakes, breads, and biscuits (2010sheikhe et al.).

Shiitake and Ganoderma mushrooms are among the largest edible mushrooms that have been extensively studied and researched for their medicinal properties.

Shiitake mushroom with scientific name *Lentinula edodes* It is an Asian edible mushroom that is consumed all over the world and is known as the shiitake mushroom. The name shiitake is actually a Japanese name and the reason this mushroom was named this way is because for the first time in Japan this mushroom was found on a tree called Shiitake. *Castanopsis cuspidate*) They took it. As the second most popular and third most cultivated mushroom in the world, shiitake mushrooms have unique flavor and wide-ranging medicinal properties that contribute to their widespread consumption. Li et al (2013) Among the key components of secondary metabolites in this fungus is the polysaccharide lentinan.¹(which is molecularly a beta-glucan) and heteroglucan-protein complex) LEM²) With anti-tumor effects and immune system strengthening, eritadine (cholesterol reducer), ergosterol (vitamin precursor) D₂), pieces RNA Antiviral (Azizi et al., 2019), oxalic acid (antibacterial compound) Chang et al (1996), Lentin protein (antifungal properties and

therapeutic properties against AIDS) HIV) and blood cancer) (Ngia et al 2003), phenolic compounds (radical scavenging) DPPH and antioxidant properties) (Barros et al. 2007 Not mentioned. Also, chitosan produced by shiitake mushrooms has an inhibitory effect on hydroxyl radicals and is a chelator of iron ions (Tourlo et al 2010).

One of the mushrooms that has been named the best medicinal mushroom due to its numerous therapeutic properties is the mushroom *Ganoderma Lucidum* (Kipour et al., 2013). *Ganoderma* mushroom originally belongs to (China, Korea, Taiwan and other Asian countries). The main characteristic in naming this mushroom was the Chinese who called it Lingzhi, which means (happy flame for rain). *Ganoderma lucidum* is also commonly known by the titles (mushroom of immortality), (mushroom of soul-enhancing) (Mumtaz et al., 2010) and has Background Hey Ancient in Improvement Health and Increase Length Age Carbohydrates were evaluated as the most abundant compound in *Ganoderma lucidum*, followed by proteins, fats, minerals and salts, respectively. Stojkovic et al 2014 (Among tocopherols, alpha, gamma and delta isoforms are found, with gamma tocopherol being the most abundant. Benefits of tocopherols: Protection from skin damage caused by sunlight and ultraviolet radiation, carrying out the oxidation process with many diseases including cancer, aging and Alzheimer's) et al 2017 Obodai *Ganoderma* contains a variety of chemical compounds, of which terpenoids, polysaccharides, and triterpenoids are the most abundant in this mushroom, respectively (Mumtaz et al., 2010).

Various products have been used to enrich various types of cakes and biscuits. For example, in 2019, Mousavi Koljahi et al. investigated the feasibility of producing functional oil cake containing lime pomace powder at three levels (0, 5, 10 percent of wheat flour content) and liquid date sugar at three levels (0, 25, 50 percent of sucrose content) and evaluated the resulting oil cakes in terms of cake dough viscosity and physicochemical properties (moisture content, weight loss, pH, sucrose percentage, color, crude fiber), rheological and sensory evaluations were performed. The results showed that increasing the amount of flour replacement with lime pulp and sucrose with liquid date sugar, the moisture

content, reducing sugar and dietary fiber of the cake samples increased and the amount of shrinkage after baking, pH, The sucrose percentage and texture firmness of the cake samples decreased.

In another study in 2016, Zare et al. examined Impact Replacement Flour Wheat With flour We will find On Features Physicochemical and Sensory For this purpose, 5 levels of elderberry flour (0, 5, 7, 10) were used as a substitute for wheat flour, and the results showed that the maximum dough viscosity was related to the control sample (without elderberry flour) and Towards No longer with Increase Replacement Flour Wheat With Flour We will find, Volume and Amount Protein Reduction But Amount Fiber Cakes Increase Found with Attention To Their results Expression They had that Alternative To become 3 Percentage Flour Wheat With Flour We will find To Title one Material Initial Pragmatic In Preparation Cake Composition Suitable For Preparation Cake Provides.

The physicochemical properties of cakes prepared with button mushroom powder as a substitute for wheat flour were investigated at four levels of 0, 5, 10, and 15 percent. The results indicated that with increasing the percentage of button mushroom powder in the formulation, the viscosity of the dough decreased and the highest viscosity was for the control sample. Also, with increasing the percentage of mushrooms in the cake formulation, the volume of the cakes increased significantly and caused a decrease in their density. With increasing the percentage of button mushroom powder, no significant difference was observed between the cakes in terms of textural properties. The results of sensory evaluation showed that the sample containing 10 percent button mushroom powder had the highest score in terms of overall acceptance (Salehi et al., 2015).

Arora et al. in 2017, worked on the enrichment of sponge cake with button mushroom powder. They prepared *Agaricus bisporus* (white button mushroom) powder by replacing wheat flour with 10, 20, 30, 40 and 50% mushroom powder. Findings: As the level of mushroom powder in the formulation increased, the dough density and specific volume of the cake sample decreased. For 20% enrichment, the dough density and specific volume decreased by 23.8 and 79.5%, respectively.

In this study, first the percentage of moisture, fat, protein, ash, fiber, wheat flour, shiitake mushroom powder and Ganoderma mushroom powder were measured, and then the antioxidant effect of the mushrooms was measured. Then the effect of replacing shiitake and Ganoderma mushroom powder at 3 levels, 5, 10 and 15% as a flour substitute in oil cake formulation was investigated. The dough rheology, volume, density and percentage of physicochemical components of the cake, color, firmness and sensory evaluation of the cakes were measured and compared with each other.

2-Materials and methods

2-1- Cake ingredients

Flour Nol (Golestan Company), Water, sugar (Yas Company), edible liquid oil of Ladan, baking powder (Brand Dr. Oetker), Vanilla (brand) Dr. Oetker, eggs (Telawang Company), invert syrup (glucose and lemon essence from reputable confectionery supplies), Ganoderma mushroom powder (Iran Ganoderma brand) and shiitake mushroom powder (Dr. Mehdizadeh Products brand) were prepared.

3-2- Preparing oil cake

All cake batters were prepared in a way that contained 100 g flour, 36 g sugar, 25 g oil, 35 g water, 2 g baking powder, 0.7 g vanilla, 12 g invert syrup, and 20 g eggs. Initially, in order to prepare the cake batter, oil, powdered sugar, and eggs were mixed using an electric mixer for 6 minutes to create a creamy mixture containing air bubbles. Then, shiitake and Ganoderma mushroom powders were substituted for the cake flour at four levels of 0, 5, 10, and 15 percent. Then, baking powder and vanilla were added to the flour, and the resulting mixture was gradually added to the previous mixture. Then, using a cloth funnel, the prepared batters were poured into special cake papers that were placed in the molds. Then, baking was performed in a laboratory rotary oven with hot air at a temperature of 170 degrees Celsius for 20 minutes. After cooling, each of the samples was packaged in polyethylene bags and stored at room temperature. The desired tests were conducted on oilcake samples two hours after production and during the first, second, and third weeks of storage at room temperature (Afsharian, Torqeba et al., 2014).

2-3- Tests of wheat flour, shiitake mushroom powder, and Ganoderma mushroom powder:

2-3-1- Chemical tests of wheat flour, shiitake mushroom powder and Ganoderma mushroom powder:

Chemical tests of flour, shiitake mushroom powder and Ganoderma mushroom powder such as moisture content, protein, ash using methods AACCThe numbers (15-44, (12-46), (01-08) were performed respectively. Fat was extracted by Soxhlet method (2000AOAC) and fiber content were measured using a FiberTech device.

2-3-2- Investigating the antioxidant activity of shiitake and Ganoderma mushrooms

In order to prepare the methanol extract, 200 ml of methanol was poured onto 30 g of powdered mushroom and kept in a shaker at laboratory temperature for 24 hours. Then, the resulting extract was filtered and concentrated by rotary distillation at reduced pressure and 40°C until the extract was obtained (Tabari et al., 2011).

2-3-2-2- Investigating the ability to remove free radicals by the method DPPH

The antioxidant effect of the extracts was measured using the radical reduction capacity (RCC) method. RSC) with the help of the 2,2-diphenyl-1-picrylhydrazyl radical DPPHIt was evaluated. Different concentrations of sample and control The wells of a 96-well microplate were added. The blank was used to neutralize the color of the extracts in the final absorbance assay. The plate was then incubated for 30 minutes at room temperature..and placed in the dark and the absorption of each well by the device Spectrophotometer It was read at 517 nm. By putting the obtained values in the formula below, the percentage of inhibition was DPPHThen, by plotting the percentage inhibition curve against concentration, the concentration of the sample at which 50% inhibition ($_{50}IC$) is observed. Therefore, the lower the amount, the higher the antioxidant property of the sample.

$$Ac - As \times \frac{100}{And} = Of$$

In the formula A_c Absorbing control, A_s Sample absorption and A_f The final absorption is (Azizi et al 2015).

2-3-2-3- Measuring the reducing power of iron

In order to measure this property, 3 ml of reagent is added to 100 microliters of sample. FRAP was added. The resulting mixture was vortexed and incubated for 10 minutes at 37°C. The absorbance of the solutions was read at 593 nm relative to the control (consisting of 100 µl of distilled water with 3 ml of reagent). Ferrous ammonium sulfate was used to draw the standard curve. To draw the standard curve of the divalent cation, a stock solution of 1 mM ferrous ammonium sulfate was prepared. Then, the values of 0, 1, 5, 10 and 20 ppm This solution was poured into test tubes and the volume of each was adjusted to 100 microliters with distilled water. 3 ml of reagent was added to each tube. FRAP was added. The resulting mixture was vortexed well and incubated for 4 minutes at 30°C. After this time, the absorbance of the solutions was read at a wavelength of 593 nm relative to the control. A test tube without ammonium ferrous sulfate was used as a control. By inserting the absorbance of the samples into the equation related to the standard curve of divalent iron cation, the reducing ability of the extracts was calculated. The data are based on milligrams of ferrous ion produced per gram of extract weight.

). Benzie et al 1999(It was stated

2.4- Cake tests

2-4-1- Rheological properties and viscosity

Review Features Rheological and Viscosity Dough Cake Before Design Processes Like System Hey Transfer Dough, Required force For Pumping and Template Woman and Before Nose Features The final cake Cooked Done Necessary It is. Viscosity and Rheological Cake dough I see With Use From Device Viscometer Rotary Brookfield (USA, model RVDV- II+ pro, Brookfield) in the shear rate range of 1.9 to 76/s, at a temperature of 25°C, with Use From Spindle Number 07S was measured (Salehi et al., 2016).

2-4-2- Measurement of cake density and composition

The volume of the cakes was calculated by the volume displacement method using rapeseed. The moisture content was determined by using an oven at 105°C for 4 hours, fat by using Soxhlet and diethyl ether solvent, and protein by Kjeldahl method. AOAC 2000).

2-4-3- Histometry

Features Textured Cake Hey rich Done So From 2 hours after production and after 1 week, 2 weeks, 3 weeks of storage at room temperature, By Device Texture Gauge (TA-XT Plus, Stable Micro Systems Ltd., Surrey, UK) and Soft Appliance Relevant (Texture Expert05/1) Size Catch The probe Cylinder Hey With Qatar 6 Meli meters, With Speed 0/1 Meli Meter per second and To Depth 10 Meli Meter Direction Done Test Influence and Checking the firmness of the cake Hey Preparation Done Used. Speed He left. and Back 0.2 miles Meter On Seconds In Opinion Taken (Salehi et al., 2014).

2-4-4- Colorimetry

Color is one of the first appearance parameters of a product that the consumer selects a food item by looking at it (Mehdizadeh et al., 2018). For colorimetry of cake samples, both the crust and the texture (to photograph the texture, the cake was cut in half and the cake core was scanned) were measured using the Hunter Lab Model 1000 colorimetry system. UltraScan VIS It was examined.

Results as *L(brightness level), *a(redness) and *b(Yellow) Reported and compared. Index *L It represents the brightness of the sample and its range varies from zero (pure black) to 100 (pure white). Index *a It shows how close the sample color is to green and red, and its range is from It varies from -120 (pure green) to +120 (pure red). Index *b It shows how close the sample color is to blue and yellow, and its range varies from -120 (pure blue) to +120 (pure yellow). Sun et al 2008 (.

2-4-5- Aquatic activity

The activity of blue cakes using the Iranian National Standard No. 2553 and with the help of the device Lab Master aw (Model Aw sprint) was measured.

2-4-6- Sensory evaluation

The sensory characteristics of the cake samples, including color, texture, flavor, and crispness, were evaluated and 10 trained evaluators were asked to give their opinions (5. Excellent, 4. Very good, 3. Good, 2. Average, 1. Poor). In this method, the sensory tests were listed and evaluated according to the scores given to the cakes by the 10 evaluators.

2-4-7- Peroxide number

To measure the peroxide index, first 3-4 cakes were cut into pieces and placed in a wide-mouth Erlenmeyer flask. Petroleum ether solvent was poured over it until it completely covered the surface of the cake. A cap was placed on it to prevent vapors from entering the atmosphere. It was left for 1 hour until the fat dissolved in the petroleum. The petroleum was filtered using filter paper and then poured into a Soxhlet flask and the petroleum was separated on moist heat and the fat remained. 2 grams to 3 grams of the extracted oil was weighed into a 250 ml Erlenmeyer flask and 30 ml of a mixture of acetic acid and chloroform was added to it. Then 0.5 ml of saturated potassium iodophor solution was added to it. It was left in the dark for 1 minute. Then 30 ml of distilled water and a few drops of starch reagent were added and the solution was titrated with 0.1 normal sodium hyposulfite or 0.01 normal sodium thiosulfate until the dark color resulting from the addition of starch glue disappeared (Anonymous, 2007).

The following formula is used to calculate peroxide.

$$\text{Peroxide number} = \frac{N (S-B) \times 1000}{In}$$

S: The volume of thiosulfate consumed by the oil sample, B: Volume of thiosulfate consumed by the witness, N: Thiosulfate normality, IN: Sample weight.

2-5- Statistical analysis

Evaluation of results using statistical software SPSS It was carried out using a factorial test in a completely randomized design with 3 replications. Also, the comparison of the treatment means with Duncan's test with a probability level of 5% error and drawing graphs were also done by the software. SPSS Done.

3-Results and Discussion

3-1- Chemical compositions of wheat flour and shiitake and Ganoderma mushroom powder

The moisture, fat, protein, ash and fiber contents of wheat flour, shiitake mushroom powder and Ganoderma mushroom powder are given in (Table 1). Analysis of the experimental data showed that the type of sample had a significant effect on the measured parameters. As shown in (Table 1), the percentage of fat, ash and protein of shiitake mushroom powder was higher than that of Ganoderma mushroom powder and

wheat flour, but the percentage of fiber of Ganoderma mushroom powder was higher than

that of shiitake mushroom powder and wheat flour.

Table 1) Chemical composition of wheat flour, Shiitake mushroom and Ganoderma mushroom powders

Sample	Fat (%)	Ash (%)	Moisture (%)	Protein (%)	fiber (%)
Wheat flour	1/01 ± 0/03	0/28 ± 0/05	13/36 ± 1/11	10/83 ± 2/05	2/04 ± 0/1
Shiitake powder	2/19 ± 0/34	5/48 ± 0/67	8/79 ± 0/4	19/57 ± 0/87	10/67 ± 0/61
Ganoderma powder	0/5 ± 0/15	3/03 ± 0/37	7/20 ± 0/37	15/58 ± 0/87	24/83 ± 1/01

Percentage of protein, fiber and ash obtained from shiitake mushroom powder with data obtained from research Baba et al., 2021. The protein and ash percentage of Ganoderma mushroom powder was consistent with the protein and ash percentage reported in the study. Garuba et al., 2019, there was no significant difference, but the percentage of fiber and fat obtained was significantly different from this study. This difference may be due to the nature of the substrate, the sample pieces, the habitat, and the place where the sample was collected (Salamat et al 2017).

3.2- Antioxidant activity of shiitake mushrooms and Ganoderma

Shiitake mushroom powder and Ganoderma showed significant differences in terms of antioxidant activity. So that the free radical scavenging power (DPPH reagent) of Ganoderma mushroom was significantly higher than IC₅₀ (14/4 ± 71.164 micrograms/ml) greater than the free radical scavenging power of shiitake mushrooms with IC₅₀ (43/3 ± 189.39 micrograms/ml) was also the iron reducing power (FRAP test) in shiitake mushroom powder (0.005) ± 0.1 mg/g is lower than the iron reducing power in Ganoderma mushroom powder (0.005 ± 1.30 mg/g).

IC rate₅₀ Obtained for Ganoderma mushroom in this study with IC₅₀ Reported in the study by Malakoot Tabari et al., 2011, which corresponds to 162.01.

3-3- The effect of adding shiitake and Ganoderma mushroom powder on oil cake characteristics

3-3-1- Rheological properties and viscosity of cake batter

In the control samples, cake enriched with 5% shiitake mushroom powder and cake enriched with 5% Ganoderma mushroom powder, the apparent viscosity decreased with increasing shear rate. The decrease in viscosity with

increasing shear rate indicates a shear-relaxing behavior.

(Pseudoplast) is a paste.

In samples containing 5% shiitake and ganoderma mushroom powder, the viscosity of the dough increased compared to the control. In other words, the fibers in shiitake and ganoderma mushroom powder have a high water absorption capacity, which leads to an increase in the volume of hydrated molecules, which helps to establish more hydrogen bonds in the cake dough, which increases the viscosity of the samples. Baixeli et al 2007)) In other words, the creation of strong structures by the fibers in the mushroom powder prevents the dough from flowing and creates many hydrogen bonds with water, resulting in a decrease in the amount of available water, leading to an increase in

The viscosity of the dough has increased. Zimeri et al 2010, Demirkesen et al 2003). The results obtained are consistent with the results of the research of Mousavi et al. (2019), Salehi et al. (2016), and Zare et al. (2016), which respectively investigated the physical, chemical, rheological, and sensory properties of functional oil cake containing lemon pulp powder and the physicochemical, sensory, and textural properties of sponge cake. Rich Done With Powder Apple and the effect of replacing wheat flour with elderberry flour on the physicochemical and sensory properties of oil cake They paid, it matches.

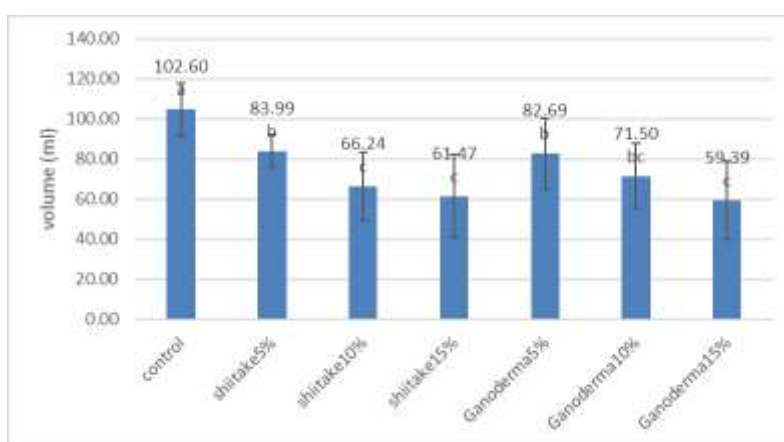
However, in samples containing 10% and 15% shiitake and ganoderma powder, the Brookfield viscometer was unable to measure viscosity. This was due to the high percentage of fiber and protein, which in shiitake and ganoderma mushrooms are protein (19.57 and 15.58 percent) and fiber (10.67 and 24.83 percent), respectively, which caused the apparent viscosity of the dough to increase significantly and the characteristics of the dough to resemble solid materials rather than viscoelastic materials. As a result, the dough did not have the ability to trap air during mixing, and

on the other hand, the gases produced during baking did not have the ability to change in volume. Ultimately, a cake with a low volume, a compact texture, and a raw and wet filling was produced.

3-3-2-Cake size

The results of cake volume measurement are shown in Figure 1. The results of variance analysis showed that the effect of shiitake and Ganoderma mushroom powders on cake volume was significant. Adding powder of both mushrooms reduced the volume of the produced

cakes. The control had the highest volume, and increasing the percentage of powder of both mushrooms also reduced the volume, and cakes containing 15% shiitake mushroom powder and 15% Ganoderma mushroom powder had the lowest volume. Adding powder of both mushrooms reduced the volume of the cake, which is probably due to changes in viscosity and bulk density. (Alabi et al 2007) Or increasing the protein content in cake flour is due to increasing the amount of shiitake and Ganoderma mushroom powder. Increasing the protein content in flour creates a stronger flour and, as a result, produces a product with a firmer and denser nature (Tabatabai-Koshki et al., 2013).



(Figure 1)- Cake volume in different treatments ($P < 0/05$).

The results of this section were consistent with the research of Zare et al. (2016) and Tabatabaei Koushki et al. (2013), who investigated the effect of replacing wheat flour with alfalfa flour and wheat flour with soy protein isolate, respectively, but were inconsistent with the research of Salehi et al. (2015), who investigated the replacement of wheat flour with button mushroom powder.

3-3-3- Colorimetry

The color of the cake crust is created by the Maillard reaction and caramelization during baking, while the cake core is influenced by the ingredients used in the formulation (Majzoubi, 2012). The results obtained from image processing of the color of the crust and core of the cake of the control sample and the samples enriched with shiitake and Ganoderma mushroom powder are given in Table 4-3. By increasing the percentage of added mushroom

(Table 2) The effect of Ganoderma and Shiitake mushroom powder s on the amount of color components of the shell and core of the oil cake compared to the control.

powder, the components L (Light) and b (yellowness) compared to the control sample decreased and the component a (red) increases. The results of this section are consistent with the research of Salehi et al. in 2015, who investigated the enrichment of sponge cake with button mushroom powder.

It has been reported in various studies that the use of fiber in cake formulations causes darkening of the product (Hajmohammadi et al., 2013, Majzoubi et al., 2015). Since shiitake mushrooms contain 0.61 ± 67.10 percent and Ganoderma mushroom $1.01 \pm 24.83\%$ fiber is the reason for the darker color of the samples. Another reason for the change in color of the enriched samples compared to the control is due to the presence of color compounds in the shiitake and Ganoderma mushroom powders.

Crust color			
Sample	L*	a*	b*
control	63/22 ± 2/69 ^a	6/46 ± 1/24 ^d	33/90 ± 3/52 ^a
Shiitake 5%	60/46 ± 2/25 ^{ab}	7/46 ± 1/13 ^{cd}	30/83 ± 3/75 ^a
Shiitake 10%	56/04 ± 3/72 ^{bc}	8/64 ± 0/85 ^{bc}	31/50 ± 2/89 ^a
Shiitake 15%	51/66 ± 1/61 ^c	12/08 ± 2/54 ^a	30/47 ± 5/95 ^a
Ganoderma 5%	44/00 ± 4/05 ^d	8/08 ± 1/00 ^{bcd}	18/25 ± 1/51 ^b
Ganoderma 10%	36/11 ± 4/34 ^c	9/15 ± 1/32 ^{bc}	13/66 ± 2/33 ^{bc}
Ganoderma 15%	29/84 ± 3/90 ^f	9/98 ± 0/52 ^b	9/69 ± 0/66 ^c

Crumb color			
Sample	L*	a*	b*
control	76/10 ± 2/42 ^a	3/18 ± 1/41 ^c	40/88 ± 7/71 ^a
Shiitake 5%	71/31 ± 0/71 ^b	4/59 ± 1/03 ^b	29/44 ± 1/85 ^b
Shiitake 10%	67/93 ± 2/33 ^b	4/17 ± 0/76 ^{bc}	25/94 ± 1/29 ^{bc}
Shiitake 15%	61/11 ± 3/11 ^c	4/70 ± 0/81 ^b	24/08 ± 1/01 ^c
Ganoderma 5%	51/17 ± 2/43 ^d	8/13 ± 0/36 ^a	18/19 ± 1/31 ^d
Ganoderma 10%	45/50 ± 5/20 ^c	8/45 ± 1/00 ^a	18/02 ± 2/16 ^d
Ganoderma 15%	39/91 ± 1/78 ^f	8/25 ± 0/14 ^a	17/38 ± 1/63 ^d



(Figure 2) Color of control sample and different percentages of mushroom powder * the sample on the right are s and the samples on the left are samples containing ganoderma powders.

3-3-4- Histometry results

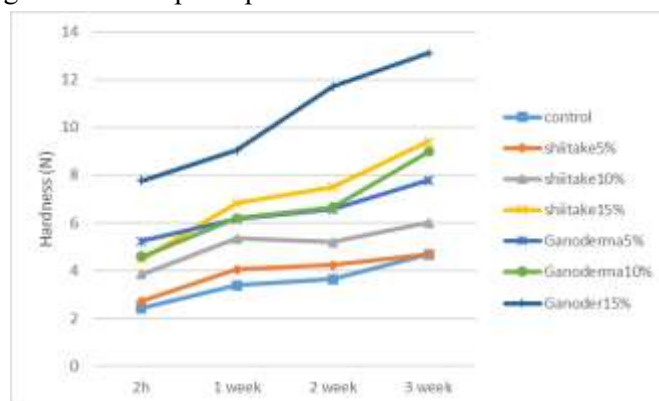
The results of the analysis of variance of cake texture using a texture analyzer showed that the effect of day and the interaction effect of the

percentage of shiitake and Ganoderma powders on cake texture were significant. Figure 2 shows the effect of day of storage and the percentage of addition of shiitake and Ganoderma powders.

The study of the effect of day of storage on cake texture firmness showed that the day of storage had a significant effect on texture firmness and the softness of the cake texture decreased over time.

Stagnation or hardening of the texture of baked goods during storage is a complex process

involving several factors such as amylopectin retrogradation, polymer rearrangement in the amorphous region, and reduction in moisture content between the amorphous and crystalline regions.



(Figure 3) The role of day and percentage of Shiitake and Ganoderma mushroom powders addition on the firmness of the control cake and enriched samples.

The effect of the percentage of addition of shiitake and Ganoderma mushroom powder on the firmness of the oil cake texture over a total of 3 weeks of evaluation is shown in Table 3. These results showed that with increasing the amount of shiitake mushroom powder and especially Ganoderma mushroom powder in the cake composition, the cake texture became firmer. The samples containing Ganoderma mushroom powder were firmer than the samples containing

shiitake mushroom powder. The reason for this can be attributed to the high fiber content of Ganoderma mushroom powder, which has a strong water-binding property, as the large number of hydroxyl groups in the fiber structure allows for more water interactions through hydrogen bonds. Ayadi et al 2009).

(Table 3) Effect of day and addition of Shiitake and Ganoderma mushroom powders on the firmness of oil cake texture (newton unit)

Sample	2h	1 week	2 week	3 week
Control	2/42 ± 0/38 ^{Cc}	3/39 ± 0/76 ^{Bd}	3/67 ± 0/08 ^{Bf}	4/67 ± 0/46 ^{Ac}
Shiitake 5%	2/72 ± 0/27 ^{Bdc}	4/05 ± 0/15 ^{Ad}	4/24 ± 0/42 ^{Bd}	4/68 ± 0/39 ^{Ac}
Shiitake 10%	3/85 ± 0/06 ^{Ccd}	5/34 ± 0/06 ^{Bc}	5/19 ± 0/42 ^{Bd}	6/01 ± 0/52 ^{Ad}
Shiitake 15%	4/47 ± 0/59 ^{Dbc}	6/83 ± 0/61 ^{Cd}	7/51 ± 0/26 ^{Bb}	9/41 ± 0/28 ^{Ab}
Ganoderma 5%	5/24 ± 0/66 ^{Bd}	6/16 ± 0/61 ^{ABc}	6/56 ± 0/43 ^{ABc}	7/79 ± 1/42 ^{Ac}
Ganoderma 10%	4/59 ± 0/30 ^{Bbc}	6/20 ± 0/20 ^{Bb}	6/66 ± 0/32 ^{Ac}	8/99 ± 0/34 ^{Abc}
Ganoderma 15%	7/77 ± 1/55 ^{Ba}	9/03 ± 0/18 ^{Ba}	11/70 ± 0/92 ^{Aa}	13/11 ± 0/92 ^{Aa}

*Capital letters indicate comparisons between rows and lowercase letters indicate comparisons between columns.

3-4- The effect of adding shiitake and Ganoderma powder on the chemical composition of oil cake

3-4-1- The effect of adding mushroom powder on the moisture percentage of oil cake

The results of the analysis of variance of cake moisture showed that the effect of day on this characteristic was significant. According to Table 4, examining the cake moisture on different days of storage showed that the day of storage had a significant effect on cake moisture and in general it can be said that the moisture content of the cakes decreased with time. The moisture content of the samples at 2 hours after baking is higher than the standard range for cakes (2553), but the moisture percentage at intervals of 1 week, two weeks and three weeks after baking is within the standard range for cakes (2553).

The results showed that replacing shiitake and Ganoderma mushroom powder with wheat flour had a significant effect on moisture content ($p < 0.05$). $> P$).

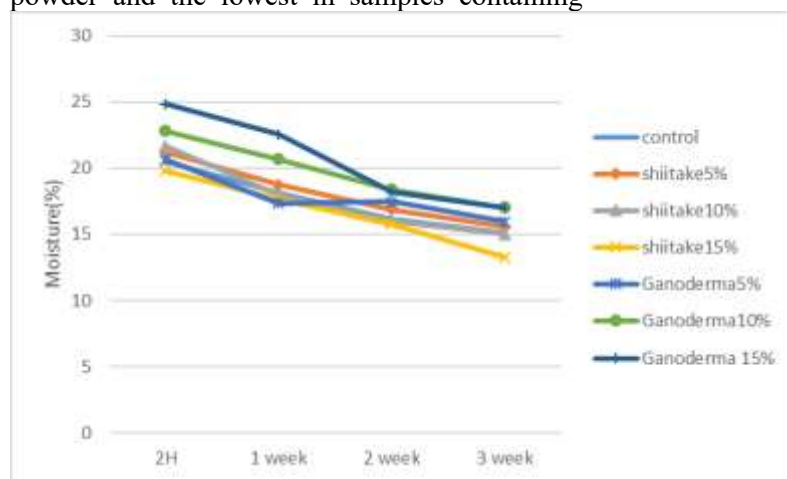
The highest moisture content was found in samples containing 15% Ganoderma mushroom powder and the lowest in samples containing

15% shiitake mushroom powder. However, there was no significant difference between the 15% shiitake mushroom samples and the control sample.

The reason why the moisture content of cakes containing Ganoderma mushroom powder is higher than that of the control sample is that a significant portion of the dry matter of Ganoderma mushroom is made up of dietary fiber (the fiber content of Ganoderma mushroom is 25%).

To increase the moisture content in cakes, McCarthy et al. (2005) say that some compounds that are hydrophilic in nature are able to interact with water and reduce the diffusion of water and the stability of its presence in the system, which is effective in increasing water absorption and maintaining the moisture content of the final product during the baking and storage process.

Since it is shiitake mushroom powder (about 20% protein and 10% fiber) and Ganoderma mushroom powder (about 16% protein and 25% fiber), it is likely that the protein and fiber in them increase the water-holding capacity of the cake and increase the moisture content of the final product.



(Figure 4) The role of day and the percentage of Shiitake and Ganoderma mushroom powders addition, on the moisture content of the control cake and the enriched samples.

(Table4) Effect of day and addition of Shiitake and Ganoderma mushroom powders on oil cake moisture

Sample	2h	1 week	2 week	3 week
Control	20/53 $\pm$ 0/23 ^{Aef}	18/13 $\pm$ 0/19 ^{Bcd}	16/17 $\pm$ 0/08 ^{Cc}	15/11 $\pm$ 0/11 ^{Db}
Shiitake 5%	21/23 $\pm$ 0/41 ^{Acd}	18/74 $\pm$ 0/49 ^{Bc}	16/88 $\pm$ 0/59 ^{Cbc}	15/55 $\pm$ 0/60 ^{Db}
Shiitake 10%	21/66 $\pm$ 0/24 ^{Ac}	17/96 $\pm$ 0/21 ^{Bcd}	16/01 $\pm$ 0/24 ^{Cc}	15/03 $\pm$ 0/41 ^{Db}
Shiitake 15%	19/81 $\pm$ 0/35 ^{Af}	17/64 $\pm$ 0/28 ^{Bd}	15/75 $\pm$ 0/53 ^{Cc}	13/27 $\pm$ 0/32 ^{Dc}

Ganoderma 5%	20/65 ± 0/35 ^{Ade}	17/36 ± 0/34 ^{Bd}	17/47 ± 0/14 ^{BCab}	15/96 ± 0/43 ^{Cab}
Ganoderma 10%	22/81 ± 0/53 ^{Ab}	20/68 ± 0/49 ^{Bb}	18/38 ± 0/42 ^{Ca}	17/05 ± 0/35 ^{Da}
Ganoderma 15%	24/84 ± 0/38 ^{Aa}	22/52 ± 0/83 ^{Ba}	18/24 ± 1/25 ^{Ca}	17/01 ± 1/72 ^{Ca}

*Capital letters indicate comparisons between rows and lowercase letters indicate comparisons between

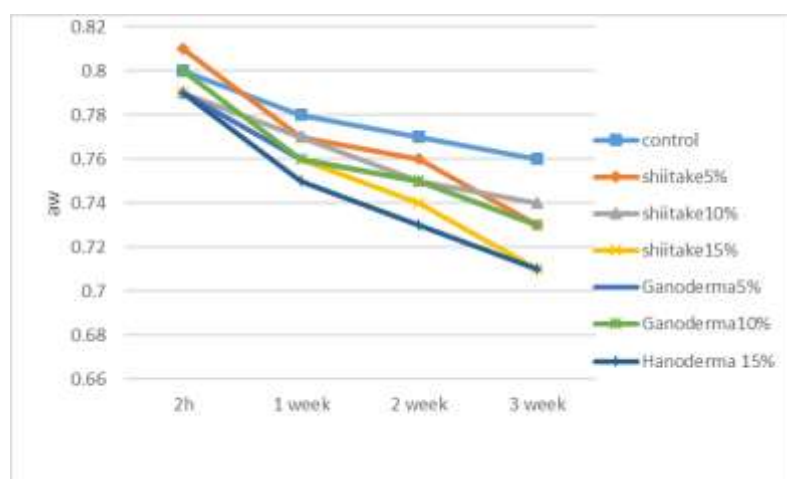
This increase in moisture content is consistent with the results of research by Sodha et al. (2007) who reported that increasing the amount of apple pomace (at levels of 5, 10, and 15% w/w) as a source of dietary fiber on the rheological properties of cake dough, and that water absorption increased significantly with increasing the amount of apple pomace from 0 to 15%, and Fallahi (2012) who studied the effect of adding date kernel powder on the properties of sponge cake. According to Russell (2001), this increase in moisture content is due to hydrogen bonding of water with hydroxyl bonds in the fiber structure.

3-4-2- The effect of adding mushroom powder on the water activity of cake

The amount of available water is measured as water activity. Water activity is a good factor for evaluating the shelf life and microbiological stability of foods. (Havens et al 2007). These results showed that at 2 hours after baking, there was no significant difference in water activity between the different cake treatments ($p < 0.05$). (P).

The lowest and highest amounts in the first and second weeks were related to the cake samples containing 15% Ganoderma and the control sample, respectively. In the first week, there was no significant difference between the samples containing 5%, 10% and 15% Shiitake and 5% Ganoderma with the control sample and 10% Ganoderma with 15% Ganoderma sample. However, in the second week, there was no significant difference between the samples containing 5% Shiitake and 5% Ganoderma with the control sample, as well as the samples containing 10% Shiitake and 15% Shiitake and 10% Ganoderma.

Amount of water activity. In the third week, the lowest amount was for samples containing 15% Shiitake mushroom powder and 15% Ganoderma, and the highest amount was for the control sample, and there was no significant difference between the remaining samples. The higher the water activity of the cake, the faster it will mold and the shorter its shelf life. Examples that show they have a lower risk of death than the control group and are also more durable.



(Figure 5) The role of day and the percentage of Shiitake and Ganoderma mushroom powders addition on the amount of aw of control cake and enriched samples.

Amount of water activity. All samples were above the standard cake range (2553) at 2 hours after baking and in the first week, but in the second

and third weeks, all samples except the control sample were within the standard cake range (2553).

(Table 5) The effect of day and the addition of Shiitake and Ganoderma mushroom powders on the aqueous activity of oil cake

Sample	2h	1 week	2 week	3 week
Control	0/80 ± 0/003 ^{Aab}	0/78 ± 0/005 ^{Ba}	0/77 ± 0/004 ^{BCa}	0/76 ± 0/007 ^{Ca}
Shiitake 5%	0/81 ± 0/01 ^{Aa}	0/77 ± 0/009 ^{Ba}	0/76 ± 0/007 ^{Bab}	0/73 ± 0/001 ^{Cb}
Shiitake 10%	0/79 ± 0/06 ^{Aab}	0/77 ± 0/006 ^{Ba}	0/75 ± 0/01 ^{Cbc}	0/74 ± 0/01 ^{Cb}
Shiitake 15%	0/79 ± 0/006 ^{Ab}	0/76 ± 0/007 ^{Babc}	0/74 ± 0/007 ^{Cbc}	0/71 ± 0/006 ^{Dc}
Ganoderma 5%	0/79 ± 0/004 ^{Ab}	0/76 ± 0/01 ^{Babc}	0/75 ± 0/01 ^{Bab}	0/73 ± 0/004 ^{Db}
Ganoderma 10%	0/80 ± 0/005 ^{Aab}	0/76 ± 0/002 ^{Abc}	0/75 ± 0/002 ^{Bbc}	0/73 ± 0/006 ^{Cb}
Ganoderma 15%	0/79 ± 0/008 ^{Aab}	0/75 ± 0/004 ^{Bc}	0/73 ± 0/01 ^{Cc}	0/71 ± 0/005 ^{Dc}

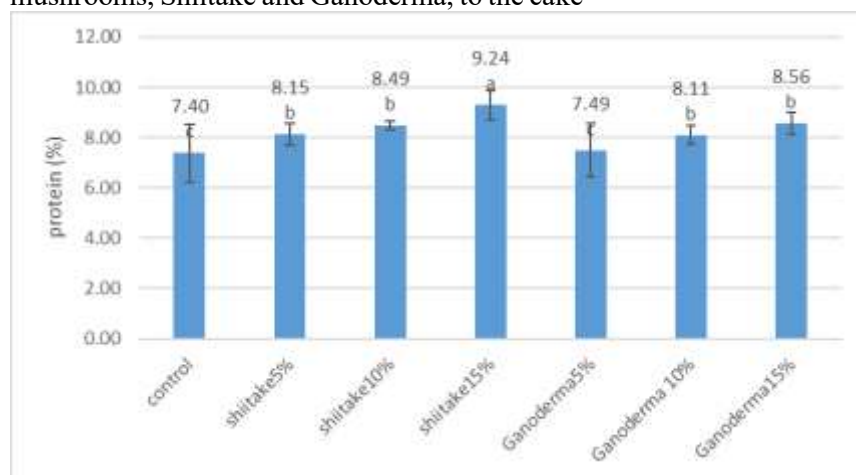
*Capital letters indicate comparisons between rows and lowercase letters indicate comparisons between columns.

3-4-3- The effect of adding mushroom powder on the protein content of oil cake

Based on the results obtained, the protein content of all samples was within the standard range defined for oilcake (at least 7% by weight based on dry matter). The results showed that the protein content of the sample containing 15% shiitake mushrooms and then the sample containing 15% Ganoderma mushrooms was higher than the other samples, and the lowest protein content was observed in the control sample.

According to Figure 5, adding powder of two mushrooms, Shiitake and Ganoderma, to the cake

mixture significantly increased the amount of protein in the enriched samples compared to the control ($P < 0.05$). The reason for this is the higher protein content in shiitake mushrooms (protein percentage = 0.87 ± 19.57) and Ganoderma (protein percentage = 87.0 ± 15.58) compared to wheat flour (protein percentage = 2.05 ± 10.83) and thus, by increasing the amount of mushroom flour substituted in the cake formula, its protein content increases. This increase in protein is consistent with the results of the research by Salehi et al. (2015) on the enrichment of sponge cake with button mushroom powder.



(Figure 6) Protein percentage of enriched and control cakes. ($P < 0.05$)

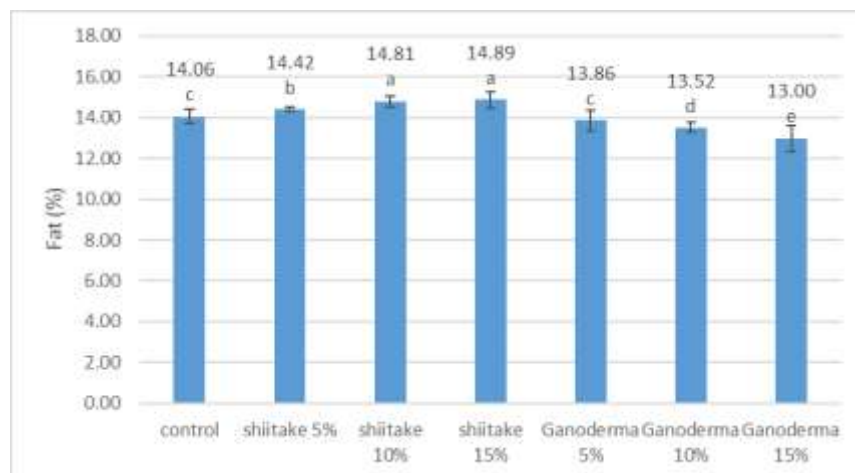
3-4-4- The effect of adding mushroom powder on the fat content of the cake

Analysis of the obtained data showed that adding shiitake and Ganoderma mushroom powder had

a significant effect on the fat content of the cake ($P < 0/05$).

Comparison of the averages in Figure 6 showed that the maximum and minimum fat content belonged to the samples containing 15% shiitake mushrooms and the samples containing 15%

Ganoderma mushrooms, respectively, which, according to the measurement of the fat percentage from the flour (fat percentage = 0.03 ± 1.01) and shiitake mushrooms (fat percentage = 0.34 ± 19), Ganoderma mushroom (fat percentage = 0.15 ± 0.5) was done, the desired result is quite logical.



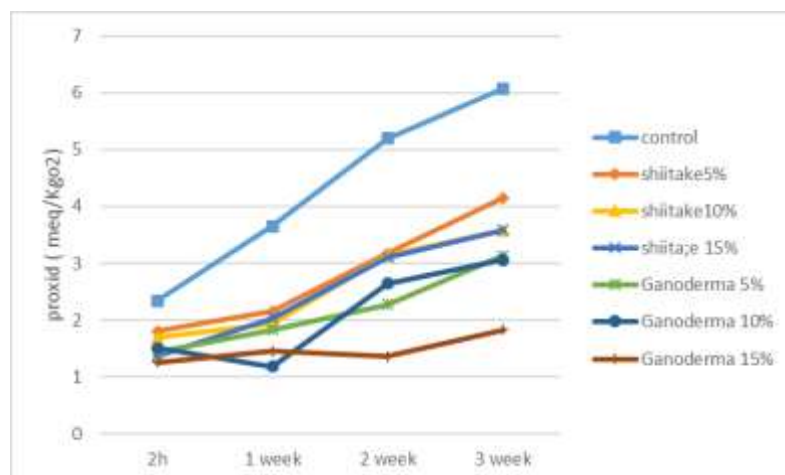
(Figure 7) Fat percentage of enriched and control cakes. ($P < 0/05$)

3-4-5- The effect of adding mushroom powder on the peroxide index

Andis Peroxide In the form of Millie Equivalent Peroxide In 1000 Sample gram that Iodide potassium particle for direct object under Conditions Test Oxide Does is stated)AA.CC(2000). Peroxide value is used to measure the oxidative rancidity of oils and is one of the most important parameters for assessing the degree of lipid spoilage. Freshly refined oils should have a peroxide value of zero, but for acceptable storage stability the peroxide value should be less than 1 mmol Kg^{-1} samples (Nasir et al., 2009).

Comparison of the means in Table 4-6 showed that there was a significant difference between the samples in terms of peroxide index ($0.05 > P$). The lowest peroxide index was for samples containing 15% Ganoderma and the highest peroxide index was for control samples. There was no significant difference in peroxide index between samples containing 5%, 10%, 15% shiitake and 5% Ganoderma. Considering that shiitake and Ganoderma mushrooms have antioxidant properties, these results are acceptable.

In general, increasing the percentage of mushroom powder reduces this index, but increasing the storage time has a negative effect on this index and increases it.



(Figure 8) - The role of day and percentage of Shiitake and Ganoderma mushroom powders addition on the peroxide index of the control cake and enriched samples

(Table 6) Effect of day and addition of Shiitake and Ganoderma mushroom powders on oil cake peroxide index in terms of meq/Kgo2

Sample	2h	1 week	2 week	3 week
Control	2/34 ± 0/34 ^{Da}	3/65 ± 0/10 ^{Ca}	5/19 ± 0/20 ^{Ba}	6/07 ± 0/24 ^{Aa}
Shiitake 5%	1/80 ± 0/29 ^{Cb}	2/15 ± 0/32 ^{Cb}	3/17 ± 0/37 ^{Bb}	4/15 ± 0/30 ^{Ab}
Shiitake 10%	1/69 ± 0/24 ^{Bbc}	1/94 ± 0/13 ^{Bb}	3/31 ± 0/17 ^{Ab}	3/58 ± 0/43 ^{Abc}
Shiitake 15%	1/37 ± 0/16 ^{Bbc}	2/03 ± 0/39 ^{Bb}	3/11 ± 0/51 ^{Abc}	3/59 ± 0/57 ^{Abc}
Ganoderma 5%	1/44 ± 0/20 ^{Cbc}	1/83 ± 0/13 ^{Cbc}	2/27 ± 0/29 ^{Bd}	3/13 ± 0/23 ^{Ac}
Ganoderma 10%	1/51 ± 0/06 ^{Bbc}	1/18 ± 0/07 ^{Bd}	2/64 ± 0/04 ^{Ac}	3/06 ± 0/5 ^{Ac}
Ganoderma 15%	1/26 ± 0/19 ^{Bc}	1/45 ± 0/20 ^{Bcd}	1/36 ± 0/11 ^{ABe}	1/83 ± 0/28 ^{Ad}

*Capital letters indicate comparisons between rows and lowercase letters indicate comparisons between columns.

6-3-4- Sensory evaluation

Sensory evaluation examines the acceptability of a product from the perspective of consumers. Whether a product is acceptable to consumers or not depends on the consumer's perception of the taste, color, texture, and overall quality of the product.

The analysis of the data obtained from the experiments showed that the addition of shiitake and Ganoderma powders had a significant effect on the sensory characteristics of the oil cake. The results showed that the color of the crust of the samples containing mushroom powder scored higher than the control sample and were more acceptable, and the samples containing 10%

Ganoderma powder obtained the highest score in terms of color. In terms of taste, the results showed that the 10% Ganoderma sample had the highest score, and the samples containing 15% shiitake and 15% Ganoderma also had the lowest score. In terms of texture and crispness, the results showed that the samples containing shiitake did not differ significantly from the control sample, but the samples containing Ganoderma obtained a low score due to their hard texture. Overall, the sample containing 5% shiitake powder received the highest score from consumers among all samples, and the 15% Ganoderma sample received the lowest score from consumers due to its firm texture and lack of crispness.

(Table 7) Effect of day and addition of powder of shiitake and ganoderma mushrooms on the sensory evaluation of oil cake (scoring in a range of 5 points)

Sample	color	taste	Texture	crips	General acceptance
Control	2/4 ± 0/51 ^{Ab}	2/5 ± 0/52 ^{Aab}	2/9 ± 0/73 ^{Aa}	2/8 ± 0/42 ^{Aa}	2/65 ± 0/58
Shiitake 5%	4/2 ± 0/63 ^{Aa}	2/2 ± 0/42 ^{Cbc}	2/5 ± 0/73 ^{BCa}	2/7 ± 0/48 ^{Ba}	2/90 ± 0/92
Shiitake 10%	3/7 ± 0/67 ^{Aa}	2/0 ± 0/66 ^{Cbcd}	2/5 ± 0/52 ^{BC}	2/7 ± 0/48 ^{Ba}	2/72 ± 0/84
Shiitake 15%	4/0 ± 0/97 ^{Aa}	1/5 ± 0/52 ^{Cd}	2/6 ± 0/51 ^{Ba}	2/6 ± 0/41 ^{Ba}	2/65 ± 1/12

Ganoderma 5%	$2/9 \pm 0/56^{Ab}$	$2/8 \pm 0/52^{Aab}$	$2/2 \pm 0/42^{Bb}$	$2/5 \pm 0/52^{Aba}$	$2/58 \pm 0/54$
Ganoderma 10%	$4/3 \pm 0/82^{Aa}$	$2/8 \pm 0/42^{Ba}$	$1/0 \pm 0/04^{Cc}$	$1/0 \pm 0/0^{Cb}$	$2/10 \pm 1/27$
Ganoderma 15%	$3/8 \pm 0/78^{Aa}$	$1/8 \pm 0/63^{Bcd}$	$1/0 \pm 0/0^{Cc}$	$1/0 \pm 0/0^{cb}$	$1/90 \pm 1/25$

7- Conclusion

Shiitake and Ganoderma mushrooms are considered a product with high nutritional value due to their bioactive and antioxidant compounds. Adding them to cakes both enriches the cake and prevents the oxidation process during storage, increasing its shelf life.

The results showed that as the amount of shiitake and Ganoderma mushroom powder replaced with white flour, the physical properties of the sample changed due to the increase in protein and fiber content.

This increase in protein and fiber causes excessive increase in dough viscosity, decrease in volume, stiffness of texture, and darkening of the samples. Since the amount of fiber in Ganoderma mushroom was higher than in samples containing shiitake mushroom powder, and Ganoderma mushroom also contains brown pigment, this increase in dough viscosity, decrease in volume, stiffness of texture, and darkening was greater in samples containing Ganoderma powder than in samples containing shiitake mushroom powder.

Due to the increase in shiitake mushroom powder in different treatments, the amount of fat in the cake increased, but with the increase in Ganoderma mushroom powder, the amount of fat in the cake decreased.

The results of the changes in peroxide value in the samples showed that the peroxide value in the control cakes was higher than the cakes enriched with shiitake and Ganoderma mushroom powder. However, since the antioxidant properties of Ganoderma mushroom powder were higher than those of shiitake mushroom powder, the peroxide value in the samples containing Ganoderma mushroom powder showed a greater decrease than the samples containing shiitake mushroom powder. Based on the results of the sensory evaluation, the sample containing 5% shiitake

mushroom powder had the highest score in terms of sensory acceptance.

Essentials

Data access

The data of this research is in the form of primary data (Primary Data) has been collected through experimental tests and direct measurements in controlled laboratory conditions at Tehran Azad University of Sciences and Research.

Conflict of interest

There is no conflict of interest.

Financing Statement

The research costs were covered by the authors.

Authors' Contributions

Yasmin Bakhtiari Bidkarpeh, ideation, conducting laboratory experiments, data analysis, and writing the initial draft of the article.

Dr. Maryam Gharachourloo, project supervision, review and editing of the final text, provision of resources and laboratory equipment.

Dr. Masoud Honrour, assistant in the methodology and statistical data analysis department.

Artificial Intelligence Statement

During the preparation of this work, no generative artificial intelligence or assistive technologies were used for content generation or data analysis.

8-Resources

- [1] AACC. (1999). *Approved method of the American Association of Cereal Chemists*. St. Paul: American Association of Cereal Chemists.
- [2] AACC. (2000). *Approved Methods of the American Association of Cereal Chemists*,

- 10th Ed., Vol. 2. American Association of Cereal Chemists, St. Paul, MN.
- [3] Afsharian Targhabeh, S. Sheikh Al-Islami, Z. Atai Salehi, A. 2015. The effect of orange peel essential oil as a natural preservative on rheological properties. Sensory and microbial properties of oil cake, *Quarterly Journal of Food Science and Industry*, 10 (13) 113-1.
- [4] AOAC. (1995). Official methods of analysis, 16th edition., *Association of Official Analytical Chemists, Washington DC, USA*.
- [5] Ahlborn, G. J., Pike, O. A., Hendrix, S. B., Hess, W. M., and Huber, C. S. 2005. Sensory, mechanical and microscopic evaluation of staling in low protein and gluten free bread. *Cereal Chemistry*, 82: 328-335.
- [6] Alabi, M.O. and Anounye, J.C. 2007. Nutritional and sensory attributes of soy supplemented Cereal Meals. *Nig Food Journal*. 25:100-110.
- [7] Arora, B., Kamal, S., & Sharma, V. P. (2017). Sensory, nutritional and quality attributes of sponge cake supplemented with mushroom (*agaricus bisporus*) powder. *Nutrition & Food Science*, 47, 578-590.
- [8] Baba, E. ULUKÖY, G. 2022. Effects of Dietary Supplemented Shiitake Mushroom Extract on Growth, Nonspecific Immune Parameters and in-vitro Resistance Against *Aeromonas hydrophila* in Rainbow Trout (*Oncorhynchus mykiss*). *Journal of Limnology and Freshwater Fisheries Research*, 8(1): 28-36
- [9] Baixauli, R., Sanz, T., Salvador, A. and Fiszman, S.M. 2007. Influence of the dosing process on the rheological and microstructural properties of a bakery product. *Food Hydrocolloids*, 21(2): 230-236.
- [10] Benzie, I.F.F., Strain, J.J. (1999). Ferric reducing / antioxidant power assay: direct measure of total antioxidant activity of biological fluids and modified version for simultaneous of total antioxidant power and ascorbic acid concentration. *Methods Enzymology*. 299: 15-27.
- [11] Beynam, 1321. Cake - characteristics and test methods, National Standard of Iran No. 2113, Institute of Standards and Industrial Research of Iran.
- [12] Chang, R. Functional properties of edible mushrooms. *Nutr. Rev.* 11-54, 1996, pp. 91-39
- [13] Dalandar Kohi, M. Azadmard Demirchi, p. Qarakhani, M. 2018. Production of sponge cake containing black seed powder and checking some of its quality characteristics during storage. *Journal of Nutrition Sciences and Food Industries of Iran*, 15th year, number 2, summer 2019, pages 83-39
- [14] Demirkesen, I., Mert, B., Sumnu, G. and Sahin, S. 2010. Utilization of chestnut flour in gluten-free bread formulations. *Journal of Food Engineering*, 101: 329-633
- [15] Garuba, T. Olahan, G.S. Lateef, A.A., Alaya, R. O. Awolowo, M., A. Sulyman A. 2019. Proximate Composition and Chemical Profiles of Reishi Mushroom (*Ganoderma lucidum* (Curt: Fr.) Karst). *JOURNAL OF SCIENTIFIC RESEARCH*. 12 (1), 103-110.
- [16] Haj Mohammadi, A. Dignity, c. Hojjat al-Islami, M. and Molavi, H. 2013. The effect of using katira gum on the texture and shelf life of sponge cake, *Journal of Herbal Medicines, Volume 4, Number 39-24*
- [17] Ismailpour Falahi, b. 2013, the effect of adding date kernel powder on the quality characteristics of sponge cake, senior thesis of Aras International Campus.
- [18] Kipour, S. Riahi, H. Rafati, M. 2012. "A review of biologically active compounds and therapeutic properties of *Ganoderma lucidum*," *Quarterly Journal of Medicinal Plants*, 12th year, second term, Shahid Beheshti University, Tehran, Iran, Spring, 15-16.
- [19] Li, B. D. (2013). Structural investigation of water-soluble polysaccharides extracted from the fruit. *Carbohydrate Polymers*, 91, 314- 321.
- [20] McCarthy, D.F., Gallagher, E., Gormley, T.R., Schober, T.J. and Arendt, E.K. 2005. Application of response surface methodology in the development of gluten

- free bread. *Cereal Chemistry*. 82(5): 609-615.
- [21] Majzoobi, M., Vosooghi Poor, Z., Mesbahi, G., Jamalian, J., & Farahnaky, A. (2017). Effects of carrot pomace powder and a mixture of pectin and xanthan on the quality of gluten free batter and cakes. *Journal of Texture Studies*, 48, 616-623.
- [22] Majzoobi, M., Dara, N., and Farahnaki, A. 2012. Effects of percentage and particle size of wheat germ on some properties of batter and cake. *Jurnal Agriculture Science and Technology*, 1:827-836.
- [23] Majzoobi, M., Habibi, M., Hedayati, S., Ghiasi, F. and Farahnaky, A. 2015. *Journal of Agricultural Science and Technology*, 17(1): 99-107.
- [24] Malkot Tabari, S., Gurbanli, M., Safaian, S., Musazadeh, S., 2013. Antioxidant properties of methanolic extract of *Ganoderma lucidum* mushroom, Flowerjan Azad University.
- [25] Ministry of Health, Medical Education, Food and Drug Deputy. General Department of Food and Beverage Supervision (2013).
- [26] Mousavi Koljahi, A. Babaei Sadr, A. 2015. Investigating the physical, chemical, rheological and sensory properties of the ultra-pleasant oil cake containing sour lemon pomace powder and date liquid sugar, theoretical research unit, Nejati Industrial Group (Anata).
- [27] Mumtaz, S. A, H, Abdul Ghaffari, A, H. (2019) "Pharmacology and therapeutic properties of *Ganoderma lucidum*." Jihad University Publications, Research Institute of Medicinal Plants, Tehran, Iran, Spring, 16-20.
- [28] Pathak, V. N, Yadav, N. and Gour, M. 1998, Mushroom production and processing technique agrobotanica. pp. 2-3
- [29] Nasir, M.; Butt, M.S.: Anjum, F .M.: Jamil, A.; and Ahmad, I. 2009. Physical and sensory properties of maize germ oil fortified cakes. *International Journal of Agriculture & Biology*, 11:311-315.
- [30] Ngai, P. H. K and Ng, T. B. 2003. Lentin, a novel and potent antifungal protein from shiitake mushroom with inhibitory effects on activity of human immunodeficiency virus-1 reverse transcriptase and proliferation of leukemia cells. *Life Sci*. 12, 2003, pp. 3363-3374.
- [31] Obodai, M, Deborah L. Narh Mensah, Angela Fernandes, Nii Korley Kortei, Matilda Dzomeku, Matthew Teegarden, Steven J. Schwartz, Lillian Matthew Teegarden, Steven J. Schwartz, Lillian Barros, Juanita Prempeh, Barros, Juanita Prempeh, Richard K. (2017) "Chemical Characterization and Antioxidant Potential of Wild *Ganoderma* Species from Ghana,". *Molecules* 22: 1-.81
- [32] Rosell, C.M., Rojas, J.A. and Benedito, C. 2001. Influence of hydrocolloids on dough rheology and bread quality. *Food Hydrocoll.* 15: 75–8.
- [33] Salamat, S.A., Shahid M.O., Najeeb J. A., 2017. Proximate analysis and simultaneous mineral profiling of five selected wild commercial mushroom as a potential nutraceutical, *International Journal of Chemical Studies* 5(3): 297-303
- [34] Salehi, F. K. (2014). Effect of different drying methods on rheological and textural properties of balangu seed gum. *Dry Tech.*, 32, 720-727
- [35] Salehi, F., Kashaninejad, M., Sadeghi Mahonek, M. 2014, Enrichment of sponge cake with button mushroom powder dried in hot air infrared system, *New Food Technologies Quarterly*, third year, number 9, page 1-9
- [36] Salehi, F., Kashaninejad, M. Alipour, N. 2015. Investigating the physicochemical, sensory and texture characteristics of sponge cake enriched with apple powder. *New Food Technologies Quarterly*, third year, number 11, page 39-47.
- [37] Salrhi, F, Aghajanzadeh, S. (2019), Effect of dried fruits and vegetables powder on cakes quality: A review, *Trends in Food Science & Technology* .
- [38] Sheikh, M., Kumar, A., Islam, M., & Mahomud, M. (2010). The effects of mushroom 820 powder on the quality of

cake. *Progressive Agriculture*, 21, 205-214.

- [39] Stojkovic DS, Barrs L, Calhelha RC, Glamocli jaj, Ciric A, Van Griensven L J et al. detailed comparative study between chemical and bioactive properties of *Ganoderma lucidum* from different origins. *International Journal of Food Sciences and Nutrition*, 2014; 65(1):42-7.
- [40] Sudha, M. L., Baskaran, V. and Leelavathi, k. 2007. Apple pomace as a source of dietary fibre and poly phenols and its effects on the rheological characteristics and cake making in: *food chemistry*, 104: 686-692.
- [41] Tabatabai Kushki, 2013, production of sponge cake enriched with wheat germ flour and soybean protein isolate, master's thesis, Gorgan University of Agricultural Sciences and Natural Industries.
- [42] Turło J, Gutkowska B, Herold F. Effect of selenium enrichment on antioxidant activities and chemical composition of *Lentinula edodes* (Berk.) Pegl. mycelial extracts. *Food Chem Toxicol* 2010 Apr 1;48(4):1085-91.
- [43] Zare, Z. Nouri, L. Fahim Danesh, M. 2015, investigating the effect of replacing wheat flour with elder flour on the physicochemical and sensory properties of oil cake. *Journal of innovation in food science and technology*, year 8, number 2, pages 53-63.
- [44] Zimeri, J. and Kokini, J. 2003. Rheological properties of inulin-waxy maize starch systems. *Carbohydrate polymers*, 52(1): 67-85.



امکان سنجی تولید کیک روغنی فرآسودمند با استفاده از پودر قارچ شیتاکه و گانودرما و بررسی خصوصیات کیفی آنها

یاسمین بختیاری بیدکرپه^۱، مریم قراچورلو^{۲*}، مسعود هنرور^۲

۱-دانش آموخته کارشناس ارشد علوم و صنایع غذایی، واحد علوم و تحقیقات، دانشگاه آزاد اسلامی، تهران، ایران

۲-دانشیار گروه علوم و مهندسی صنایع غذایی، واحد علوم و تحقیقات، دانشگاه آزاد اسلامی، تهران، ایران

اطلاعات مقاله

چکیده

تاریخ های مقاله :

تاریخ دریافت: ۱۴۰۴/۱۱/۰۵

تاریخ داوری: ۱۴۰۴/۰۷/۳۰

تاریخ پذیرش: ۱۴۰۴/۰۸/۰۴

کلمات کلیدی:

کیک روغنی،

غنی سازی،

پودر قارچ شیتاکه،

پودر قارچ گانودرما.

DOI: 10.48311/fsct.2026.83362.0

* مسئول مکاتبات:

Gharachorloo.m@gmail.com,
maryam.gharachorloo@iau.ac.ir

کیک به سبب طعم مطلوب، ارزش غذایی بالا و سهولت مصرف از کاربرد بالایی برخوردار بوده لذا تغییرات بسیاری در فرمولاسیون آن جهت افزایش ارزش تغذیه ای، بهبود کیفیت و زمان ماندگاری محصول انجام شده است. در این تحقیق غنی سازی کیک روغنی با پودر قارچ شیتاکه (*Lentinula edoes*) و پودر قارچ گانودرما (*Ganoderma Lucidum*) انجام شده است. ابتدا درصد چربی، پروتئین، رطوبت، فیبر و خاکستر آرد گندم و پودر قارچ ها و فعالیت آنتی اکسیدانی قارچ ها بررسی شد. سپس پودر قارچ های شیتاکه و گانودرما در سطوح 5، 10 و 15 درصد به عنوان جایگزین آرد در فرمولاسیون کیک روغنی مورد استفاده قرار گرفت. خصوصیات کیک های تولیدی شامل درصد ترکیبات، حجم، اندیس پراکسید، رنگ، میزان سفتی توسط دستگاه بافت سنج و ارزیابی حسی در مقایسه با شاهد مورد بررسی قرار گرفت. مقدار پروتئین، چربی و خاکستر پودر قارچ شیتاکه بیشتر از پودر قارچ گانودرما و آرد گندم ارزیابی شد. میزان فیبر و فعالیت آنتی اکسیدانی پودر قارچ گانودرما بیشتر از پودر قارچ شیتاکه و آرد گندم بود. حجم کیک با افزایش جایگزینی پودر قارچ به طور معنی داری کاهش، درحالیکه میزان پروتئین، فیبر و سفتی نمونه ها به طور معنی داری افزایش یافت. میزان چربی در نمونه های حاوی قارچ شیتاکه نسبت به نمونه شاهد افزایش یافت. با افزایش درصد پودر قارچ های اضافه شده مؤلفه های L^* (روشنایی) و b^* (زردی) در مقایسه با نمونه شاهد به طور معنی داری کاهش و مؤلفه a^* (قرمزی) به طور معنی داری افزایش پیدا کرد. میزان فعالیت آبی در نمونه های 2 ساعت بعد از پخت تفاوت معنی داری نداشتند اما پس از گذشت چند هفته در نمونه های غنی شده در مقایسه با نمونه شاهد کاهش بیشتری یافت. افزایش درصد پودر هر دو قارچ باعث کاهش معنی دار عدد پراکسید شد. از لحاظ حسی نمونه های حاوی 5 درصد پودر قارچ شیتاکه بیشترین امتیاز را در میان همه نمونه ها و در مقایسه با شاهد، بین مصرف کنندگان داشته است.