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Usage of Edible Mushrooms in Various Food Products

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A B S T R A C T

Use of edible mushrooms which are generally consumed in houses in dried form is based on mainly instant soup and sauce formulations. Recently, the cultivations of *Agaricus bisporus* and *Pleurotus ostreatus* species have become widespread. Utilization of these cultivated mushrooms in recipes would bring added value to related food products. For this purpose, *A. bisporus* and *P. ostreatus* species farmed in Osmaniye Korkut Ata University Mushroom House were dried and then pulverized. Firstly, a snack was prepared with *A. bisporus* powder. *A. bisporus* powder was substituted for wheat flour at the rates of 5%, 10%, 20% and 30% and thus the potential of food product which had relatively lower carbohydrate and fat level and higher fiber content was investigated. In the second part of the study, either 5%,10 % of *A. bisporus* powder or 5%, 10% of *P, ostreatus* powder were added into traditional Turkish meatball (beef mince, salt) which was cooked in conventional oven, so meat flavor could be replaced by herbal flavor coming from mushroom. This property mat obey the purpose that, the created new product will be consumed fondly especially by children. Sensory and physical (colour and texture) analysis were performed in both snack and meatball samples and the results were evaluated statistically.

Yenebilir Mantarların Çeşitli Gıda Ürünlerinde Kullanımı

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Ö Z E T

Kurutulmuş şekilde tüketilebilen yenebilir mantarların kullanımı ağırlıklı olarak hazır çorba ve sos formülasyonları şeklindedir. Son zamanlarda yetiştiriciliği yaygınlaşan *Agaricus bisporus* ve *Pleurotus ostreatus* mantarlarının çeşitli gıda formülasyonlarında kullanılması ile bu mantar türlerine katma değer kazandırılması gerektiği düşünülmektedir. Bu amaçla, Osmaniye Korkut Ata Üniversitesi mantarhanesinde yetiştirilen *A. bisporus* ve *P. ostreatus* mantarları uygun koşullarda kurutularak toz haline getirilmiştir. İlk olarak *A. bisporus* tozu ile atıştırmalık hazırlanmıştır. Buğday unu ile %5 - %10 - %20 ve %30 oranlarında yer değişimi yapılmış ve bu şekilde karbonhidrat ve yağ değerleri göreceli olarak daha düşük ve lif oranı daha yüksek bir ürünün potansiyeli araştırılmıştır. Çalışmanın ikinci bölümünde ise geleneksel fırın köfte (dana kıyması, tuz) tarifine % 5 ve % 10 oranlarında *A. bisporus* ve *P. ostreatus* mantar tozları eklenmiş ve bu şekilde köftedeki etsi aromanın mantardan gelen aroma ile yer değiştirmesi böylece köftenin daha kolay tüketilebilmesi amaçlanmıştır. Hem atıştırmalıklar hem de köfte örnekleri fiziksel (tekstür ve renk) ve duyusal olarak analiz edilmiş olup, duyusal analiz sonuçları istatistiksel olarak değerlendirilmiştir.

Introduction

Mushrooms are known as healthy foods and dietary nutrients in all over the world, because they include rich amounts of vegetable proteins, chitin, essential amino acids, vitamins, minerals and low fat and calories (Manzi et al., 1999; Pedneault et al., 2008). On dry basis, an edible mushroom has 56.8% carbohydrate, 25.0% protein, 5.7% fat and 12.5% ash contents (Demirbaş, 2002; Mendil et al., 2004). However, mushrooms are considered as not only a food source but also having medicinal properties because of bioactive compounds (Chiu et al., 2000; Chang and Miles, 2004). Also, edible mushrooms could be useful for many diseases such as hypertension, cancer and cholesterol (Bobek and Galbavy, 1999; Borchers et al., 1999).

For many years, cereal products have been existing in human's life and they are the most preferred food materials in the world (Kramer, 1996). Because of this reason, baking industry has grown rapidly and bakery products such as bread, croissant, snack etc. have taken huge part in international food market. But obesity, cardiovascular diseases, diabetes and some types of cancers are directly related to dietary habits (Hu, 2002). In order to reduce the risks, consumers tend to try new but healthier food products. Hence, baking industry should follow last and healthy trends (Byrne, 2000; Kohn, 2000; Kotsianis et al., 2002). This may be succeeded through processing or reformulation of food products such as non-thermal operations or functional foods (Reisch and Gwozdz, 2011; Kaur and Das, 2011; Aschemann-Witzel, 2015). Researchers have focused on substitution of various flour types for wheat flour to satisfy demands for healthier foods recently (Coelho and Salas-Mellado, 2015).

Meat and meat products include significant amount of proteins, vitamins and minerals and the consumption of these foods has been growing in developing countries (FAO, 2013; Ledesma et al., 2016). Especially red meat contains high amount of iron, zinc, selenium, potassium and a range of B-vitamins including niacin, riboflavin, thiamine and vitamin B12 (Wyness et al., 2011). Because of saturated fatty acids, doctors and researchers had suggested to reduce red meat in daily diet for several years. But studies conducted in Europe and North America showed that, there were no correlation between red meat consumption and various diseases such as cancer and cardiovascular disorders (Siri-Tarino et al., 2010; Kappeler et al., 2013; Rohrmann et al., 2013; Chowdhury et al., 2014). Recent studies also pointed out that unprocessed and processed meat products (salami, sausages etc.) should be distinguished (Binnie et al., 2014). Instead of consuming synthetic food additives or chemicals from processed meats, unprocessed meats like mince could be seasoned with natural compounds.

In previous studies, some fungi species were investigated by different researchers as food additives (Chockchaisawasdee et al., 2010; Wakchaure et al., 2010; Okafor et al., 2012; Aishah and Wan Rosli, 2013; Hafel et al., 2014). The present study is an important indicator on availability as a food additive in products such as meatball and snacks from dried *A. bisporus* and *P. ostreatus* and focuses colour, textural and sensorial properties of mentioned novel foods.

Materials and Methods

Production, Harvesting and Drying of Mushrooms

Agaricus bisporus ve *Pleurotus ostreatus* were produced by using composts in Mushroom House of Osmaniye Korkut Ata University. Air conditioning, ventilation and humidification systems are available in mushroom house. Firstly, rooms were disinfected by using 1% formaldehyde during 7 days before setting composts. Composts were placed to these rooms adjusted to the environmental conditions for mycelial growth. *P. ostreatus* mushrooms were cultivated at the lighting conditions after mycelial growth, while *A. bisporus* mushrooms were cultivated in a dark room. Mushrooms were harvested before opening their caps. Harvested mushrooms were dried by dehydrator (Kangye, KYS 329) during 1 day at 60°C. And then, dried mushroom samples were powdered by commercial blender (Waring, Germany) and were stored in glass jars at +4°C until analysis.

Preparation of Snacks

Recipe was modified from Anonymous, 2015a. Control sample includes 77% wheat flour, 19% margarine, 3.8% yoghurt and 0.2% salt. *A. bisporus* powder was the only type used in production of snacks since it is cheaper and more available than *P. ostreatus* and snacks are generally composed of more affordable components in terms of other food materials. *A. bisporus* mushroom powder was substituted for wheat flour at the rates of 5%, 10%, 20% and 30%. Doughs were made by manually and cooked in a house-type conventional oven (Arçelik, MF 44) at 180°C for 10 minutes. A snack was produced from approximately 15 grams of dough.

Preparation of Meatballs

A meatball which had no mushroom powder (control) contains only beef mince and salt. *A. bisporus* or *P. ostreatus* powders were used in production of meatballs. 5% or 10% of mushroom powders were added into meatballs. Preparation was made by manually and cooked in a commercial-type oven (Öztiryakiler, 10 GN2/1) at 150°C for 150 minutes. A raw product had 30 grams of weight.

Colour Analysis

Minolta Chroma meter CR 400 was used for determining colours of samples. Total colour differences (ΔE) between products were evaluated by means of L (brightness), a (redness-greeness) and b (blueness-yellowness) values after cooking. Total colour difference could be expressed as follows;

$$\Delta E = \sqrt{(L - L_{ref})^2 + (a - a_{ref})^2 + (b - b_{ref})^2} \qquad (1)$$

Reference values were belonged to standard white plates of chroma meter. Colour of every sample was read two times from both top and bottom. Average L, a and b values were used for evaluation (Hunt and Kropf, 1987).

Texture Analysis

In order to perform an instrumental texture evaluation of both snack and meatball samples, Brookfield Texture Analyzer (CT3, Load cell: 4500 g) was used. Texture profile analysis (TPA) performed two compression cycles and was applied to all samples by using penetration probe moving at a speed of 1 mm/s. Pre-test speed and post-test speed were 1 mm/s and 2 mm/s respectively (Raymundo et. al., 2014). Hardness was expressed as Newton (N). This parameter can be defined as the resistance of solid material when a pressure force is applied (Anonymous, 2015b).

Sensory Analysis

Thirty panelists for snack and twenty two panelists for meatball drawn from Osmaniye Korkut Ata University, Engineering and Arts and Science Faculties who were familiar with mushroom and non-smoker participated in sensory evaluation and tests were carried out within 1-2 hour after baking. Five types of snack (contained %0, 5%, 10%, 20% and 30% *A. bisporus* powder) and five types of meatball (included %0 mushroom powder, 5%, 10% *A. bisporus* powder and 5%, 10% *P. ostreatus* powder) were served to people. Both snack and meatball samples were named with 3 digits number. Panelists scored each sample using a 5-point Hedonic scale where 1=very bad and 5=very good. For the sensory assessment of snack; colour, taste, texture and overall acceptability and for meatball; colour, taste, chewiness and overall acceptability were questioned. Both food types (bakery and meat product) were compared in themselves. The results were analysed by SPSS Version 18.0 using one-way ANOVA while the means were separated with the help of Duncan test at 5% confidence level.

Results and Discussion

Colour Analysis

ΔE values of snacks and meatballs are given in Figure 1 and 2, respectively. For snack samples, colour levels of products which contained 5% and 10% *A. bisporus* powder were considerably close to control. Total colour differences of 20% and 30% were slightly different than product that had no *A. bisporus* powder. The reason might be enzymatic and/or non-enzymatic reaction (Maillard) (Ulziijargal, 2009; Chen, 2009) and oxidation of phenolics (Ulziijargal et. al., 2013) taking place on the mushroom powder due to the applied heat treatment. In their research, Eissa et. al., (2007) showed that increased amount of mushroom flours in Egyptian balady bread and biscuits enhanced the values of L, a and b. On the other hand, for meatballs, there were no significant differences between samples involved either *A. bisporus* or *P. ostreatus* powder in terms of colour. Because the main component that creates colour in meat and meat products is proteins and proteins may probably more dominant than mushroom powders. Similiarly, Rosli et. al., (2011) reported that addition of *Pleurotus sajor-caju* mushroom up to 50% to the formulation of chicken patties was not influenced redness (a) values of samples.

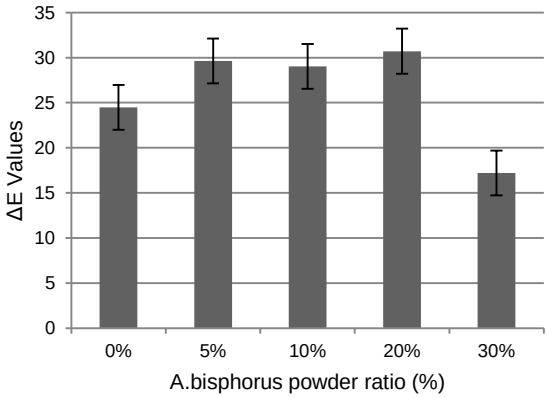

Figure 1 Total colour differences of snack samples with various mushroom powder ratios

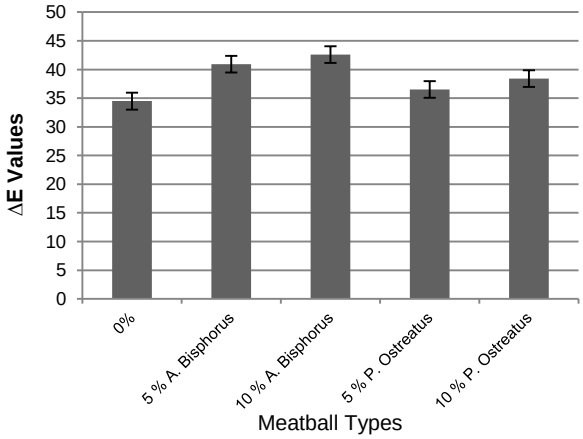

Figure 2 ΔE values versus meatball types

Texture Analysis

Any kind of mushroom powder addition into snack and meatball formulation enhanced the hardness value. Figure 3 and 4 shows the hardness levels of products versus percentage of mushroom powder. There was not any direct proportion between *A. bisporus* powder content and textural properties in snacks. Minimum hardness force belonged to sample comprised 10% *A. bisporus*. This may be due to nonuniform mixing of components while preparing dough. The texture of bread supplemented with 5% mushroom powder was significantly different than control bread, bread with 10% mushroom powder and 15% mushroom powder in Mahamud et. al.'s study (2012). Similar results were also found by Ulziijargal et. al. (2013). The mushroom mycelia addition into bread samples did not display a consistent trend. They attributed this situation to moisture loss during storage. Besides that, the concentration of *A.*

bisporus powder has a positive effect on hardness in meatball samples. Needed force increased in parallel to the amount of *A. bisporus* powder. However, *P. ostreatus* powder behaved in an opposite way. Increment in the amount of *P. ostreatus* powder caused decrease in hardness of meatballs. The rehydration capacity and fat retention of *P. ostreatus* are relatively higher than the other, thus the differences may result from this situation (Aleson-Carbonella et al., 2005). Several researchers also claimed that some ingredients had a softening effect on meat structure and texture (Comer and Dempster, 1981; Tsai et al., 1998; Rosli et. al., 2011).

Sensory Analysis

According to the statistical analysis results of sensory tests of snacks (Table 1), the most favourite sample with respect to colour, taste and overall acceptability was the product which had 5% *A. bisporus*, after control. The lowest taste score pertained to 30% *A. bisporus* snack. The panelists indicated that this percentage gave themselves very intense aroma. Okafor et. al., (2012) produced breads containing up to 25% mushroom powder and indicated that the most preferable one was bread included 5% mushroom power after 0%. Also they showed that when mushroom powder concentration rose, sensory scores decreased. Our results gave similarities with Okafor et. al.'s (2012) findings. In the framework of texture, panelists categorized samples into two groups. There was not any significant difference between control sample and 5% *A. bisporus* and also between 10% , 20% and 30% *A. bisporus* ($P<0.05$). Meatball contained 5% *P. ostreatus* was the best-liked one other than the control and 10% *A. bisporus* was the least (Table 2). Similiary, in a study of pork patties which contained mushroom powder stated that increased amount of shiitake (*Lentinus edodes P.*) mushroom powder in patties with phosphate decreased overall acceptability of U.S. consumers. Although, samples without phosphate enhanced the acceptability level of U.S. people. This could be originated from increasing effect of tripolyphosphate in juiciness (Chun, et. al., 2005). Colour and taste differences between control sample and 5% *P. ostreatus* meatball were found unimportant statistically, but the difference among other samples was seen significant ($P<0.05$). So, using of *P. ostreatus* powder at the rate of 5 % would be acceptable. This result could make the consumption of meatball possible especially by children. Because, meat flavor might probably be replaced with herbal flavor coming from mushroom.

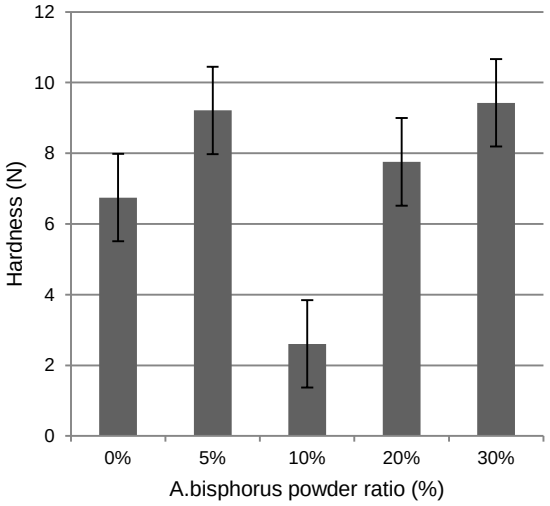

Figure 3 Hardness values of snacks

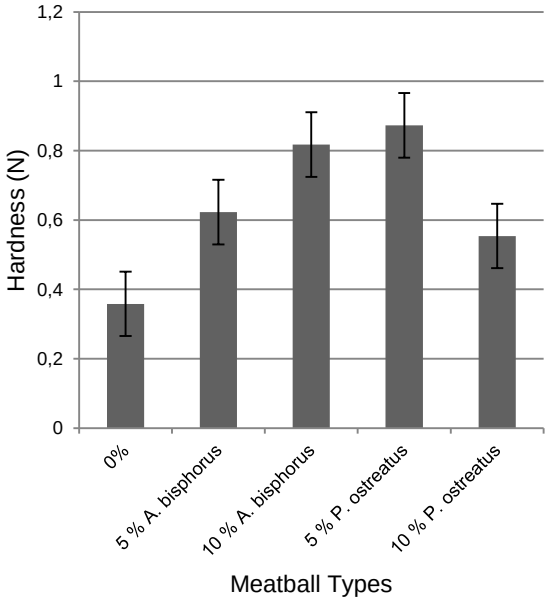

Figure 4 Hardness levels versus meatball types

Table 1 Sensory scores of *A.bisphorus* snacks (N=30)

Sensory Attributes	*A.bisphorus* powder concentration				
	0%	5%	10%	20%	30%
Color	4.100 ± 0.884^{a}	3.166 ± 0.746^{b}	3.133 ± 0.973^{b}	2.200 ± 0.664^{c}	1.500 ± 0.682^{d}
Taste	3.866 ± 0.937^{a}	3.166 ± 0.746^{b}	2.766 ± 1.006^{b}	2.200 ± 0.847^{c}	1.533 ± 0.681^{d}
Texture	3.933 ± 0.868^{a}	3.533 ± 0.899^{a}	2.733 ± 1.230^{b}	2.600 ± 1.037^{b}	2.233 ± 1.194^{b}
Overall Acceptability	3.967 ± 0.890^{a}	3.266 ± 0.691^{b}	2.766 ± 0.971^{c}	2.166 ± 0.746^{d}	1.600 ± 0.674^{e}

Mean values within the same row expressing different letters differ significantly ($P<0.05$); (Score 1 = very bad and score 5 = very good)

Table 2. Sensory scores of mushroom meatballs (N=21)

Sensory Attributes	Mushroom Powder Type - Concentration				
	WMP[1]	*A.bisphorus*		*P.ostreatus*	
	0%	5%	10%	5%	10%
Color	3.952 ± 1.071^{a}	3.238 ± 0.944^{b}	1.666 ± 0.730^{d}	4.142 ± 0.853^{a}	2.238 ± 0.995^{c}
Taste	3.476 ± 1.364^{a}	2.381 ± 1.203^{b}	2.762 ± 1.300^{ab}	2.905 ± 0.889^{ab}	2.857 ± 1.108^{ab}
Chewiness	3.952 ± 0.921^{a}	3.095 ± 0.889^{bc}	2.619 ± 1.071^{c}	3.476 ± 0.872^{ab}	3.190 ± 1.123^{bc}
Overall Acceptability	3.476 ± 1.364^{a}	2.714 ± 0.956^{bc}	2.428 ± 0.870^{c}	3.381 ± 1.071^{ab}	2.809 ± 0.981^{abc}

1WMP: Without mushroom powder; Mean values within the same row expressing different letters differ significantly (P<0.05); (Score 1 = very bad and score 5 = very good)

Conclusion

The results of snack with 5% *A. bisporus* powder and meatballs with 5% *P. ostreatus* were promising for the production of aromatic and novel foods. But it is believed that the cooking parameters should be optimized and / or especially meat formulations is ought to be remodified in order to eliminate the undesirable colour or taste. This study is also believed to add value to two of the most produced mushroom species of Turkey.

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