

MUSHROOM ACCEPTABILITY AND CONSUMPTION INTENTION FOR THE MAIN MUSHROOMS PRODUCED IN BRAZIL

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ABSTRACT

Mushrooms are known for their functional and nutritional importance. However, there are few works about their acceptance as food by Brazilian consumers, which are important as directives for mushroom producers. The objective of this study was to evaluate *Agaricus bisporus*, *Pleurotus ostreatus*, *Agaricus blazei* and *Lentinula edodes* for mushroom acceptability and consumption intention. A dish with rice and *A. bisporus*, *P. ostreatus*, *A. blazei* or *L. edodes* mushrooms was prepared. The dishes (samples of 20 g) were given to 192 randomly-chosen untrained panelists. The acceptability was determined on a 5-point hedonic scale, and the habit of consumption and purchase intention were evaluated. The mushroom global score acceptability was 3.61 for *A. bisporus*, 3.48 for *A. blazei*, 3.24 for *P. ostreatus* and 2.89 for *L. edodes*. For *L. edodes* the color was the main rejected characteristic. There were no differences to the mushroom acceptability according to the panelists socio-economic characteristics. Although most of the panelists did not have the habit of buying mushrooms, the majority (90.6%) was willing to purchase mushrooms and 38.5% were willing to pay as much as US\$ 80 per dried kilogram of mushrooms. Due to the high commercial prices of mushrooms in Brazil - at least US\$ 100 per dried kilogram they are still considered exotic and are likely to be bought as functional food, because of health benefits than sensorial characteristics.

Keywords: sensory analysis, basidiomycete, food consumption, functional food

INTRODUCTION

Mushrooms are an important product in global trade with an estimated production of 3.4 million metric tons in 2007. China is the biggest producer with a market of US\$ 82.9 million in 2008 and 2009 [1]. In Brazil, the mushroom marketing is still a challenge due to low production technology and the need for consumer market development. There are few data about Brazilian mushroom consumption, but it was 8 g *per capita* in 1984 and 80% of the cultivated mushroom was *Agaricus bisporus* [2]. The main produced and commercialized mushrooms in Brazil are *A. bisporus* (Lange) Imbach, *P. ostreatus* (Jacq. ex Fr.) Kumm., *A. blazei* Murrill ss. Heinem (*A. brasiliensis* Wasser *et al.*; *A. subrufescens* Peck) and *Lentinula edodes* (Berk.) Pegler. *A. bisporus* mushrooms are the most cultivated and consumed worldwide [1] and in Brazil [2]. *P. ostreatus*, *A. blazei* and *L. edodes* mushrooms, despite having an exotic and peculiar taste, are much less consumed. Nutritionally, mushrooms have low caloric value, and high protein and fiber content. Moreover, they are a source of immune modulator compounds [3] with antioxidant [4], anti-inflammatory [5] and antitumor [6,7] activities. The action mechanisms of those bioactive substances are still not well understood. Nevertheless, it was suggested that the main active principle is beta-D-glucan, which is known as potent activator of the immunological system [3].

Despite the functional importance of these basidiomycetes there are few studies on mushroom acceptability by Brazilian consumers. Escouto *et al.* [8] evaluated *A. blazei* mushroom acceptability by Brazilian consumers but without comparing it with other mushrooms. Thus, due to mushroom functional importance, economic potential, and lack of information on mushroom acceptability, this study aimed to compare the acceptability of *A. bisporus*, *P. ostreatus*, *A. blazei* and *L. edodes*. This research provides information about consumers' acceptability of mushrooms and allows pointing out the commercial potential of the most cultivated mushrooms in Brazil.

MATERIALS AND METHODS

P. ostreatus, *A. bisporus*, *A. blazei* and *L. edodes* were produced according to Aguilar-Rivera *et al.* [9], Mamiro and Royse [10], Colauto *et al.* [11] and Royse and Sanchez [12], respectively. They were harvested with closed basidiocarp, before rupture of the inner veil, except *P. ostreatus* that was harvested with closed basidiocarp edge and *L. edodes* that was harvested with 50-70% opened basidiocarps, after rupture of the inner veil, and pileus edge slightly convex. After drying at 60 °C in an oven with air circulation, a 35 g sample of each mushroom was rehydrated in 700 ml of boiling water for 20 min. Mushrooms were sliced (1 cm large), *sautéed* with 12 ml of soybean oil for 3 min. Afterwards 200 g of rice (*Oryza sativa*, cultivar Atalanta, Embrapa), 500 ml of leftover water from mushroom-rehydration and 4 g of salt was added. The pan was maintained semi covered at low heat for 15 min until completely cooked.

The research was approved by the Ethic Committee involving Humans (registration number 11500). Consumer acceptability was done in individual booths illuminated with white lighting in the morning at 10-11 h and in the afternoon at 15-17 h. The samples (20 g) were assigned with three-digit random numbers and served under identical conditions. The randomly chosen participants (n = 192) were male and female adults who voluntarily agreed for the study. They signed a consent agreement to provide socioeconomic data and frequency of purchase and consumption of mushrooms at home and restaurants. The panelists evaluated the dishes with a 5-point hedonic scale from 1 (“dislike extremely”) to 5 (“like extremely”) [13]. Each consumer evaluated the sample for color, aroma, consistency and flavor. After sensorial evaluation, a sample of dried mushrooms (50 g) was submitted to each participant and they were asked about how much they were willing to pay for it. The results were submitted to analysis of variance (Analysis of One-way Variance – ANOVA) followed by Tukey’s test ($p < 0.05$).

RESULTS AND DISCUSSION

A. bisporus, *P. ostreatus* and *A. blazei* received the highest ($p < 0.05$) appreciation rates for color (Table 1). *L. edodes* had the highest ($p < 0.05$) rejection for color with 49.5% for the sum of “I disliked it” and “I disliked it very much” (Table 1). *P. ostreatus*, *A. blazei* and *L. edodes* presented the lowest “indifferent” percentage for color (Table 1). These mushrooms had distinct colors such as light caramel, caramel and dark brown (close to black), respectively, differently. *A. bisporus* had a very light caramel color. *A. bisporus* and *P. ostreatus* had light colors, whereas *A. blazei* had medium color. Light and medium colors are considered common for food, known and accepted by consumers. However *L. edodes* has a dark brown color – which is less common in food – reducing acceptance. Dark-colored foods could be rejected because they are associated with roasting and spoilage. Thus, the high rejection rate of *L. edodes* could be associated with its dark color.

Many authors described the role of light in mushroom cultivation [14-16]. For *A. bisporus* light is not essential for fruiting and may inhibit mycelial growth [17,18]. On the other hand, light is necessary for *L. edodes* for its vegetative and fruiting stages [19]. Excessive light exposure can reduce the number of fruit bodies and produce dark mushrooms, whereas a lack of light reduces pileus diameter, stipe length and promotes a light beige color in basidiocarps. According to Tokimoto and Komatsu [18] fruiting bodies apparently develop abnormalities and sporulation reduction when *L. edodes* are grown under filtered light using colored cellophane papers. Thus, light is an important factor in determining the color of *L. edodes* fruiting bodies and could be used by mushroom growers in order to produce a less dark mushroom as an alternative for consumers.

For aroma the highest ($p < 0.05$) values for acceptability were for *A. bisporus* and *A. blazei*. *L. edodes* presented the highest ($p < 0.05$) rejection rate for aroma with 52.1% for the sum of “I disliked it” and “I disliked it very much” (Table 1). The highest acceptability of *A. bisporus* aroma might be associated to its familiarity by Brazilians [2] and worldwide cuisin [1]. Also *A. bisporus* aroma is dependent of at least eight compounds of carbon-epoxy, including benzyl isothiocyanate, and 1-3 octanol, responsible for 59.0% of the mushroom aroma [20].

For *A. blazei* the high acceptability for aroma (Table 1) is related with seven volatile compounds, mainly by the benzaldehyde that is responsible for 43.2% of the flavoring [21]. This is the main compound related to almond aroma for this mushroom

[22]. Other important compounds are benzyl alcohol and methyl benzoate that probably contribute to the sweet floral note of this mushroom [22]. *A. blazei* has 41.67 mg kg⁻¹ of 1-3-octanol, an aliphatic volatile constituent of other mushroom aromas [22]. Therefore, the aroma complexity of *A. blazei* compounds characterizes it as an exotic mushroom with distinct traits easily noticed by panelists. Differently from other mushrooms, *A. blazei* stood out in the dish for its distinct aroma and flavor. According to Escouto et al. [8], *A. blazei* had 68% acceptability and tasters “like it” or “dislike it” but very few chose “indifferent”.

Table 1. Answers (n = 192) to hedonic scale for *Agaricus bisporus*, *Pleurotus ostreatus*, *Agaricus blazei* and *Lentinula edodes* mushroom sensorial evaluation

Fungus	“I liked it” “I liked it very much” (%)	“Indifferent” (%)	“I disliked it” “I disliked it very much” (%)	Mean scores for acceptability	F	p-Value
Answers for color						
<i>A. bisporus</i>	55.67 ^a	29.90	14.43	3.61 ^a	6.3	<0.001
<i>P. ostreatus</i>	58.76	14.43	26.81	3.47 ^a		
<i>A. blazei</i>	56.70	14.43	28.87	3.41 ^a		
<i>L. edodes</i>	39.94	10.57	49.49	2.85 ^b		
Answers for aroma						
<i>A. bisporus</i>	48.95	32.29	18.76	3.45 ^a	5.1	<0.01
<i>P. ostreatus</i>	39.58	17.71	42.71	2.95 ^b		
<i>A. blazei</i>	47.91	10.42	41.67	3.09 ^a		
<i>L. edodes</i>	33.33	14.58	52.08	2.71 ^c		
Answers for consistency						
<i>A. bisporus</i>	71.14	16.49	12.37	3.88 ^a	5.3	<0.01
<i>P. ostreatus</i>	56.70	14.43	28.87	3.41 ^b		
<i>A. blazei</i>	59.79	16.49	23.71	3.54 ^b		
<i>L. edodes</i>	48.45	14.43	37.11	3.16 ^c		
Answers for flavor						
<i>A. bisporus</i>	54.63	23.71	21.65	3.50 ^a	5.7	<0.001
<i>P. ostreatus</i>	46.39	17.53	36.09	3.15 ^b		
<i>A. blazei</i>	41.24	10.31	48.45	2.90 ^c		
<i>L. edodes</i>	37.12	15.46	47.42	2.85 ^c		

*Different letters in the same column for the same sensorial descriptor indicate statistical differences by Tukey’s test ($p < 0.05$).

Similar to *A. bisporus*, the main compound responsible for *L. edodes* aroma is 1-3 octanol whose concentration is reduced when the basidiocarp is opened [23]. Opened basidiocarps have 44% of total volatiles represented by 1-3 octanol whereas closed basidiocarps have 63%. In Brazil *L. edodes*, differently from *A. bisporus* and *A. blazei*, is mainly consumed with opened basidiocarps. In general, it is an advantage for growers that get more biomass for their product but it has low quality aroma. Moreover, it is possible that *L. edodes* mushroom color had negatively affected the aroma-evaluation of this mushroom for first sensorial perception by panelists. Also, in China, the biggest mushroom producer and consumer in the world [24], *L. edodes* is the second most cultivated mushroom [1]. It suggests that cultural characteristics might be a variable to be analyzed in future experiments.

For consistency, *A. bisporus* was the most ($p < 0.05$) accepted followed by *P. ostreatus* and *A. blazei*. *L. edodes* had the highest ($p < 0.05$) rejection with 37.1% for the sum of “I disliked it” and “I disliked it very much”. *A. bisporus* and *A. blazei* have an average of 28% and 20.6% of total dietary fiber. On the other hand, *L. edodes* has 53.3-57.5% of total dietary fiber and 14.4% of them is chitin, an insoluble long-chain polymer of a N-acetylglucosamine with great resistance to biting [25]. Thus, the biting resistance is higher for *L. edodes* (0.81 to 1.23 kg mm⁻²) whereas it is just 0.33 kg mm⁻² for *P. ostreatus* [26]. Mushroom rehydration is a process that does not allow a full restoration of the mushroom and it is different to each species. Apparently, it is more difficult for *L. edodes* mushrooms.

Regarding flavor, the answers were divided between “I liked it” and “I disliked it” with polarized perception for mushroom flavor. *A. bisporus* had the highest ($p < 0.05$) acceptability followed by *P. ostreatus*, and after *A. blazei* and *L. edodes*. Edible mushroom flavor primarily consists of nucleotids, soluble sugars, polyols and mainly free aminoacids such as glutamate. The glutamate and nucleotide concentration, responsible for umami taste, varies from 6.04 to 13.50 mg g⁻¹ in *A. bisporus* [24, 27], 1.28 to 4.4 mg g⁻¹ in *A. blazei* [22, 24], 0.84 to 2.14 mg g⁻¹ in *P. ostreatus* [24] and 1.30 to 1.71 mg g⁻¹ in *L. edodes* [24, 28]. The glutamate and nucleotide concentration varies enormously with strain, cultivation condition and with maturity stage of the mushroom. Mushrooms harvested at various maturity stages had different nonvolatile component profile depending on the mushroom species. Investigations on the umami ingredients at different maturity stages of *A. bisporus* indicated that the two umami amino acids - Asp and Glu - showed an increase at stage two (closed basidiocarp). After stage two Asp content gradually decreased, while the Glu content increased with maturity stage [24]. Therefore, the highest glutamate concentration in *A. bisporus* can be an important factor to its acceptance; moreover, 18 free amino acids participate in the flavor formation for *A. bisporus* [29], 13 for *P. ostreatus* in which two were sweet, four were bitter and eight were flavorless [28], and 12 for *A. blazei* [30] and *L. edodes* [28]. On the other hand, the greatest acceptance of *A. bisporus* flavor (Table 1), described as a smooth taste, can also be related to the panelists’ familiarity since *A. bisporus* is popular in pizzas and other dishes in Brazil.

The global score (average for color, aroma, consistency and flavor answers) were 3.61 ± 0.19 for *A. bisporus*, 3.48 ± 0.33 for *A. blazei*, 3.24 ± 0.24 for *P. ostreatus* and 2.89 ± 0.19 for *L. edodes*. It indicates the general order of acceptability for the most cultivated mushrooms in Brazil. There were 192 panelists, most of them female, with education background equal or superior to high school, over 30 years old and with income under US\$ 690 per month (Table 2). The socio-economic factors did not affect the mushroom acceptability level i.e. regardless of economic status, gender, age or education background, mushroom acceptance was based on personal criteria.

Most of the volunteers do not have a habit of buying and consuming mushrooms since 60.4% do not “buy mushrooms at the supermarket”, and 65.6% do not “order dishes with mushrooms at restaurants”. Despite the reduced consumption habit, 13.5% of the panelists “know somebody who consumed mushrooms to treat diseases”. The most cited answers were for the treatment of stomach diseases, cancer, diabetes, weight loss and as immune stimulator.

Table 2. Analysis of variance and significance level for the hedonic scale for the acceptance of a dish with rice and mushroom in function of gender, education background and age of 192 panelists

Panelists	Number of individuals	p-Value
Male	84	0.5828
Female	108	
Primary education	24	0.0856
High school education or higher	168	
Income lower than US\$ 690	122	0.3079
Income higher than US\$ 691	70	
30 years old or higher	72	0.2901
29 years old or lower	120	

Although most of the panelists do not have the habit of buying mushrooms, the majority (90.6%) would like to buy this food. *A. bisporus* mushroom presented the greatest ($p < 0.05$) purchase intent of 42.7% followed by *P. ostreatus* with 16.7%, *A. blazei* 15.6% and *L. edodes* 15.6%. Among the answers, most of them intend to purchase industrialized (canned) *A. bisporus* but not fresh one because “it is difficult to find them at local supermarkets”.

When the panelists were asked how much they were willing to pay for 50 g of dried mushrooms, 26.0% were willing to pay US\$ 2.00; 38.5% US\$ 4.00 and, surprisingly, 27.1% more than US\$ 4.00. In Brazil, 50 g of dried mushrooms are sold at *Pão de açúcar*-delivery market (<http://www.paodeacucar.com.br/>) for US\$ 9.59 for *A. bisporus*, US\$ 6.62 for *P. ostreatus* and from US\$ 2.22 to 13.00 for *L. edodes*, and, at *DEC Enterprises Comercial Ltda.* (<http://www.agaricusblazeimurrill.com.br/>) for US\$ 11.13 for *A. blazei*. The reduced purchase intent by panelists associated with the higher commercial value at markets indicates that mushrooms still have limited consumption and are likely bought for consumption due to healthy benefits than sensorial characteristics.

CONCLUSION

The most accepted mushroom is *A. bisporus* followed by *P. ostreatus*, *A. blazei* and *L. edodes*. There are no differences for mushroom acceptability according to the panelists' socioeconomic characteristics. Most of the volunteers do not have a habit of buying and consuming mushrooms regularly, even though 90.6% are willing to purchase mushrooms and 38.5% are willing to pay as much as US\$ 80 per dried kilogram of mushrooms. Mushrooms in Brazil are still considered exotic and are likely to be purchased as functional food, for their healthy benefits, rather than their sensorial characteristics.

ACKNOWLEDGMENTS

The authors thank Paranaense University for the financial support and fellowship.

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