# SCREENING OF FILAMENTOUS TROPICAL FUNGI FOR THEIR NUTRITIONAL POTENTIAL AS SOURCES OF MINERALS AND NUTRITIONALLY IMPORTANT FATTY ACIDS

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## ABSTRACT

Seven edible mushrooms cultivated in Brazil were analyzed for calcium, magnesium and zinc contents as well as for their fatty acids profiles. Salmon Hiratake presented major levels of magnesium and zinc (763 and 71 mg/100 g fw, respectively) while calcium was more available from Champignon de Paris (330 mg/100 g fw). Some omega 3 fatty acids (C18:3-*n*3, C20:3-*n*3, C20:5-*n*3 and C22:6-*n*3) were present in most species, with a highlight for Salmon Hiratake that showed to be constituted by 21.97% of C18:3-*n*3 (α-linolenic acid). Linoleic acid, an omega 6 fatty acid (C18:2-*n*6) was present in relatively high percentages in Champignon Portobello (15.17%), Salmon Hiratake (20.21%) and Champignon de Paris (41.67%). EPA and DHA were founded in all mushrooms studied. Shiitake presented 3.8% of EPA from the total fatty acid quantified and black Shimeji presented 5.6% of DHA.

**Keywords**: mushrooms, calcium, magnesium, fatty acids, α-linolenic acid

## INTRODUCTION

Mushrooms are widely consumed worldwide, especially because of the peculiar tastes and aromas that vary from species to species. Many cultures consume mushrooms due their nutritional and medicinal value, however their use as a functional foods is more notable in oriental cultures [1]. Around 25 species are widely accepted as food but only a few reached a production at a commercial level [2]. In Brazil, the species most commonly cultivated and consumed are *Agaricus bisporus, Lentinula edodes* and *Pleurotus* spp. [1].

FAO data (2004) [3] point out that 2.4 million tons of mushrooms were produced in 2002, mostly by China (708 thousand tons), USA (390 thousand tons), Netherlands and Japan. The two later, along with Germany and China are the biggest consumers. Latin America produces only 1.3% of the total of cultivated mushrooms worldwide. Mexico (58.6%), Chile (17.6%) and Brazil (10.6%) head this production [4].

The nutritional value of edible mushrooms, cultivated or wild, has been extensively studied [5-9]. In general, mushrooms are good sources of proteins, carbohydrates, fibers and, at the same time, poor in fat and energy contents [10].

Literature points out that mushrooms contents are severely affected by seasonal variations. The aim of the present work was to evaluate the fatty acids profiles and quantify levels of calcium, magnesium and zinc present in some mushrooms cultivated in Brazil, and to compare the results with reported data found in the literature for the same species, grown in other countries.

## MATERIALS AND METHODS

**Materials.** Samples of *Agaricus bisporus*, *Lentinula edodes*, *Hypsizygus marmoreus, Pleurotus ostreatus* and *Pleurotus* spp., were acquired in the city of Belo Horizonte (MG, Brazil) and maintained frozen prior to the analysis. For GC analysis, a standard containing a mixture of 37 fatty acids methyl esters (FAME) from C4 to C24 was used (Supelco, Bellefonte, USA) together with an internal standard of methyl-nonadecanoate (C19:0) (AccuStandard, New Haven, USA). Reagent used for methylation reaction was $BF_3$/methanol (14% p/v) (Sigma, St Louis, USA) while purified water used in the reactions was obtained from a Milli-Q apparatus (TGI Pure Water Systems).

**Analysis of Ca, Mg. Zn and Fe contents.** For mushrooms mineralization, 200 mg of each sample were individually heated (450 $^{o}$C) on an oven [11]. After 6 h, 2 mL of nitric acid were added to each sample and further heating was carried out on the oven for additional 15 min. The material was then removed from heat and 1 mL of HCl was added. Samples were again heated by 5 min on a hot plate (120 $^{o}$C) and quantitatively transferred to 5 mL volumetric flasks completing the volume with deionized water. Levels of Calcium (Ca), magnesium (Mg), zinc (Zn) and iron (Fe) were determined using atomic absorption spectrometry on a Hitachi-Z8200 spectrometer coupled to a graphite Hitachi oven (Japan).

**Fatty acid methyl esters analyses .** Sliced mushrooms were extracted with distilled hexane (300 mL) for 24 hours and then ultra sonicated by 10 min. Extraction was repeated three times, after which the extracts were combined and the solvent was vacuum-removed. Then, samples were hydrolyzed and methylated using $BF_3$/methanol (14% p/v) solution at 80 °C. 100µL of a solution (2 mg/mL) containing methyl-nonadecanoate (C19:0) were added to each fatty acid ethyl esters (FAME) sample before injection to set an internal standard. In the same way, a Supelco 37 FAME mix was used to identify the FAME present in the mushroom samples. A Gas Chromatograph Varian 3380, equipped with flame ionization detector coupled with a capillary column DB-WAX (J&W Scientific, 30m x 0.25mm internal diameter x 0.25 µm) was used. Column temperature was 100 ºC by 1 min, increasing to 240 ºC by a rate of 7 ºC/min and maintained by 10 min. Detector and injector (splitless 1:100) were kept at 260 °C. Volume injected was 2 µL. Hydrogen was used as carrier gas. Data were acquired and treated by the Software Star 5.52 (Varian).

## RESULTS AND DISCUSSION

Nutritional potential of mushrooms Champignon Portobello, Champignon Paris, Salmon Hiratake, White Hiratake, Black Shimeji, White Shimeji and Shiitake was evaluated based on the analysis of minerals and fatty acids contents. The scientific names of the mushrooms studied, as well as the percentages of the major saturated and unsaturated fatty acids (detected as their respective FAME) found are compiled in Table 1.

**Table 1.** Scientific and popular names and composition of major saturated and unsaturated fatty acids (%), detected as the respective methyl esters (FAME) of the studied edible mushrooms.

| Mushroom commom name | Mushroom scientific name | Major saturated FAME (%) | Major unsaturated FAME (%) |
|---|---|---|---|
| Black Shimeji [12] | *Hypsizygus marmoreus* | C16:0 (9.84) | C18:2n6 (6.00) |
| Champignon Paris [13] | *Agaricus bisporus* | C16:0 (17.58) | C18:2n6 (41.67) |
| Champignon Portobello [14] | *Agaricus bisporus* | C16:0 (24.53) | C16:1 (24.70) |
| Hiratake white [15] | *Pleurotus ostreatus* | C16:0 (8.81) | C18:2n6 (7.27) |
| Salmon Hiratake [16] | *Pleurotus ostreatus* | C16:0 (20.55) | C18:3n3 (21.97) |
| Shiitake [17] | *Lentinula edodes* | C16:0 (17.69) | C18:2n6 (11.34) |
| White Shimeji [18] | *Hypsizygus marmoreus* | C16:0 (26.78) | C18:1n9 (18.46) |

According to the fatty acids profile determined by GC present by the studied mushrooms (Table 1), all of them presented palmitic acid (C16:0) as the major FAME. Black Shimeji and White Hiratake presented the lower levels of palmitic acid (9.84 and 8.81, respectively) while the better sources of this fatty acid were Champignon Portobello (24.53%) and White Shimeji (26.78%). Presence of miristic (C14:0), pentadecanoic (C15:0) and stearic (C16:0) acids were also detected in the samples as minor constituents. Among the unsaturated fatty acids, distribution was not the same in the mushrooms. Four mushrooms (Black Shimeji, Champignon Paris, White Hiratake and Shiitake) presented linoleic acid (C18:2n6) as the principal unsaturated fatty acid but in very different concentrations (6.00, 41.67, 7.27 and 11.34, respectively). Linoleic acid was reported as the major fatty acid present in two *Pleurotus* species studied by Pedneault *et al.* [19]. Champignon Portobello was richer in the C16:1 (palmitoleic acid), while Salmon Hiratake showed linolenic acid as the principal unsaturated components. Unusual FAME C20:3n3, C20:5n3 and C22:6n3 were also detected in some samples, especially in White Hiratake and Black Shimeji, however in lower levels.

Contents on saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids were calculated for the analyzed mushrooms (Figure 1). PUFA contents were almost the half of the FAME detected in Salmon Hiratake and Champignon Paris. In White Hiratake, levels of PUFA were higher than other type of fatty acids. Salmon Hiratake presented nearly equivalent amounts (~21%) of $\alpha$-linolenic acid and linoleic acids.

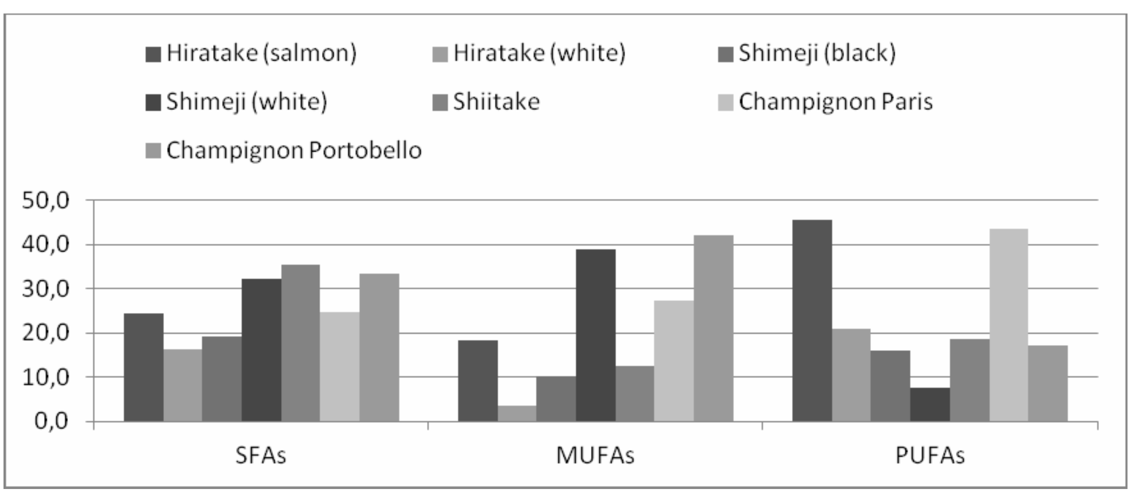


**Figure1**. Total SFA, MUFA and PUFA in edible mushrooms.

White Shimeji and Champignon Portobello species showed to possess high levels of MUFA-type fatty acids, with the proportion of SFA:MUFA:PUFA of 33:42:18 and 32:39:9 %, respectively. Both presented high levels of palmitoleic (C16:1 *n*–7) and oleic (C18:1 *n*–9) acids (Table 3). Shiitake presented SFA contents (35.4 %) higher than the total amount of PUFA (22%) and MUFA (13%).

Levels of Ca, Mg, Zn and Fe were determined by atomic absorption (Table 2), that showed the most abundant one to be magnesium, followed by calcium and zinc in the species studied. The values determined are important because there is a great variation of values reported, that may be due to seasonal or related variations [20] as exemplified by the works of Mattila *et al.* [21] and Çağlarırmak [16]. In the present work Calcium levels reached 329 mg and 210 mg/100g of fresh Champignon Paris and Champignon Portobello, respectively, while magnesium and zinc levels reached not more than 762 and 71 mg/100 g fw, as detected for Salmon Hiratake sample. It is worth to observe that mushroom species studied in the present work have higher Zn levels than the minimum required daily consuming amount [22]. The Zn values found for Brazilian cultivated mushrooms are higher than values reported by Gençcelep (2009) [23] and Mattila *et al.* [21].

**Table 2**. Levels of calcium, magnesium and zinc in edible mushrooms in fresh weight (fw).

| Common name | Ca (mg/100g) | Mg (mg/100g) | Zn (mg/100g) |
|---|---|---|---|
| Champignon Portobello | 210.0 | 426.4 | 14.0 |
| Champignon Paris | 329.5 | 464.4 | 19.8 |
| Salmon Hiratake | 73.0 | 762.5 | 70.9 |
| White Hiratake | 56.7 | 626.2 | 24.8 |
| Black Shimeji | 23.3 | 659.0 | 28.8 |
| White Shimeji | 49.6 | 520.4 | 21.9 |
| Shiitake | 39.4 | 548.1 | 32.1 |

## CONCLUSIONS

This comparative analysis of the fatty acids and Mg, Ca, Fe and Zn contents present in mushrooms commercialized and consumed in Brazil showed different values from those reported for the same species cultivated in other countries and even in different regions of the country. Some species showed to be rich in calcium, magnesium and even zinc, being able to supply the daily recommended consumption amount. Presence of the essential fatty acid linoleic acid, as major components in Champignon Paris and Hiratake salmon reinforces the potential of these species as health foods, especially because omega-3 and omega-6 fatty acids were remarkably detected in all studied species. This work contributes for the knowledge of the regional variation of minerals and fatty acids contents of mushrooms aiming at stimulating their consuming as rich nutritional sources in countries like Brazil and other tropical countries where mushrooms are still most often regarded only as delicacy foods.

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