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Sensory properties of Nordic edible mushrooms

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ABSTRACT

Edible mushrooms are a global food with a history of consumption spanning several millennia. However, studies utilizing modern sensory methods on mushrooms are still scarce. In this study, the sensory properties of Nordic edible mushrooms were analyzed by two methods. In the sensory profile, *sous vide* processed wild mushroom species *Cantharellus cibarius, Craterellus tubaeformis, Boletus edulis,* and *Lactarius camphoratus* were studied with cultivated *Agaricus bisporus* as a control species. The sensory profile consisted of 18 descriptors, and the 5 mushrooms differed from each other in all of them. Only *B. edulis* and *A. bisporus* were linked to typical mushroom-like odor. In projective mapping, consumers evaluated blanched wild *C. cibarius, C. tubaeformis* and *Suillus variegatus* as well as cultivated *Lentinula edodes* and both blanched and fresh *A. bisporus* based on odor and on flavor. The consumers intuitively grouped the samples into three groups: wild, fresh cultivated and processed cultivated mushrooms. Wild mushrooms had a high odor intensity and various odor descriptions but a low flavor intensity. Cultivated mushrooms had opposite descriptions. Both tests showed differences in the sensory descriptors between the cultivated and wild mushrooms with the former linked to typical 'mushroom', indicating the importance and need for descriptive profiles for different mushroom types.

1. Introduction

Edible mushrooms have an important role in various food cultures around the world. There are approximately 2200 species of edible fungi in 110 countries and about 800 of them are confirmed as food (Boa, 2004). The majority of edible fungi species grow in the nature and are collected for personal use (Boa, 2004). Nordic forests are home to a wide selection of wild edible mushrooms species. These species have marked differences in their sensory properties – for example the reported odor descriptions range from fruity and nutty to seafood and curry. Furthermore, the amount of edible mushrooms that grow yearly is estimated to be very plentiful 10^9 kg already in Finland alone (Salo & Lindroos, 2008).

Several wild mushrooms, especially chanterelle *(Cantharellus cibarius)* and porcini *(Boletus edulis),* are popular mushrooms that are exported and sold all over Europe. Furthermore, similar species to the ones found in Nordic forests are also growing in North America. Therefore, research on local species will benefit the global mushroom research. Mushrooms have substantial unused economical potential, and thus it is not surprising that there has been significant research activity on the nutritional, bioactivity-related (Kalač, 2013) as well as technological aspects of mushrooms. Recent reviews (Reis, Martins, Vasconcelos, Morales, & Ferreira, 2017; Roncero-Ramos & Delgado-Andrade, 2017) focusing on health benefits argue that interest on edible mushrooms will only grow in the coming years as the general public becomes more aware of their value as food. Furthermore, increased knowledge on specific bioactive compounds will help in formulating new mushroom products which further increases their demand in the global market.

Based on this increased interest in mushrooms, it is surprising that research on their sensory properties, particularly of forest mushrooms, has been scarce. Especially few studies have utilized trained panels and descriptive sensory profiles on explaining what mushrooms are like in terms of their sensory properties. Many consumers dislike mushrooms but the reason for it has not been studied before. Due to this avoidance consumers will not benefit from the health effects of mushrooms. As stated above, edible mushrooms span hundreds of species; focusing on just a few common species for food consumption severely limits the sensory space of mushrooms products. Additional research could show alternatives that further consumers could enjoy. As a summary, previous studies have evaluated the sensory quality from a technological aspect, such as effects of packaging films and modified atmosphere on

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the sensory properties of shiitake (*Lentinula edodes*) mushrooms (Ares, Parentelli, Gámbaro, Lareo, & Lema, 2006) as well as processing methods for preserving porcini (Jaworska & Bernaś, 2009), chanterelle (Politowicz, Lech, Sánchez-Rodríguez, Szumny, & Carbonell-Barrachina, 2017) and shiitake (Politowicz, Lech, Lipan, Figiel, & Carbonell-Barrachina, 2018) mushrooms. Other studies have examined the sensory differences of matsutake mushrooms (*Tricholoma matsutake*) of different quality grades (Cho et al., 2007) and compared and grouped the odor properties of different wild edible mushrooms (de Pinho et al., 2008).

However, these studies offer limited value for describing the species common in Northern Europe. First, most of these studies have focused on the changes in sensory quality due to different food processes and only within one species. Second, the studies have mostly created condensed profiles, with emphasis often in overall quality related parameters instead of flavor descriptors. There is still a need for inter-species comparison of mushroom flavor characteristics. Additionally, there is no published literature utilizing projective mapping or other recent consumer profiling techniques on the sensory properties of mushrooms. Thus, there are no reports on which sensory properties are those that can distinguish mushroom species for untrained consumers.

Several studies have compared the strengths and weaknesses of conventional profiling techniques such as generic descriptive analysis and modern methods such as projective mapping. These studies have used either trained (Dehlholm, Brockhoff, Meinert, Aaslyng, & Bredie, 2012) or both trained and consumer panels and various matrices (Cadena et al., 2014; Moussaoui & Varela, 2010; Pickup, Bremer, & Peng, 2018; Risvik, McEwan, & Rødbotten, 1997). Common conclusions in these studies are that conventional profiling techniques with trained panels still give the most repeatable and precise sensory information. However, the training period is laborious and the profile is always somewhat reductionistic. On the other hand, projective mapping and similar methods are quite quick to perform, and the participants have described these tasks as easy and even enjoyable. Furthermore, while projective mapping in these studies has been reported to produce less discriminatory or at least different information than conventional profiling, its data collection is more holistic and more relatable to consumer preference data. Recent reviews on the subject (Ares & Varela, 2017; Varela & Ares, 2012) have thus argued that depending on the research aims, the quantitative and sensitive information that conventional profiling provides can be redundant. The lack of publications utilizing consumer panels once more demonstrates how sensory mushroom research is lagging behind other mushroom-related science.

This study aimed to find the main sensory differences of popular Nordic edible mushrooms. This was done with generic descriptive analysis by a trained sensory panel. Wild species were compared to commercially available, cultivated mushrooms. In order to assess whether untrained consumers also notice a difference between the sensory properties of cultivated and wild mushrooms, the sensory space was additionally overviewed using projective mapping.

2. Materials and methods

2.1. Sensory profile with a trained panel

2.1.1. Samples

Four edible forest mushrooms hand-picked from forest and one cultivated mushroom species were used as samples (Table 1). As has been reported (Boa, 2004), most of these species are highly appreciated and widely used all over Europe with substantial market activity as well.

2.1.2. Sample preparation

The picked mushrooms aside from curry milk cap (*Lactarius camphoratus)* were stored at +4 °C and processed within 36 h of picking.

Table 1
Mushroom samples used in the sensory profile with a trained panel.

Mushroom[a]	Latin name	Origin
Porcini	*Boletus edulis*	Köyliö, Finland
Chanterelle	*Cantharellus cibarius*	Salo, Finland
Funnel chanterelle	*Craterellus tubaeformis*	Kainuu region and Salo, Finland
Curry milk-cap	*Lactarius camphoratus*	Tampere, Finland
Cultivated white button mushroom	*Agaricus bisporus*	Mykora Ltd., Eura, Finland

[a] All mushrooms were processed by sous vide cooking, frozen, pooled and tempered to 50–60 °C.

The mushroom samples were processed by *sous vide* cooking, which is a controllable method that is widely used in food industry and *haute cuisine*. The rationale was to minimize batch-to-batch variation in heat treatment, and to avoid leaching and evaporation of flavor compounds to the cooking medium and air, respectively. This method and samples from the same batch were used in a recent publication examining the free amino acids and 5′-nucleotides (Manninen, Rotola-Pukkila, Aisala, Hopia, & Laaksonen, 2018).

In short, the soil material was cleaned off mushrooms individually with a brush, the mushrooms were cut into 1–2 cm slices, and packaged into plastic *sous vide* bags in 200 g aliquots in a single layer. The sous vide bags were vacuum heat sealed with a Supervac Maschinenbau GmbH (Vienna, Austria) vacuum packaging instrument model GK 113/2. The vacuum level was 7 (range 0–9) and sealing time was 4 (range 0–9). The sealed bags were placed into an 80.0 °C (σ = 0.5 °C) circulating water bath for 10 min (heater P/2 and box 25B, Julabo GmbH, Seelbach, Germany). Each bag was chilled by placing it to cold water bath (< 20 °C) for 2 min immediately after heat treatment and then to ice water bath (5–9 °C) for 5 min. After chilling, each bag was immediately frozen at −20 °C.

For curry milk cap, the mushrooms were first dried by convectional drying at approximately 36–37 °C for 7—8 h using an Evermat food dehydrator (Evermat AB, Bjurholm, Sweden) and stored for approximately 10 months at room temperature in an airtight glass jar. After this, the dried mushrooms were rehydrated by adding 700 g of active-carbon filtered water to 100 g dried mushrooms and incubating for 15 min at ambient temperature. Finally, the mushrooms were placed in sous vide bags and processed further like other samples. This differing preprocessing protocol had to be used due to poor availability of fresh curry milk cap. However, it was checked with a pilot panel that this rehydrated sample resembled one made from fresh curry milk cap.

The mushrooms were cut and pooled after storing the bags in the freezer for 1–12 weeks (depending on the sample). The frozen mushrooms were cut one aliquot at a time at 4 °C with chilled cutting boards and knives to approximately 1–2 cm^3 cubes. Each aliquot was then immediately moved back to −20 °C and pooled. The combined mushroom sample was divided using dimension reduction and cone quartering methods on a large tray and repackaged into plastic bags. The bags were stored at −20 °C until analysis for a maximum of 8 months.

On evaluation day, frozen samples were thawed in 50–100 g aliquots in *sous vide* bags in a 70 °C water bath for 5 min. Representative samples (10–15 g) containing both solid mushroom and dissociated liquid were served in 70 ml transparent glass bowls covered with glass plates. The samples were tempered on a hotplate to 50–60 °C for at least 15 min before evaluation. Sample cups were coded with three-digit numbers.

2.1.3. Sensory panel

The descriptive profiling was done with 11 voluntary assessors (4 men, 7 women, age 27–49, median age 38 years). The assessors were experienced via several projects using sensory profiling. They were known to be able to identify and rank taste solutions, recognize flavor