Utilization and management of mushroom production wastes into high value food and feed nutraceuticals.

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Abstract

During the production of mushrooms there is a great part of fresh waste byproducts which is currently underutilized and disposed of. These wastes refer to the removal of part of the stalks of the mushrooms as well as from the rejection of an important percent of the caps due to the fact that they do not comply to commercial standards and prototypes. The byproducts and wastes of the mushroom industries in Greece are estimated at about 400 tones per year. At the same time, there are about 8500 tones of extra waste per year which result from the disposal of the substrates in which they grow.

These wastes can be converted into high value food and feed nutraceuticals (β-glucans) which can be incorporated into various diets producing specified health care products for which there is a market demand as functional foods. Present global nutraceutical market is estimated at $ 14 billion with an increasing annual fast rate (~15%-20%). It was in the last few decades that a diet – health message has evolved which initiated the development of functional foods. Therapeutic components such as β-glucans can be extracted from mushroom wastes which when incorporated into food and feed can render them to qualify as "Functional Foods". Processing such agro-industrial wastes like mushroom wastes to produce nutraceuticals and functional foods will go a long way in providing food, nutrition and health security to our ever-increasing global population.

This paper deals with the utilization, monitoring and management of agroindustrial mushroom wastes of the most popular cultivated mushroom in Greece *Pleurotus ostreatus* into high value nutraceuticals, namely β-glucans and review some of the results from its incorporation into dairy products namely yogurt and cheeses. The aim is to provide a platform to all interested in functional foods to interact and formulate recommendations which may serve as guidelines to those engaged in research and development in this area.

Figure 1: *Pleurotus ostreatus*

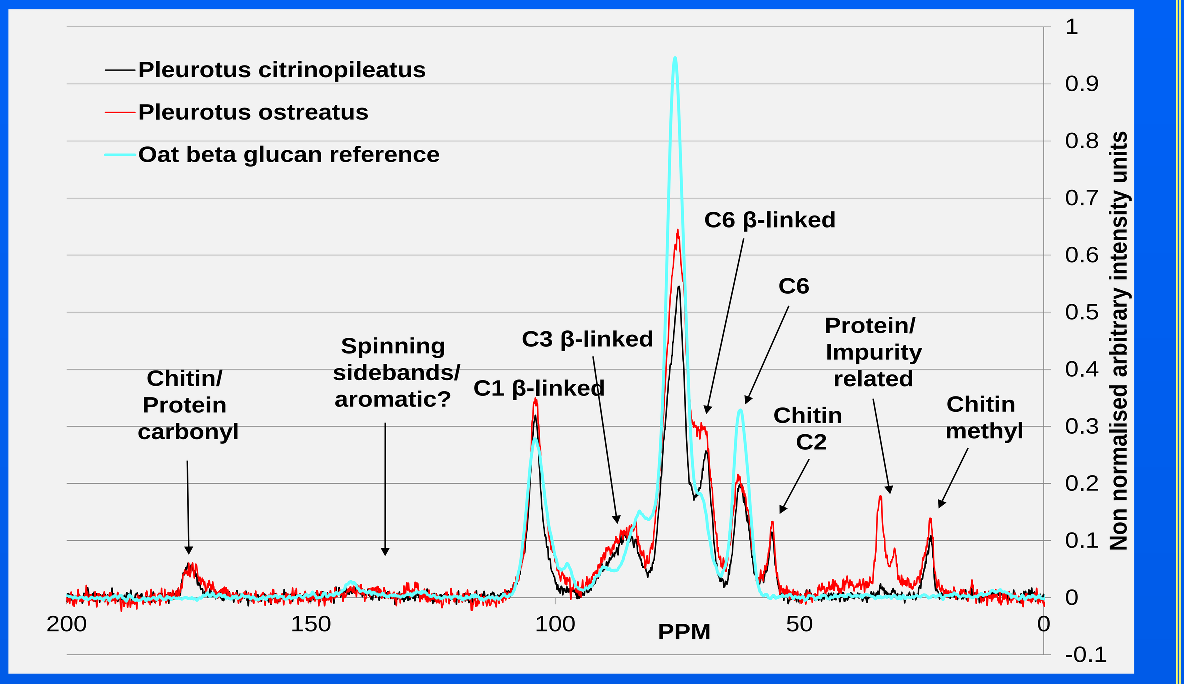

Figure 2. ^{13}C CPMAS NMR spectra for reference and extracted Mushroom β-glucans showing assignments of carbons assuming majority β-glucan carbohydrate present. Impurity signals also shown

Figure 2 shows the solid-state NMR (CPMAS) spectra for *Pleurotus ostreatus* β-glucan. Two other β-glucans from *P. citrinopileatus* and Oat β- glucan reference are also depicted for comparison purposes. The graph shows high peaks in the region of 104 ppm which is indicative of the presence of beta-glucans in all three samples. There are also some regions of impurities from peaks related to protein and chitin which are most likely to be present in the samples.

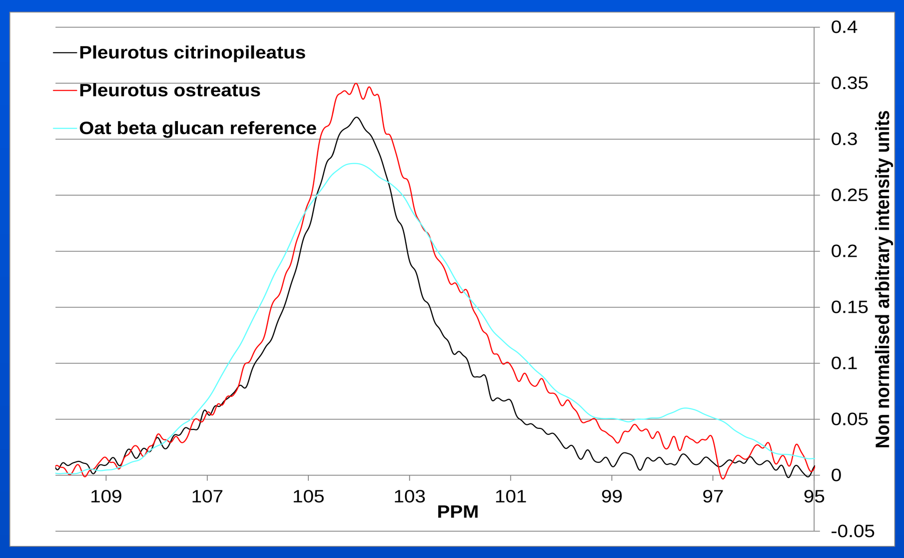

Figure 3. Expanded spectra for *Pleurotus ostreatus* and *P.citrinopileatus* in the 104 ppm region which is characteristic of the C1 carbon in various β-linkages

Fig.3 shows the expanded spectra for *Pleurotus ostreatus* and *P.citrinopileatus* in the 104 ppm region which is characteristic for C1β-linked carbons in this region. The C1 β-linkage is not particularly diagnostic for β-glucans, having a broad peak, being sensitive to mis-setting of the ppm scale and having a similar value for 1-3, 1-6 and amorphised1-4 linkages. It is only when other parts of the spectrum are considered that a more accurate assignment of the spectrum to β-glucan can be made. For instance the peaks at 62 and 69 ppm are indicative of C6 carbons in 1-3 and C6 of 1-6 linkages in β-glucans, with broad peaks in the 86 ppm region being characteristic of C3 in 1-3 linkages.

Molecular weight for *Pleurotus ostreatus* β-glucan was estimated at 309 kDa with simultaneous high polydispersity and broader MW distribution.

"Functional" yogurt with addition of B-Glucans

With regard to incorporation of β-glucan in yogurt it was shown that microbial population, pH, titrable acidity, ash and syneresis were not affected by the addition of different levels of glucan. In general, yoghurt with 0.3% β-glucan exhibited comparable viscosity to the control while yoghurt with 0.5% β-glucan had the lowest viscosity compared to all other yogurts with the rest of β-glucan concentrations tested. Yogurt with β-glucans appeared to be better in flavour and texture compared to control.

Regarding similar experiments with low-fat feta-type cheese with β-glucans, no significant differences (P>0.05) were observed for pH, moisture, fat, salt, ash content, color and compression to fracture between cheese with β-glucans and control cheese, during ripening and storage . However, cheese with β-glucans showed lower (P<0.05) hardness and fracturability compared to control. The addition of β-glucans did not affect (P>0.05) appearance and flavour scores and it was very much appreciated by the sensory panellists

"Functional" Cheese with addition of B-Glucans

Conclusions

From mushroom byproducts and wastes, the bioactive β-glucan can be isolated and incorporated into various foods and feeds for the production of functional foods and nutraceuticals.

The incorporation of various β-glucan concentrations isolated from the edible mushroom *Pleurotus ostreatus* to milk to make functional yogurt, not only does not affect the final product but could result in a product of acceptable biochemical, textural and organoleptic properties which is similar or even better than the control. Similar results can be achieved from the manufacturing of low-fat feta type cheese with β- glucan making another novel dairy product very promising to be acceptable to the consumer with potential commercialization and higher profits.

This could be a method of appropriate utilization of one of many agricultural wastes for the production of high added value nutraceuticals with simultaneous protection of the environment.