Analytical Quantification of Essential Minerals in Cremini Mushrooms

Ch. Kethani Devi and P. Sudhakar✉

Mobile Number: +91 9493101093

Department of Biotechnology, Acharya Nagarjuna University, Guntur–522 510, Andhra Pradesh, India.

Abstract

The study aimed to quantitatively evaluate the essential mineral content in cremini mushrooms using multiple analytical techniques to assess their nutritional composition and potential health benefits. Cremini mushrooms (*Agaricus bisporus*) are widely consumed for their nutritional and medicinal benefits. Samples of cremini mushrooms were collected, cleaned, and prepared through standardized procedures before mineral extraction. The analysis was performed using Flame Emission Spectroscopy, Colorimetry, and Atomic Absorption Spectroscopy. Essential macro- and micronutrients, including sodium, potassium, calcium, magnesium, iron, and zinc, were determined quantitatively. Results revealed significant variation in mineral concentrations in cremini mushrooms (*Agaricus bisporus*). Potassium with 5602.22 mg/100 g was identified as the most abundant macro element, followed by calcium 284.45 mg/100 g, magnesium 156.65 mg/100 g, and sodium 211 mg/100 g. Among the trace elements, iron 61.6 mg/100 g and zinc 31.33 mg/100 g were predominant. The comparative evaluation of analytical techniques confirmed the precision and reliability of Flame Emission Spectroscopy, Colorimetry, and Atomic Absorption Spectroscopy for mineral quantification in mushroom matrices. The observed mineral composition highlights the nutritional richness of cremini mushrooms and their potential contribution to dietary mineral intake Cremini mushrooms (*Agaricus bisporus*) are a valuable source of essential minerals, notably potassium, iron, and zinc. The applied analytical methods proved suitable for accurate quantification of mineral elements. These findings provide baseline data useful for dietary assessments, food fortification initiatives, and further research on functional foods.

Keywords: Cremini mushrooms, mineral composition, FES, Colorimetry, AAS, macro- and micronutrients

Introduction about brown edible mushrooms

Brown edible mushrooms are a popular variety of fungi known for their rich flavor, firm texture, and numerous culinary uses. These mushrooms, which include types like cremini, portobello, and shiitake, are commonly found in kitchens around the world and are prized for their earthy taste and nutritional benefits.

Cremini mushrooms, also known as baby Bellas, are a cultivated variety of *Agaricus bisporus*, the same species as the common white button and portobello mushrooms. They are harvested at a slightly later stage than white button mushrooms, giving them a darker brown color, larger size, and deeper flavor. Essentially, cremini mushrooms are the intermediate stage between the young white button mushroom and the fully mature portobello mushroom.

Brown mushrooms are low in calories but abundant in antioxidants, selenium, and B vitamins, among other vital minerals. In addition to being an excellent source of dietary fiber, they have been linked to a number of health advantages, such as anti-inflammatory and immune-boosting qualities.

In cooking, brown mushrooms are versatile and can be roasted, grilled, sautéed or added to soups, sauces, and stir-fries. Their robust flavor makes them an excellent meat substitute in vegetarian dishes [1], brown edible mushrooms are a valuable addition to a healthy diet and a flavorful ingredient in diverse cuisines.

Cremini mushrooms are younger than Portobellos and have a smaller, firmer cap. They are essentially the "middle-aged" version of the species, often harvested before they reach full maturity [2]. Cremini mushrooms have a firm, but tender texture, making them suitable for sautéing, stir-fries, or soups [3]. They have a milder flavor compared to Portobellos, though still rich and earthy [4]. Cremini mushrooms generally offer a higher level of antioxidants [5], including ergothioneine and glutathione [6], which are known for their antioxidant and anti-inflammatory properties. They also have slightly more vitamins and minerals than Portobellos due to being harvested earlier in their life cycle [7]. Cremini mushrooms contain more amount of agaritine and 4 hydroxy methylphenyl hydrazines [8].

Importance of mineral composition in Cremini mushrooms

Table 1 :Mineral composition of brown edible mushrooms (Cremini)

Mineral		Support system
Macro	Potassium (K) [7]	Regulates fluid balance, muscle and nerve function
	Magnesium(Mg) [9]	Muscle function, nerve transmission, energy production
	Calcium (Ca) [10]	Essential for bones, teeth, and muscle function
	Sodium (Na) [11]	Involved in maintaining fluid balance, nerve transmission, and muscle function
Micro	Iron (Fe) [12]	Supports oxygen transport in blood
	Zinc (Zn) [14]	Important for immune function and metabolism.

Sodium: Is a vital nutrient that is involved in blood pressure (BP), fluid and electrolyte balance, and the preservation of proper cellular homeostasis. Due to its significant osmotic activity, sodium plays a critical function in regulating the amount of extracellular fluid (ECF). It is also essential for the excitability of muscle and nerve cells as well as for the passage of nutrients and substrates via plasma membranes[14].

Potassium: Is the most prevalent intracellular cation, a necessary nutrient that may be found in a variety of foods and as a dietary supplement. Because of its function in preserving intracellular fluid volume and transmembrane electrochemical gradients, potassium, which is found in all bodily tissues, is necessary for appropriate cell function [15]. Sodium, the primary regulator of the amount of extracellular fluid, including plasma, is closely related to potassium.

Iron: Plays a significant part in fundamental biological processes such DNA synthesis, energy generation, and oxygen transport, making it a necessary component of almost all living systems [16]. It is an essential part of hemoglobin and myoglobin, two proteins that let animals breathe and metabolize by carrying and storing oxygen in the blood and muscles. Iron is also a cofactor in a variety of enzymes, such as those that are involved in antioxidant defense and cellular respiration. For plants to synthesize chlorophyll and transmit electrons during photosynthesis, iron is required. A deficiency in iron can impair these processes, leading to anemia in humans or chlorosis in plants, while excess iron can be toxic due to its ability to catalyze harmful free radical formation, making its regulation crucial for health.

Zinc: Plays a pivotal role in brain function, influencing neurotransmission and neuronal signaling. Alterations in zinc homeostasis [17] have been implicated in neurological disorders such as Alzheimer's disease. Recent research has focused on the dual role of zinc as both a structural component of proteins and a signaling ion, exploring its involvement in synaptic plasticity and cognitive functions. Beyond human health, zinc is essential for the growth and development of plants. Plant growth-promoting bacteria (PGPB) and zinc mineral nutrition interact to improve zinc absorption and use in tropical agricultural settings, which benefits crop yields and plant health. For food security and sustainable agriculture, these relationships are essential.

Calcium : Is crucial for living systems, serving as a primary component of teeth and bones enabling muscle function [18] and nerve signal transmission, regulating hormone release, assisting in blood clotting, and maintaining a healthy heart rhythm. Over 99 % of the body's calcium is stored in the skeleton, serving as a reservoir for calcium and providing structural strength needed by other tissues.

Magnesium: Is an essential mineral critical for both animals and plants due to its central role in biological processes. In animals [19], magnesium is a cofactor for more than 300 enzymatic processes, including as blood glucose management, muscle and neuron function, DNA/RNA synthesis, and ATP metabolism. By controlling the movement of calcium and potassium, it also supports cardiovascular stability and bone health. Magnesium is essential to photosynthesis in plants since it is the primary atom of chlorophyll [20]. Additionally, it stabilizes ribosomes, activates enzymes in carbohydrate metabolism, and maintains ion balance.

Health Benefits of Cremini Mushrooms: Cremini mushrooms contain trace levels of vitamins and minerals, although other variables are usually responsible for their health advantages. Cremini mushrooms' microorganisms and enzymes provide a number of health advantages.

Immune System Boost: Consuming cremini mushrooms may help strengthen the immune system. Cremini mushrooms contain a considerable quantity of beneficial microorganisms. The human digestive tracts microbiome benefits from some of these microorganisms. These beneficial bacteria can strengthen the body's defenses against disease and aid in better digestion.

Preventing Cancer: Cremini mushrooms may offer protection against lung and breast cancer. The aromatase inhibitors in cremini mushrooms are responsible for this action. Inhibitors of the aromatase enzyme prevent the production of estrogen, a hormone that stimulates the growth of some malignant tumors.

Reduce Blood Pressure: According to one study, eating mushrooms during pregnancy can lower the risk of high blood pressure. 15 % of pregnant women experience high blood pressure. A pregnant woman's risk of high blood pressure can be decreased by consuming 100 grams of mushrooms daily, particularly cremini mushrooms.

Decreased Consumption of Salt: Consuming less salt helps maintain heart health. The majority of Americans should reduce their daily intake of salt by at least 1,000 milligrams, according to the American Heart Association. By enhancing the flavor of food, cremini mushrooms may help cut back on salt. Cremini mushrooms have a powerful, savory flavor that makes people feel less of the need to add salt to meals that include them.

Nutrition: Cremini mushrooms are high in protein and carbs but low in fat. They had a low-calorie count and just trace levels of calcium, iron, and vitamins.

Application of cremini mushrooms in daily life

Domestic applications : Cremini mushrooms were a versatile and nutrient-rich ingredient widely used in home cooking due to their earthy flavor and meaty texture. They serve as an excellent substitute for white button mushrooms, offering a deeper umami profile, making them ideal for enhancing a variety of dishes.

Industrial applications: Cremini mushrooms have gained significant industrial importance due to their rich nutritional profile, umami flavor, and versatile applications in food processing. Recent studies highlight their expanding role in functional foods, nutraceuticals, and value-added products.

Medicinal applications: Cremini mushrooms possess several medicinal properties that contribute to health and wellness. One of the most notable is their rich antioxidant content, particularly ergothioneine, a naturally occurring amino acid with strong antioxidant properties. This compound helps combat oxidative stress in the body, which is linked to chronic diseases such as cancer, cardiovascular disorders, and neurodegenerative conditions. Regular consumption of cremini mushrooms can thus support cellular health and reduce the risk of oxidative damage

Experimental

MATERIALS AND METHODS

Ash content: 5 grams of dry cremini mushroom powder were put in a crucible that had been weighed and ashed beforehand. It was then burned at a high temperature of 550°C for four to six hours in a muffle furnace until ash residue was produced. The crucible was cooled in a desiccator, and its inorganic mineral content (ash) was measured by reweighing it and calculating its percentage of the initial dry weight. This method follows standard protocols (e.g., AOAC 942.05) and provides insight into the mineral composition of the mushrooms, including essential elements and trace metals. The ash content reflects the non-combustible residue remaining after organic matter oxidation, which was useful for nutritional analysis and quality control.

$$\text{Ash content (\%)} = \frac{\text{Weight of ash}}{\text{Original sample weight}} \times 100$$

Wet digestion method: 10 mL of concentrated nitric acid and 2 mL hydrogen peroxide were used to digest dry cremini mushroom powder ash, which was then heated to 60 °C until a clear digestate was formed. After filtering the mixture in a 50 mL volumetric flask, distilled water was added to get it up to par. For the elemental analysis of the cremini mushrooms, this solution was utilized.

A flame emission spectrophotometer was used to quantify sodium and potassium, a colorimeter was used to determine the amount of iron, an atomic absorption spectrophotometer was used to determine zinc, calcium and magnesium.

$$\text{Element (mg/100 g)} = \frac{\text{Element (ppm)} \times \text{Dilution factor} \times \text{Final volume (mL)} \times 0.1}{\text{Weight of ash (g).}}$$

Quantitative Estimation of Sodium and potassium: The sodium and potassium content of the dried cremini mushroom powder ash was quantified using Flame Emission Spectroscopy (FES) (Nielsen, 2010). The instrument was calibrated with a series of sodium and potassium standard solutions of known concentration (5,10,20,30,40,50 ppm) and (2,4,6,8,10,20,30,40 and 50 ppm) prior to analysis. The principle of this analysis is based on the measurement of the emission intensity of the sodium and potassium doublet at 589 nm and 770 nm, which is proportional to its concentration in the sample (Skoog *et al*., 2013).

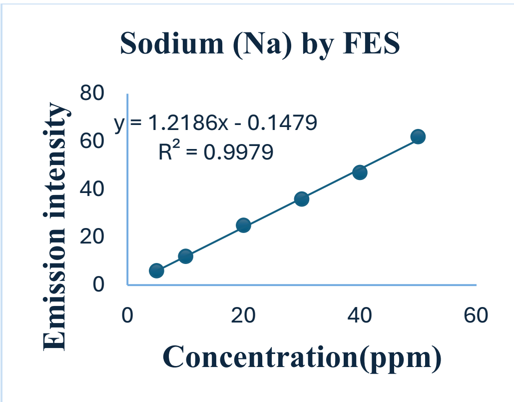
Quantitative estimation of Iron by Colorimetry: The quantity of iron in cremini mushroom dry powder ash was determined by a colorimetric method using a visible spectrophotometer, based on the formation of a red complex between iron (III) ions and thiocyanate ions (SCN^-) in an acidic medium. A stock solution was prepared from Mohr's salt, and a series of standard solutions (0.5–8 ppm) were made by adding appropriate aliquots of the stock to 50 mL volumetric flasks along with 5 mL of 2 M potassium thiocyanate and 3 mL of 4 M nitric acid to prevent hydrolysis and ensure color stability. A blank was prepared similarly without iron. The absorbance of each standard and the sample was measured at 420 nm against the blank, and the iron concentration in the sample was determined by interpolating its absorbance from the calibration curve plotted between absorbance and known iron concentrations.

Quantitative estimation of Zn, Ca and Mg by AAS

The quantification of zinc, calcium, and magnesium in cremini mushroom dry powder ash was determined using atomic absorption spectroscopy (AAS), with stock solutions (1000 ppm) prepared by dissolving 4.398 g of

$ZnSO_4 \cdot 7H_2O$, 3.668 g of $CaCl_2 \cdot 2H_2O$, and 8.361 g of $MgCl_2 \cdot 6H_2O$, respectively, in deionized water. Each 50-ppm working standard was prepared by diluting 2.5 mL of the stock to 50 mL, and calibration standards (0.5–5 ppm) were serially prepared in 50 mL volumetric flasks. Absorbance was measured at wavelengths of 415 nm for zinc, 420 nm for calcium, and 285 nm for magnesium, and the concentrations in the sample were determined by interpolation from respective calibration curves, with final results calculated using the formula.

Results and Discussion



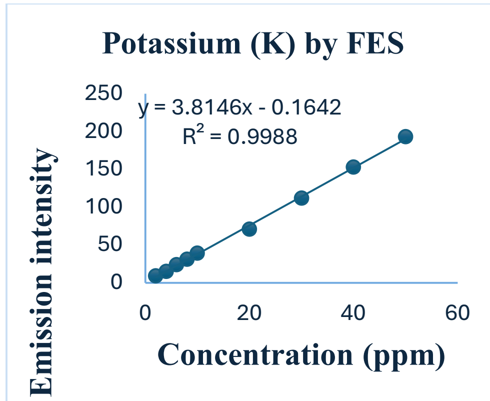
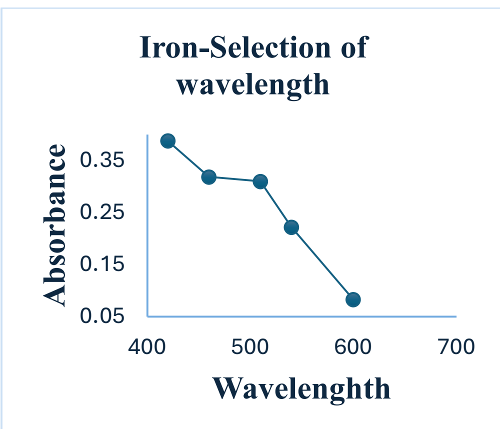


Figure 1: Calibration Curve of Na by FES Figure 2: Calibration Curve of K by FES



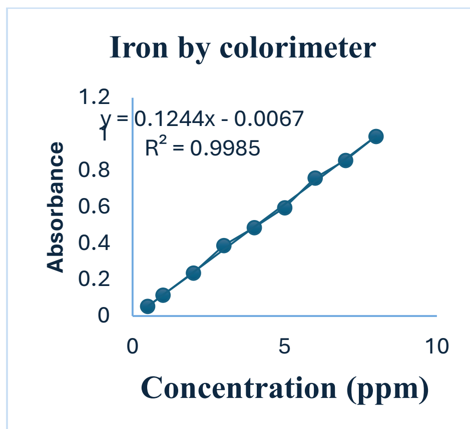
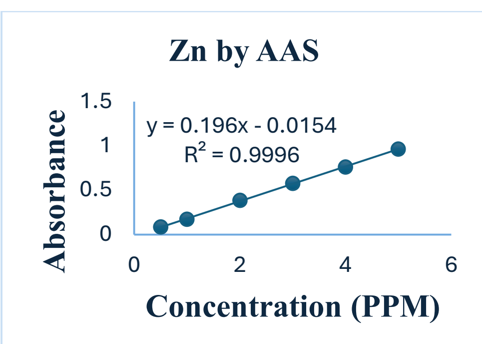


Figure 3 (A): Selection of wavelength

Figure 3 (B): Calibration Curve of Fe



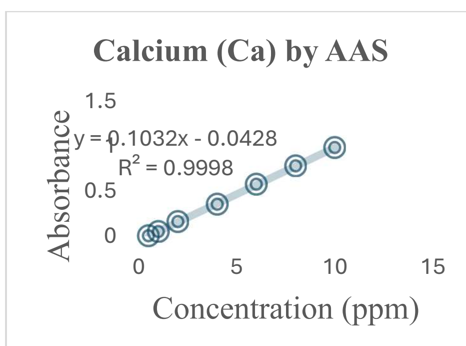
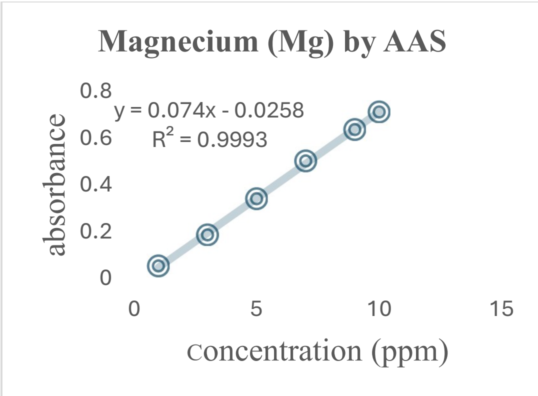


Figure 4:Calibration Curve of Zn by AAS

Figure 5: Calibration Curve of Ca by AAS



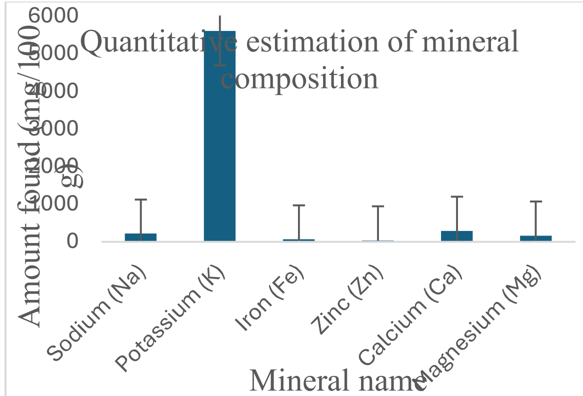


Figure 6: Calibration Curve of Mg by AAS Figure 7: Mineral Profiling of plant material

Table 2: Mineral Composition of Dry Cremini Mushroom Powder

Name of the mineral	Amount found (mg/100 g)
Sodium (Na)	211
Potassium (K)	5602.22
Iron (Fe)	61.6
Zinc (Zn)	31.33
Calcium (Ca)	284.45
Magnesium (Mg)	156.65

DISCUSSION: The mineral composition of dry cremini mushroom powder reveals that it is a highly nutrient-dense food source. Among the minerals analyzed, potassium is present in the highest concentration (5602.22 mg/100 g), highlighting its key role in supporting muscle function, cardiovascular health, and electrolyte balance [21]. Iron (61.6 mg/100 g) and zinc (31.33 mg/100 g) are also abundant, suggesting that dry cremini mushrooms could serve as a valuable plant-based source of trace minerals important for oxygen transport, immune function, and enzymatic activity [22]. Calcium (284.45 mg/100 g) and magnesium (156.65 mg/100 g) contribute to bone health and neuromuscular regulation [23], while sodium content (211 mg/100 g) remains relatively moderate compared to the other minerals, making the powder suitable for low-sodium diets [24]. Overall, the data indicate that drying mushrooms significantly concentrates their mineral profile, enhancing their nutritional value for use as a functional food ingredient [25].

CONCLUSION: Ash content analysis indicated a value of 4.5 %, consistent with typical mushroom mineral content. Minerals like potassium, sodium, calcium, magnesium, iron, and zinc were quantified. Potassium was present in the highest concentration, playing a vital role in cardiovascular and neuromuscular function. The significant levels of iron and zinc support the idea that mushrooms can serve as plant-based alternatives for trace minerals crucial for oxygen transport and immunity. Calcium and magnesium contribute to bone and nerve health, respectively. These findings underscore mushrooms as a nutrient-dense food source with functional benefits.

APPLICATION : The quantitative estimation of the mineral composition of dried cremini mushrooms provides valuable insights into their nutritional significance and potential applications in food science and health. By determining the concentrations of essential minerals such as Sodium, potassium, iron, zinc, calcium, and magnesium, the study highlights the role of cremini mushrooms as a natural source of vital micronutrients. This information can be applied in dietary planning, functional food development, and fortification strategies, especially for populations with mineral deficiencies. Moreover, the data serves as a reference for quality control in the mushroom processing industry, supports the promotion of mushrooms as a sustainable dietary component, and contributes to research on the health benefits of edible fungi.

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