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Canning Mushrooms with Watermelon (*Citrullus lanatus* (Thunb.) Juice: Nutritional and Health Interest

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Abstract: Canning edible mushrooms using water bath is commonly applied for long-term storage. However, nutrients and bioactive substances can be leached out from mushrooms during the canning process. The objective of this study was to investigate the potential of watermelon juice as alternative to the boiling water bath and as a means of improving the nutritional value of canned mushrooms. Three samples of *Pleurotus sajor-caju* were canned as follows: the first (CKKwmj) with 150 ml of "Kaolack" watermelon juice, the second (CKLwmj) with 150 ml of "Koloss" watermelon juice and the third (Cwt) "control" with 150 ml of tap water. After sterilization, samples were brought to room temperature for 45 days. Carbohydrate content was increased (6.68 ± 0.03 g /100 g and 6.65 ± 0.05 g /100 g dry weight), respectively in samples from CKKwmj and CKLwmj cans compared with Cwt (6.50 ± 0.04 g /100 g dw). The filling mediums KKwmj and KLwmj were also a source of carbohydrates with respectively 7.05 ± 0.06 g /100 g and 7.22 ± 0.04 g /100g dw. The proteins levels of CKLwmj and CKKwmj were approximately equal to Cwt (3.35 ± 0.03 g/100 g dw). L-citrulline content from CKLwmj (66.34 ± 0.07 mg /100 g dw) was higher than CKKwmj (48.15 ± 0.05 mg/100 g dw) and Cwt (48.06 ± 0.08 mg/100 g dw). In addition, L-citrulline contents of cans filled with KLwmj and KKwmj were respectively 297.5 ± 0.08 mg/100 g dw and 258.5 ± 0.09 mg/100 g dw. Energy content of samples were low, the highest value was observed in mushrooms from CKLwmj (45.11 ± 0.15 Kcal/100 g dw) and was slightly above on the "control" (43.72 ± 0.15 Kcal/100 g dw). This study shows that canning mushrooms with watermelon juice could be a source of minerals (potassium, phosphorus, magnesium).

Keywords: Mushroom, Canning process, Watermelon juice

Introduction

Many studies have shown the nutritional and health interest of fresh edible mushrooms (Valverde et al., 2015; Feeney et al., 2014; Babu and Subhasree., 2008; Konuk et al., 2006). Indeed, mushrooms provide proteins, fatty acids, carbohydrates, vitamins, minerals (Soares et al., 2013; Khatun et al., 2012; Kalmiş et al., 2011; Barros et al., 2007; Silva et al., 2002), they have therapeutic properties (Badalyan., 2014) and have been used in folk medicine throughout the world (Valverde et al., 2015; Finimundy et al., 2014; Obodai et al., 2014; Soares et al., 2013; Mirunalini et al., 2012; Smith et al., 2002; Wasser et al., 1999). It has been reported that *Pleurotus sajor-caju* has antitumor effects and antioxidant properties (Valverde et al., 2015). However, fresh mushrooms are highly perishable with short shelf life under ambient environment (Karaaslan and Havuz., 2014; Lakshmipathy et al., 2013; Kitinoja and Kader., 2002). Then, for long-term storage of mushrooms, canning is the most common process used in order to maintain their supply to consumers throughout the year (Bernaś et al., 2006).

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Canning is a method of preserving in which the food contents are processed and sealed in an air tight container. Therefore, canning provides a long shelf life (Karaaslan and Havuz., 2014; Kapica and Weiss., 2002) of foods in an edible state from one to many years. Nonetheless, canning process induces important changes in physical and chemical properties of mushroom (Caglarrlmak et al., 2011; Vivar-Quintana et al., 1999). Nutrients can be leached out from the product during water blanching (Rickman et al., 2007; Reyes De Corcuera et al., 2004), then bioactive substances that confer mushroom's nutritional and health virtues could be affected by the physicochemical conditions during the canning process (Rickman et al., 2007). In fact, mushroom canning is generally processed with water bath and even if the sanitary quality of the product is ensured by sterilization, nutritional quality may be reduced. In addition, usually, people pour water or oil contained in the cans to keep and eat food only.

Watermelon (*Citrullus lanatus*) provides many nutrients (Perkins-Veazie et al., 2001; El-Badry et al. 2014). Also, watermelon seeds are loaded in vitamins B, minerals (magnesium, potassium, sodium, copper, zinc) (Rimando et Perkins-Veazie., 2005) proteins and fats (Okokon et al 2010). Canning foodstuffs of plant or animal origin with watermelon juice offer a means to incorporate more nutrients for consumption. Then, in order to test this hypothesis we investigated the possible functionality and use of watermelon juice as alternative to the boiling water bath in canning mushrooms process.

2. Materials and Methods

Plant Material

Watermelon

Red-fleshed watermelons ("Kaolack" and "Kolloss" varieties) were purchased from local market at Dakar.

Mushrooms

The edible mushrooms *Pleurotus sajor-caju* used in this study were obtained from local suppliers trained by ITA team. After cleaning them, fresh mushrooms were sun dried at 35°C for 48 h. Dried mushrooms are kept in vacuum bags at room temperature for future use.

Canning Process

In this study watermelon juice was the filling medium of canning mushrooms.

Watermelon Juice Preparation

Each watermelon was gently and completely hollowed and all components of the fruit (flesh, peels, juice, and seeds) except rinds were pureed until completely changed into juice. Watermelon juice is preheated to 80 ° C to remove air before canning preventing oxidation.

- **Lidding and clinching**

Three cans were filled up as follows: the first (CKKwmj) with 150 ml of "Kaolack" watermelon juice, the second (CKLwmj) with 150 ml of "Koloss" watermelon juice and the third (Cwt) "control" with 150 ml of water. Then, 5 g of *Pleurotus sajor-caju* cutted in 3 cm pieces were poured into each can. The cans were hermetically sealed using a clinching process in which the lid of each can was placed. No food preservative have been added.

- **Sterilization**

Sterilization is the process of heating the cans to prevent the spoilage by microorganisms during storage, it has been reported that the optimum conditions for mushrooms sterilization are a temperature of 118-121°C for 20 mn (Bernaś et al., 2006). In this study, mushrooms sterilization was done using an autoclave, filled cans were together placed inside and were sterilized at 100 °C for 15 minutes in order to preserve a large amounts of nutrients. After the sterilization process, cans were cooled immediately at room temperature.

Analysis

All analyzes were performed after 45 days of preservation of the products at room temperature to 30 ° C.

Chemical analysis

Samples of mushrooms and watermelon juices containing them were analyzed for moisture, crude protein, crude fat, minerals (sodium, calcium, magnesium, phosphorus, potassium, iron) and amino acids (L-arginin, L-citrulline). Analysis were conducted at the " Laboratoire National d'Analyses et de Contrôle" in Dakar (Senegal) following NF EN ISO 20483, NF ISO 2911, NF EN ISO 3947, Régl (UE) No 1169/2011, ISO-712, NF EN 15505, NF EN 1134, NF EN 15505, NF EN 1136, NF EN 1134, NF EN 14084, NF EN ISO 13903, NF EN ISO 13903 respectively for proteins, carbohydrates, lipids, energy, fibers, sodium, calcium, magnesium, phosphorus, potassium, iron, L-arginine and L-citrulline.

Microbiological Analysis

Mushrooms canned samples were transported to the laboratory. Microorganisms researched included Thermotolerant bacteria, *Escherichia coli (E. coli) and Salmonella* spp. commonly used as indicators of sanitary quality of water and foods. Microbiological analysis was performed using NF ISO 4832, NF ISO 16649-2, NF EN ISO 6579 methods respectively for Thermotolerant bacteria, *E. coli* and *Salmonella* spp. All determinations were carried out in duplicates.

Data analysis
All the analyses were replicated two times and the data are presented as mean ± SD.

Results and Discussion
Results from chemical analysis are presented in Table 1. Carbohydrate contents were increased (6.68 ± 0.03 g /100g and 6.65 ± 0.05 g /100g dry weight), respectively in mushrooms samples from CKKwmj and CKLwmj cans compared with Cwt (6.50 ± 0.04 g /100g dry weight). The filling mediums "Kaolack" watermelon juice (KKwmj) and "Koloss" watermelon juice (KLwmj) were also a source of carbohydrates with respectively 7.05 ± 0.06 g /100g and 7.22 ± 0.04 g /100g dry weight.

The proteins levels of mushrooms from CKL wmj (3.51 ± 0.06 g/100g dry weight) and CKKwmj (3.30 ± 0.03 g/100g dry weight) were approximately equal to Cwt (3.35 ± 0.03 g/100g dry weight). However, in term of amino acids supplying, results showed that canning *Pleurotus sajor-caju* with watermelon juice could help increase L-citrulline and L-arginine. L-citrulline content of mushroom sample from CKLwmj (66.34 ± 0.07 mg /100g dry weight) was higher than those from CKKwmj (48.15 ± 0.05 mg/100g dry weight) and Cwt (48.06 ± 0.08 mg/100g dry weight). In addition, L-citrulline contents of cans filled with KLwmj and KKwmj were respectively 297.5 ± 0.08 mg/100g dry weight mg and 258.5 ± 0.09 mg/100g dry weight. Hence we recommend consumption of the canned mushrooms and the watermelon juice filling mediums at the same time. It has been demonstrated that L-citrulline administration using watermelon juice could be associated with increased plasma concentrations of L-citrulline and L-arginine (Moinard et al., 2008; Schwedhelm et al., 2008). Then, our results suggest that canning mushrooms with watermelon juice could be a means to increase plasma concentration of L-citrulline and L-arginine.

Tarazona-Diaz et al. (2013) investigated the potential of watermelon juice as a functional drink for athletes and reported that L-citrulline is an excellent candidate to reduce muscle soreness. In the same way, consumption of canned mushrooms with watermelon juice (CMwWmJ) as filling medium could bring likely advantages as L-citrulline food vehicle.

L-citrulline bypasses splanchnic sequestration (Bahri et al, 2013), and has an effect on muscle protein synthesis, this helps explain its significance against decreasing muscle mass in humans and may contribute in sarcopenia protection in the elderly. Consequently, based on the foregoing, CMwWmJ may be useful in daily dietary intake, managing and preventing specific diseases. The L-arginine level of mushrooms from cans with watermelon juice (87.8 ± 0.2 mg /100g dry weight for CKK wmj and 87.5 ± 0.14 mg /100g dry weight for CKLwmj) was higher than the "control" (85.9 ± 0.16 mg /100g dry weight). This difference could be explained by the contribution of L-arginine from watermelon juice.

L-arginine has a beneficial effect on the immunity (Pekarova et al., 2011 ; Tadié et a, 2009). In consideration of this allegation, CMwWmJ could be a healthy food. These results suggest that canning mushrooms with watermelon juice process could help increase potassium, phosphorus and magnesium, those minerals play an important function in human metabolism. Also, the quantity of minerals from KKwmj and KLwmj was considerable and may help to increase the nutritional value of mushrooms. It may be noted that the potassium level of mushroom sample from CKLwmj (425.8 ± 0.5 mg /100g dry weight) and CKKwmj (425.8 ± 0.1 mg /100g dry weight) are similar to the "control" (425.9 ± 0.04 mg /100g dry weight), it is the same for phosphorus, magnesium and calcium. Then a serving portion of 100 g of canned *Pleurotus sajor-caju* consumed with the watermelon juice filling medium may provide sufficient amounts of potassium. The highest sodium level was observed in sample from CKLwmj (18.8 ± 0.04 mg /100g dry weight). Sodium is an essential nutrient that is required for the functioning of human body (Health Canada, 2012). However, excessive amounts of sodium may cause high blood pressure that is a major death risk factor. Results showed that canning with watermelon juice did not increase the sodium level of *Pleurotus sajor-caju* because watermelon itself is naturally low in sodium (6.18 mg/100g for KLwmj and 8.15 mg/100g for KKwmj). According to the UWHealth (2011) amount of sodium per serving in a low sodium food must be 35 mg or less. Sodium content of all samples were low, it has been demonstrated that a low sodium food presents a nutritional and health interest (Agrahar-Murugkar and Subbulakshmi, 2005) particularly in reducing sodium diet. A low sodium diet is recommended in case of high blood pressure, heart and kidney diseases. In consideration of this guidance from the UWHealth (2011), results suggest that canned mushrooms with watermelon juice may be useful in dietary sodium reduction and preventing high blood pressure or cardiovascular diseases.

Fibers ranged from 1.5 g in mushroom from Cwt to 1.7 g in CKLwmj, those concentrations are relatively low compared to some mushroom species reported by Agrahar-Murugkar and Subbulakshmi (2005). Energy content of samples were low, the highest value was observed in mushrooms from

CKLwmj (45.11 ± 0.15 Kcal) and was slightly above on the "control" Cwt (43.72 ± 0.15 Kcal). This may be a good nutritional and healthy food for person in low diet intake, this is especially true given that the fat content of those samples were also very low (0.45 ± 0.04g for CKKwmj and 0.53± 0.03g CKLwmj).

Results from microbiological analysis are given in Table 2. The microbiological quality of all samples were acceptable. *Salmonella spp* was not present in any of the samples, also levels of Escherichia coli and Thermotolerant coliforms were conform to referenced Standards (NF ISO 16649-2 and NF EN ISO 4832).

Table 1: Nutritional value (/100 g dry matter basis) of the filling medium and canned mushrooms

Values are means ± standard deviation for 2 repetitions

Samples	Carbohydrate (g)	Fats (g)	Proteins (g)	Sodium (mg)	Calcium (mg)	Magnesium (mg)	Phosphorus (mg)	Potassium (mg)	Iron (mg)	L-Arginine (mg)	L-Citrulline (mg)	Fibers (g)	Energy (Kcal)
KKwmj	7.05 ± 0.06	0.38 ± 0.04	0.65 ± 0.05	8.15 ± 0.02	1.08 ± 0.05	15.02 ± 0.05	16.23 ± 0.1	202.6 ± 0.04	0.38 ± 0.06	61.13 ± 0.20	258.5 ± 0.09	0.38	34.22 ± 0.03 ±0.1
KLwmj	7.22 ± 0.04	0.25 ±	0.68 ± 0.03	6.18 ± 0.06	0.95 ± 0.05	13.95 ± 0.08	16.54 ± 0.09	209.75 ± 0.04	0.45 ± 0.05	60.25 ± 0.16	295.5 ± 0.08	0.38	33.85 ± 0.08 ± 0.12
CKKwmj	6.68 ± 0.03	0.03	3.30 ± 0.03	16.40 ± 0.05	3.47 ± 0.06	18.88 ± 0.08	121.80 ± 0.5	425.80 ± 0.1	1.30 ± 0.09	87.80 ± 0.2	48.15 ± 0.05	1.60	43.97 ± 0.08 ± 0.08
		0.45 ± 0.04											
CKLwmj	6.65 ± 0.05	0.53 ± 0.03	3.51 ± 0.06	18.80 ± 0.04	3.76 ± 0.05	18.38 ± 0.05	123.36 ± 0.04	425.80 ± 0.5	1.33 ± 0.04	87.50 ± 0.14	66.34 0.07 ±	1.70	45.11 ± 0.04 ± 0.15
Cwt	6.50 ±0.04	0.48 ±0.03	3.35 ± 0.03	16.5 ±0.06	4.01 ±0.05	18.04 ±0.08	120.88 ±0.09	425.90 ±0.04	1.30 ±0.05	85.90 ±0.16	48.06 ±0.08	1.50	43.72 ± 0.08 ± 0.12

Table 2: Microbiological quality of the canned mushrooms and filling medium

M.O **CKKwmj**	**Cwt**	**CKL wmj**	KKwmj	KLwmj	Reference value method used (Unit u: g or ml)	Reference
Therm < 10/g Coliforms	< 10/g	< 10/g	<10/ml	< 10/ml	10/ml-10^2/u ISO 4832	NF EN
E. coli < 10/g	< 10/g	< 10/g	< 10/ml	<10/ml	10/ml-10^2/u 16649-2	NF ISO
Sulphite-reducing < 10/g *anaerobes*	< 10/g	< 10/g	<10/ml	<10/ml	< 10/u 061	NF V08-
Salmonella spp. 0 /25g	0 /25g	0/25g	0/25/ml	0/25 ml	0/25 u ISO 6579	NF EN

M.O : Microorganisms

0: signifies an absence of *Salmonella* spp. ; Therm Coliforms = Thermotolerant Coliform

Conclusion

This paper demonstrates the nutritional and health interest of using watermelon juice in canning mushrooms. The results showed that canning *Pleurotus sajor-caju* with watermelon juice offers a means to incorporate more nutrients for consumption compare to the method using boiling water bath. This study suggests that canning mushrooms with watermelon juice could be a source of L-citrulline and L-arginine as a means against decreasing muscle mass and may contribute in sarcopenia protection for elderly people. Also, canning mushrooms with watermelon juice can be an alternative solution to the reduction of post-harvest losses of watermelon particularly in African countries. However, future research should be focused on the sensory evaluation with panelists in order to investigate if canned mushrooms with watermelon juice will be appreciated by consumers.

Conflict of interest

The authors have no conflict of interest.

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