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Effects of Storage Temperature and Packaging Combinations on the Storage Quality of Fresh Yacon [*Smallanthus sonchifolius* (Poepp.) H. Rob.]

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Abstract

The yacon tuber has gained interest due to its health-promoting components, such as high amounts of fructooligosaccharides (FOS) and phenolic compounds with strong antioxidant properties. However, the high water content and the soft, delicate internal tissues render it highly perishable, leading to significant losses during postharvest handling. The packaging and storage temperatures, two important factors in maintaining quality when storing fresh yacon tubers, were studied. The results showed that modified atmosphere packaging (MAP) combined with low temperature (10°C) had positive effects on the visual quality of yacon. Weight loss and shriveling were reduced in MAP compared to the unpacked yacon under room and 10°C storage temperatures. The use of MAP under room temperature for an extended storage period was limited by the development of disease and the occurrence of root sprouts and surface cracks in yacon, which reduced its visual quality. FOS hydrolysis by fructan exohydrolase occurred during storage, leading to higher amounts of fructose, glucose, and sucrose. The use of MAP regardless of storage temperature delayed the onset of rapid FOS decline. The total phenolic contents in the range of 4.84-5.98 mg Gallic acid equivalent per gram dry sample and antioxidant activity of yacon did not decrease relative to its initial content. Yacon could be stored at 10°C in conjunction with MAP to maintain quality and extend the shelf life of fresh yacon tubers.

Keywords: modified atmosphere packaging, fructooligosaccharides, total phenolic content, antioxidant

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Yacon [*Smallanthus sonchifolius* (Poepp.) H. Rob.], which belongs to Asteraceae family, is a tall, perennial plant that is native to the Andean region and has been cultivated in the Philippines in the late 90s. The plant has rhizophores and tuberous roots as underground reserve organs. The rhizophores serve as reproductive organs while the tuberous, or storage roots, also known as yacon, are the edible parts similar to sweet potato in appearance. Yacon can be eaten raw or cooked. When raw, it is crunchy, watery and sweet due to an abundance of soluble carbohydrates such as fructose, glucose, sucrose, and fructooligosacharides (Grau and Rea, 1997). The texture and flavor have been described as a cross between a fresh apple and a watermelon (Gusso, Mattana, and Richards, 2014). Water is the most abundant component of the yacon tuberous root, decreasing its energy value.

Interest in yacon has increased since it has been known as a plant with the largest content of fructooligosaccharide (Manrique, Parraga, and Hermann, 2005), which can reach up to 70-80% of its dry matter (Lachman, Fernandez, and Orsak, 2003). Fructooligosaccharides (FOS) are fructans consisting of a short linear chain of fructose molecules, and are storage carbohydrates in certain plant foods. They are synthesized from the sucrose in the cell vacuoles of plant leaves, stems, and roots. Fructooligosaccharides resist hydrolysis by human small intestinal digestive enzymes since the body is not capable of producing enzymes to hydrolyze FOS. Thus, they have been classified as non-digestible oligosaccharides. The FOS is completely fermented in the colon by probiotics, mainly species of the genera *Lactobacillus* and *Bifidus* (Pedreschi, et al., 2003), that improve digestive function and alleviate many digestive disturbances. The fermentation of FOS in the colon has been related to the strengthening of immune responses, better absorption of certain minerals, and reduced cholesterol and triglyceride levels, as well as the inhibition of toxins known to contribute to colon cancer (Manrique et al, 2005).

In addition to FOS, yacon is also rich in phenolic compounds with strong antioxidant properties (Lachman et al, 2005) that protect the human body from oxidative processes. This is due to their ability to scavenge free radicals, donate hydrogen atoms or electron, or chelate metal ions. The regular consumption of phenolic-rich natural foodstuff has been correlated with the reduced risk of certain types of cancer, as well as certain inflammatory and cardiovascular disorders.

Most of the beneficial effects of yacon consumption have been attributed to its content of FOS, phenolic compounds, and antioxidants (Campos, et al., 2012). However, FOS content in yacon significantly decreases during postharvest storage since it is a reserve carbohydrate and that storage can influence its contents. FOS in yacon tends to depolymerize into sucrose and reducing sugars (glucose and fructose) fairly quickly after harvest by the enzyme fructan exohydrolase (FEH). According to Graefe, et al. (2004), 30-40% of the FOS would transform into simple sugars after a week of storage at room temperature. Data on the changes in FOS content during storage is important to consider given the fact that yacon's primary health benefits are due to its high FOS content. If FOS decreases and free sugars increase, yacon's low-calorie, low-glycemic, and prebiotic status will begin to deteriorate as well, making it important to avoid phenol oxidation and FOS hydrolysis to maintain the tuber's dietary value.

The high water content and the soft, delicate internal tissues render yacon perishable, leading to high losses during postharvest handling. Thus, there is a need to establish storage conditions that would lengthen the shelf life of fresh yacon tubers as well as to determine the changes that occurred during storage.

Materials and Methods

Two storage temperatures (room temperature and 10°C) and 3 packages (control/open, MAP 1, MAP 2) were used in the study. Modified atmosphere was created using a perforated low-density polyethylene (LDPE) bag having a size of 8x14" with a thickness of 0.05mm. For MAP 1, 8 pinpricks were made by pinpricking the middle portion of the bag with a hot 1 mL gauge needle, while for MAP 2, 8 perforations were made using a standard puncher having 6mm in diameter. Preliminary trials were done before the choice of the number of perforations in the plastic films used in the study. There were 3 yacon tubers, with an average weight of 135g/tuber, in each pack.

After packaging, yacon tubers were stored at room temperature (25±2°C) and at cold room with a temperature of 10°C for 14 weeks. After storage weeks 1, 2, 3, 4, 6, 8, 10, 12, and 14, samples of yacon tubers (3 replications or packs with 3 yacon tubers per pack per treatment) were analyzed for physico-chemical properties.

Visual quality, disease incidence, and severity

The overall visual quality of yacon tubers was evaluated on a 9 to 1 scale, where 9 is excellent and field fresh, with no defects; 7 is good, with minor defects; 5 is fair, with moderate defects; 3 is poor, with major defects/limited marketability; and 1 is unusable.

The severity of decay was evaluated using severity index on a 1–5 scale, where 1 = none, 2 = slight (up to 5% surface affected), 3 = moderate (>5–20% surface affected), 4 = moderately severe (>20–50% surface affected), and 5 = extreme (>50% surface affected). Percentage of infected yacon tubers was computed as follows:

$$\% \text{ disease incidence } = \frac{(\text{number of tubers infected})}{(\text{ total number of yacon tubers})} \text{ x } 100$$

Degree of shrivelling

The degree of shrivelling of yacon tubers was evaluated on a 1-4 scale where 1 = shriveling absent, 2 = slight shriveling, 3 = moderate shriveling, 4 = severe shriveling (Figure 1).

Figure 1. Degree of shriveling index of yacon tubers (1 - shriveling absent, 2 - slight shriveling, 3 - moderate shriveling, 4 - severe shriveling).

Weight loss

The weight of yacon before and during storage was measured using an electronic weighing scale. Cumulative weight loss (CWL) was computed using the following formula:

$$\% \text{ CWL} = \frac{(\text{initial weight, g} - \text{weight at time t, g})}{(\text{initial weight, g})} \times 100$$

Determination of fructooligosaccharide content in yacon tubers

The concentration of FOS in yacon was analyzed by the enzymatic spectrophotometric method using Megazyme, a commercial fructan assay K-FRUC kit. The FOS content was calculated as follows:

$$\text{FOS (\% w/w as is)} = \Delta_A \times \frac{V}{W} \times 2.48$$

where:

Δ_A = sample absorbance – sample blank absorbance
V = factor to convert absorbance values to µg of D-fructose
= 54.5 µg D-fructose/absorbance for 54.5 µg D-fructose
W = weight (mg) of sample extracted

Determination of fructose, glucose and sucrose contents

Fructose, glucose and sucrose contents of yacon were determined enzymatically using a commercial kit (K-SUFRG Megazyme). All reagents were prepared according to the manufacturer's instructions. The manufacturer's suggested procedures were strictly followed, and the contents of individual sugars were calculated and expressed as percentages (%) on a dry weight basis.

Total phenolic content and antioxidant using DPPH assay

The total phenolic content was determined using the Folin-Ciocalteu method. Total phenolics were quantified by the calibration curve obtained from measuring the absorbance of known concentrations of Gallic acid standard. The results were expressed as mg of Gallic acid equivalent per g of dry weight (mg GAE/g).

The DPPH (1, 1-diphenyl-2-pidrylhydrazyl) assay was based on the determination of scavenging free DPPH radicals. The method of Castro, et al. (2012) was followed.

Statistical analysis

Statistical analysis was done using Analysis of Variance (ANOVA) for 2 factorial in Completely Randomized Design (CRD) with 3 replications. Treatments were compared using the least significant difference test (LSD).

Results and Discussion

Visual quality rating (VQR)

A decline in the visual quality of yacon tubers was observed in all treatments during storage. Among yacon tubers stored at 10°C, the highest visual quality (with a rating of 9 in a 9-1 scale) was retained up to 2 weeks and 4 weeks storage period in MAP 2 and MAP 1, respectively, compared to 2 weeks at room temperature (Figure 2). The visual quality rating of modified atmosphere-packed yacon tubers at the end of storage testing (14 weeks) fell between 4 and 7, with MAP 1 at 10°C having the highest VQR. Meanwhile, the visual quality of unpacked control yacon tubers rapidly declined during storage as early as 2 weeks when stored at room temperature, and 3 weeks at 10°C.

The causes of visual quality reduction among yacon tubers were shriveling, decay, hair sprouts (appearance of roots at the end portion of the tuber), and surface cracks. Shriveling and decay resulted in the visual quality decrease of the unpacked control yacon tubers, as well as in MAP stored at room temperature, while shriveling in MAP at 10°C was limited. As Adawiah, Azrianingsih and Mastuti (2019) found in their study, "weight loss in tubers causes shrinkage, which is one of the criteria for quality standards for agricultural products".

Weight loss is the main indicator of quality decline, including changes in appearance, texture, as well as the product's nutritional value, in turn decreasing the selling price. Surface cracks and root sprouts, which started to appear on week 6, also contributed to the visual quality decrease of MAP 1 yacon at room temperature. Root sprouts and surface cracks in MAP 2 started appearing only on weeks 12 and 14, respectively. High humidity inside the package at elevated temperatures and changes in gas composition within the package likely promoted rooting and surface/skin cracking among yacon tubers.

Atmospheric gas composition during storage has been shown to affect the potato tuber dormancy period (Nyankanga, Murigi, and Shibairo, 2018). The increased carbon dioxide concentration, combined with the reduction of oxygen to a certain concentration, has been associated with a faster dormancy break, an increased number of sprouts, and cell elongation (Coleman and Mclnerney, 1997). In this study, high CO_2 and low O_2 have been achieved due to the respiration of yacon tubers and the limited exchange of gases in the package.

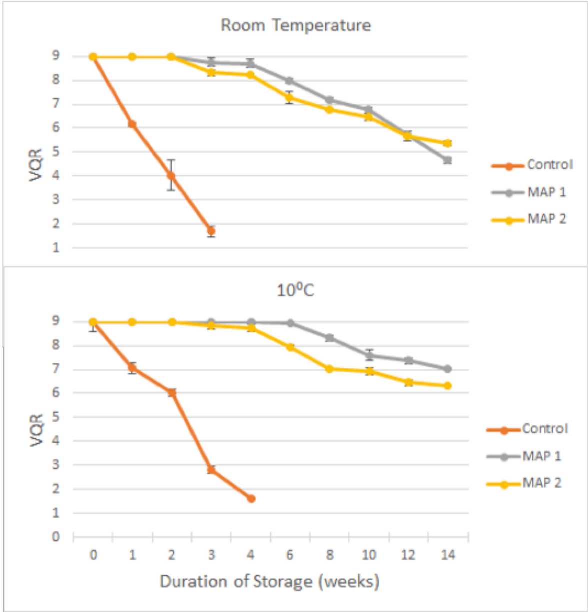

Figure 2. Effect of storage temperature and packaging combinations on the VQR of yacon tubers.

Disease incidence and severity

Storage temperature was the most important factor in disease development and severity in yacon tubers. Low temperature storage delayed the onset of disease in yacon tubers as they delay the growth and development of microorganisms. The disease severity of MAP-treated yacon tubers was lower than that of the unpacked control group, and MAP 1 and MAP 2 conditions had similar effects.

Unpacked control tubers started to develop diseases on the first week of storage at room temperature, but only did so on the third week when stored at 10°C (Figure 3). Rapid water loss, which occurred during the said weeks, caused disruption and cell collapse in yacon, making them susceptible to microorganisms. When cells are disrupted, nutrients are made readily available for the growth and multiplication of microorganisms.

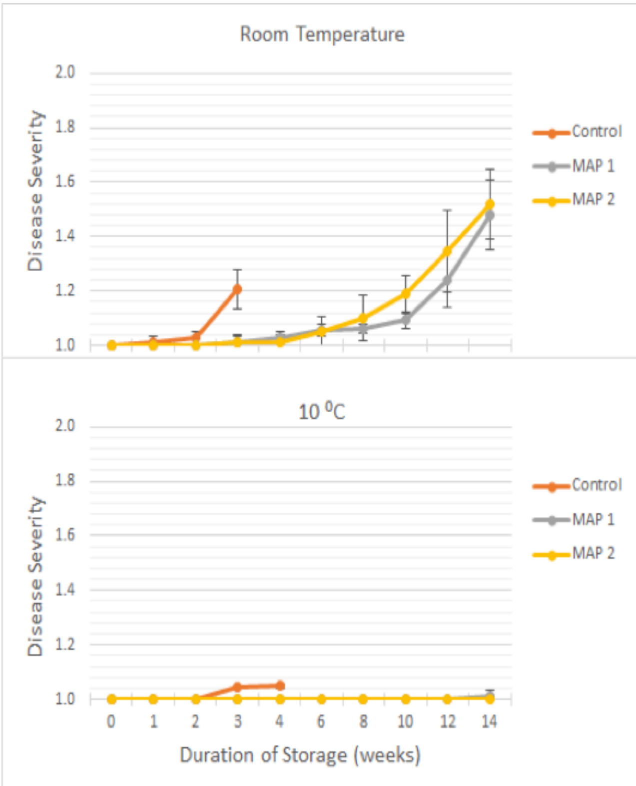

Figure 3. **Severity of disease (evaluated using decay index) of yacon tubers as affected by storage temperature and packaging.**

Mold growth was extensive in MAP groups stored at room temperature as storage time progressed, with disease incidences being higher in MAP 1 by the end of the storage period (Table 1). Symptoms of decay among yacon tubers in both MAP 1 and MAP 2 were observed on the third week of storage at room temperature with a disease incidence of 1.23%, while disease incidence rose only for MAP 1 tubers (stored at 10°C) to 3.7% by the end of storage time. There was no evidence of disease development or decay in MAP 2 at 10°C. The increased incidence of disease and severity in yacon tubers stored in MAP at room temperature could be due to high humidity inside the package with prolonged storage, favoring the growth of microorganisms.

In addition to this, water vapor condensation, which may lead to the buildup of microorganisms and increased decay, may occur in the package due to the film's lower permeability to water vapor (Nyankanga et al, 2018). The commodity's potential postharvest life in modified atmosphere packaging is diminished by the onset of decay favored by the high relative humidity in the pack (Esguerra and Bautista, 2007). Poor air circulation causes heat buildup and increases moisture from respiration, promoting spores and pathogenic growth (Adawiah et al, 2019). However, when stored at 10°C, the onset of disease in the tubers was minimized despite high humidity, due to low temperatures being unfavorable to microorganisms.

Table 1. Effect of storage temperatures and packaging combinations on disease incidence (%) of yacon tubers during storage.

TREATMENT	TIME IN STORAGE (week)									
	0^{ns}	1*	2*	3*	4*	6*	8*	10*	12*	14*
Room Temp.										
Control	0.00	1.23^{b}	2.78^{b}	19.05^{d}						
MAP 1	0.00	0.00^{a}	0.00^{a}	1.23^{b}	2.78^{c}	4.76^{c}	5.56^{b}	8.89^{b}	13.89^{b}	25.93^{d}
MAP 2	0.00	0.00^{a}	0.00^{a}	1.23^{b}	1.39^{b}	1.59^{b}	5.56^{b}	11.11^{c}	16.67^{c}	22.22^{c}
10°C										
Control	0.00	0.00^{a}	0.0^{0a}	4.17^{c}	4.76					
MAP 1	0.00	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	3.70^{b}
MAP 2	0.00	0.00^{a}	0.0^{0a}	0.0^{0a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}

^{ns} not significant
*significant
Means in the same column with different letters are significantly different

Cumulative weight loss (%)

Water loss is one of the main causes of deterioration and weight loss that reduces the marketability of fresh produce. According to Pereira, et al. (2013), water is a major component of yacon tubers, which makes the root susceptible to rapid degradation, with a shelf life of approximately 7 days in ambient conditions. Water accounted for roughly 89% of the total content of the yacon tubers used in the study, which means that the intercellular spaces in yacon tubers were nearly saturated with water vapor. This meant that the tubers had a tendency to release water to the surrounding atmosphere when the relative humidity of the external environment fell considerably below 100% due to an increased pressure deficit. The rate at which water is lost from the fresh tubers depends on the difference between the water vapor pressure within the tubers and the water vapor pressure of the surrounding air, with moisture passing from higher to lower pressure (Diop, 1998).

Weight loss was higher when stored at room temperature than at 10°C (Figure 4), likely due to higher respiration and transpiration rates at higher temperatures than at lower ones. Unpacked control yacon tubers had the highest weight loss during storage, with moisture loss reaching 31-33% by the end of the storage period (week 3-4). Conversely, the weight loss of yacon tubers in modified atmosphere packaging was significantly reduced, with MAP 1 being the most effective in controlling yacon tubers' weight loss. According to Serrano, et al. (2006), MAP's effect on reducing weight loss is due to the limitation of water vapor diffusion by plastic film, resulting in high water vapor pressure and high relative humidity inside the package. The weight loss differences among the treatments were due to differences in temperature and relative humidity among the storage environments, which coincides with the report of Manjunatha and Anurag (2014). Thus, the reduced rate of respiration and transpiration and higher relative humidity inside the package could be the reason for such a reduced rate of weight loss of yacon tubers in MAP 1 at 10°C. Although MAP effectively reduced the weight loss of yacon tubers during storage, it increased the percentage and severity of decay incidence when stored at room temperature. The use of MAP in yacon tubers for an extended period of time is beneficial if used in conjunction with low temperature storage.

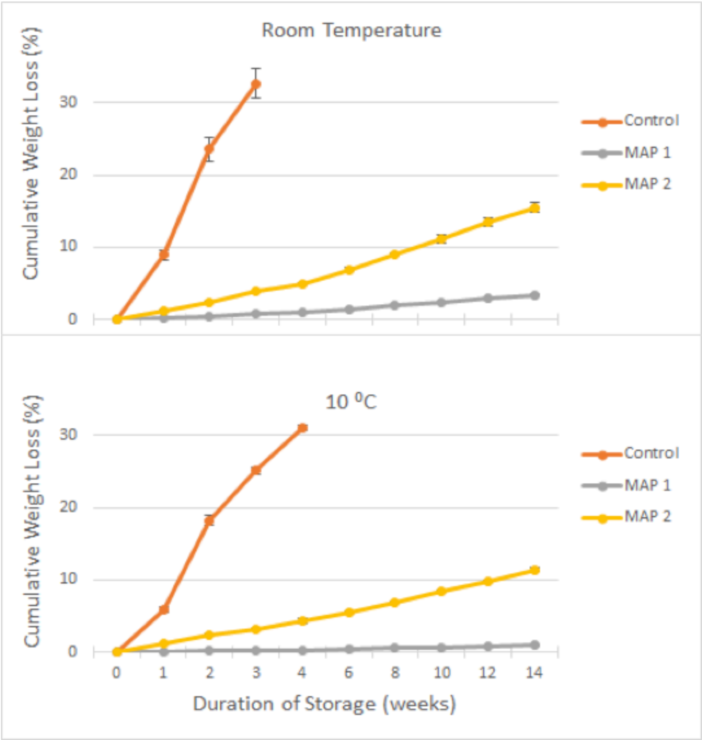

Figure 4. Effect of storage temperature and packaging combinations on the weight loss (%) of yacon tubers.

Degree of shriveling

The shriveling of yacon was mainly due to water loss. The degree of shriveling is directly related to the tubers' weight loss during storage, with greater weight loss correlating to greater shriveling observed. This resulted in weight loss and caused the skin to shrivel, especially at the root ends.

Severe shriveling occurred in unpacked control yacon tubers during the 3rd and 4th week storage periods (Figure 5). The result of this study is similar to that of Scheid, et al. (2013), where yacon tubers became 100% wrinkled after 24 days of storage at 25°C. Modified atmosphere packaging significantly lessened the shriveling of yacon tubers, with MAP 1 as most effective. Visible shriveling in yacon tubers stored in MAP at room temperature was observed after 2nd week storage period, while at 10°C, shriveling occurred only on week 3 in MAP 2, and on week 6 in MAP 1.

The differences in the degree of shriveling were due to differences in weight loss among the treatments, which appear to be due to variances in temperature and relative humidity among storage environments. The study of Maalekuu, Saaja & Addae (2014) showed that the respiration, transpiration, and sprouting are the factors responsible for weight loss, influencing the appearance and causing yam tubers to shrivel. The reduced rate of respiration and transpiration at 10°C and higher relative humidity inside the package could be the reason for such a reduced rate of weight loss, as well as shriveling of yacon tubers in the MAP.

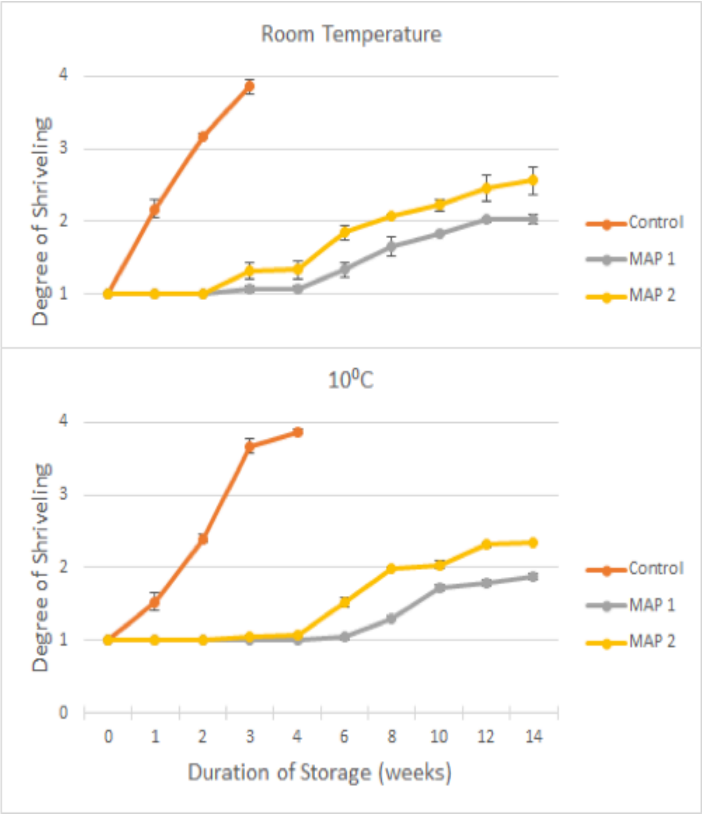

Figure 5. **Effect of storage temperature and packaging combinations on the degree of shriveling of yacon tubers.**

Fructooligosaccharide, fructose, glucose, and sucrose contents

During storage, the FOS content of yacon tubers, which accounted for 51.36% of the dry weight at the onset of the experiment, decreased in all treatments (Figure 6). FOS content decreased rapidly during the first three weeks of storage and the content was lower under room temperature than at 10°C, being lower for control than the packaged one. The studies of Doo et al (2000) and Graefe et al (2004) showed that FOS conversion in yacon tubers takes place more rapidly especially during the first days after harvesting and in relation to storage conditions. In the study of Shiomi (2008), FOS degradation in onion bulbs of different cultivars during long-term storage at different temperatures showed that FOS hydrolysis was faster at the beginning of storage. The percentage loss of FOS content in yacon tubers during the first week of storage at room temperature is similar to the findings of Graefe et al (2004). In the study of Asami et al (1991), total oligofructan content in yacon decreased to 41% after two weeks at 25°C storage.

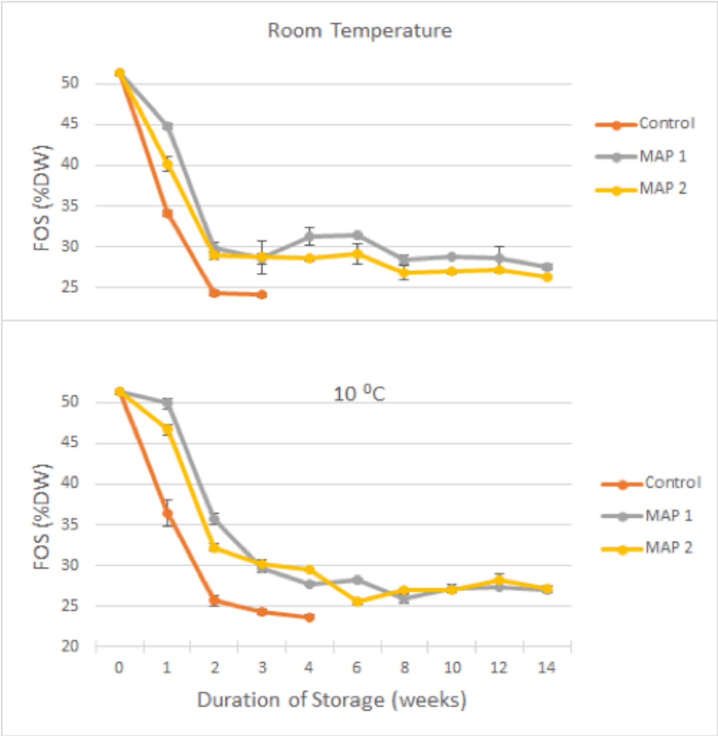

Figure 6. Effect of storage temperature and packaging combinations on the FOS content of yacon tubers.

Meanwhile, the use of modified atmosphere packaging delayed the onset of the rapid decrease of FOS content in yacon and resulted in higher FOS content, with MAP 1 having a higher content than MAP 2. This result aligns with the study of Di Venere, et al (2004), in which the modified atmosphere packaging of 'winter' artichoke heads, with the use of plastic films, contributed to counteracting the decline of inulin during storage. FOS content decline was similar for both room temperature and 10°C, showing that low temperatures do not suppress the degradation of FOS, but merely slow down the onset or conversion of FOS degradation.

The results of the current study indicated FOS hydrolysis by fructan exohydrolase during storage, leading to a larger amount of fructose, sucrose, and glucose during the first few weeks of storage (Figures 7-9). The results also show a significant negative correlation between FOS, sucrose and reducing sugars such as glucose and fructose, which indicate hydrolyzing during storage. In the study of Scheid et al (2013), an inverse relationship between FOS and reducing sugars was observed in yacon samples stored at room and refrigerated temperature. Since yacon had no starch (Asami, et al 1989), the result of the study of Kanayama, Tokita & Aso (2007) suggested that the accumulated FOS in yacon tubers was broken down and utilized to supply the energy necessary to maintain metabolic activity at the tissue level. The breakdown of FOS into simple sugars is catalyzed by fructan exohydrolase, which in turn catalyzes the release of free fructose that will be used for the re-synthesis of sucrose for export (Itaya, et al 2002). In this study, there was a highly negative correlation between FOS and fructose, indicating the interrelationships of the metabolites in depolymerization. The reduction of FOS in yacon tubers stored at room temperature may be partly due to the temperature favoring enzymatic activity, while at 10°C, the onset of FOS conversion was delayed. Furthermore, faster respiration rates occur at higher temperatures than at lower temperatures.

The decline in fructose, sucrose, and glucose contents towards the end of the storage period could be linked to the consumption of this sugar during the metabolic activity of yacon tubers during storage. According to Modler, Jones, and Mazza (1993), the fructose formed from the breakdown of long-chain FOS was utilized in the metabolic activity of Jerusalem artichokes.

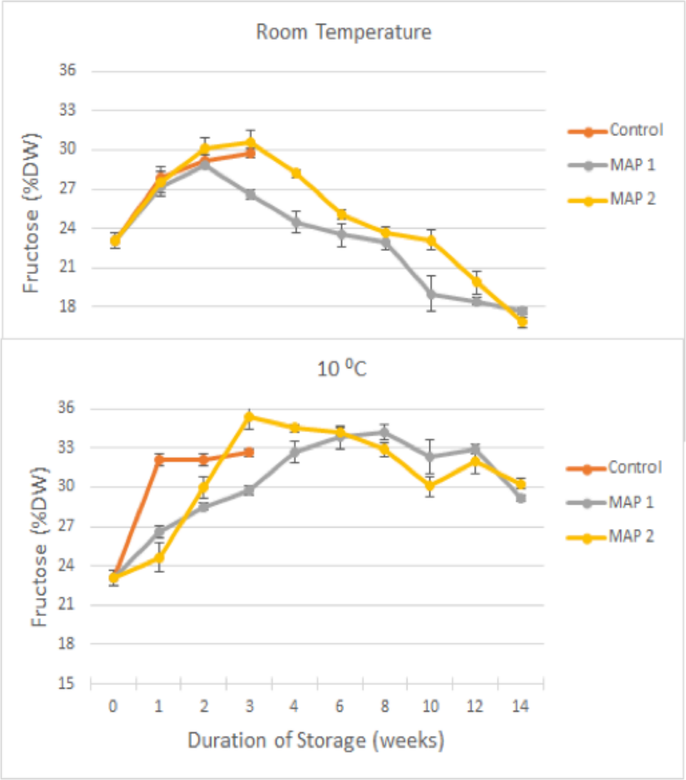

Figure 7. Effects of storage temperature and packaging combinations on the fructose content of yacon tubers.

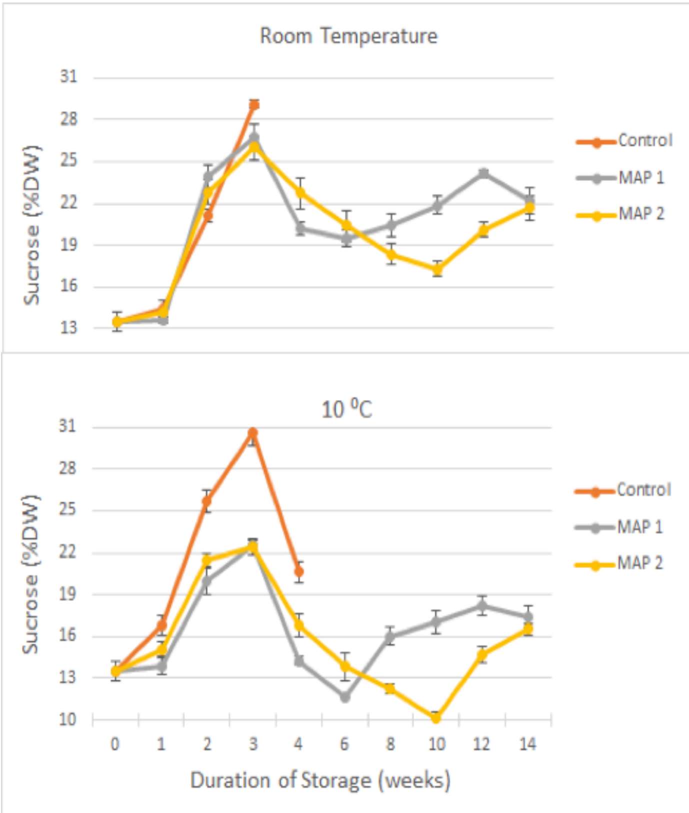

Figure 8. Effects of storage temperature and packaging combinations on the sucrose content of yacon tubers.

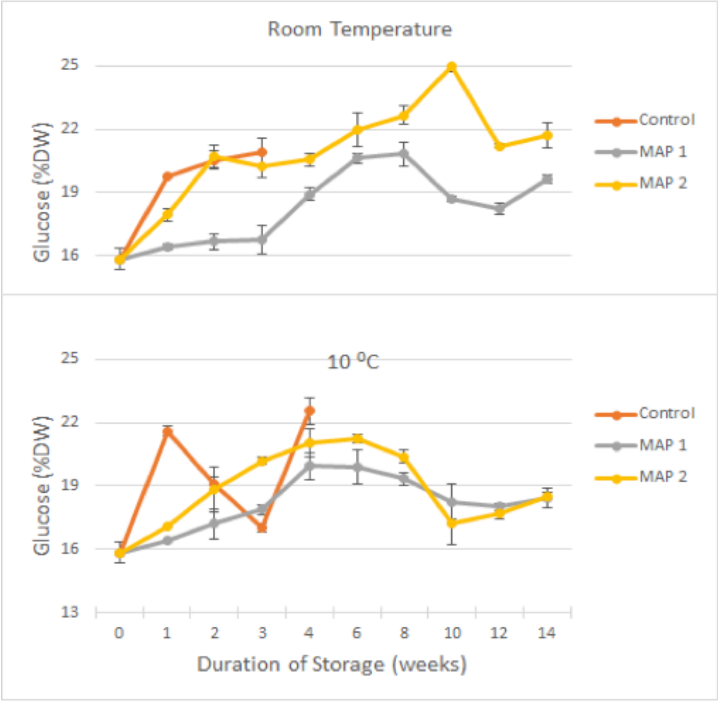

Figure 9. Effects of storage temperature and packaging combinations on the glucose content of yacon tubers.

Total phenolic content (TPC)

The initial phenolic content, determined by Folin-Ciocalteu method and expressed as mg Gallic acid equivalent per gram of dry sample, was 4.95. This is lower than what was reported by Lachman et al (2007), in which the TPC of fresh yacon was between 5 and 15 mg GAE/g in terms of dry matter, and Pereira et al (2013), which was 10,686.7 mg GA/kg. Plant phenolic compounds depend on genetic potential and environmental factors during growing and postharvest (Harborne, 1984).

TPC levels initially showed an increasing trend, followed by a decrease. This was in turn followed by another increase towards the end of storage (Figure 10). The increasing TPC might indicate further polyphenol biosynthesis for plant protection in the first days after harvest, presumably triggered as a reaction to stress in plants (Carlea, et al 2011). According to Amanatidou, et al (2000), phenol accumulation is a physiological response to infection or injury. In this study, a high incidence of microbial infection was found in yacon stored at room temperature, as well as in MAP 1.

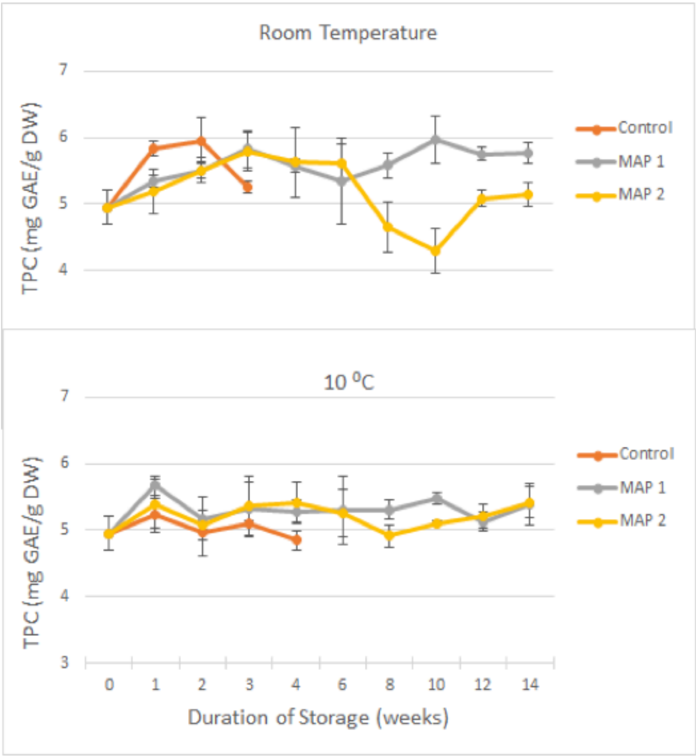

Figure 10. Effects of storage temperature and packaging combinations on the total phenolic content (TPC) of yacon tubers.

The increase in TPC content in yacon tubers stored in MAP 1 at room temperature after the 6-week storage period could be attributed to the wound response mechanism, as the yacon surface cracks were evident on week 6 and worsened towards the end of storage. Further, microbial invasion occurred during these weeks. Wounding stimulates adjacent cells to produce more phenolics to initiate the repair process (Rai, et al 2011). The increase in TPC after week 10 in MAP 2 could also be due to tissue response to both infection and injury, as the rapid invasion of microorganisms, as well as surface cracks, occurred by the end of storage.

1, 1-diphenyl-2-pidrylhydrazyl (DPPH) scavenging activity

The radical scavenging activity of yacon tubers, determined in terms of DPPH inhibition percentage, showed an initial rapid increase, followed by a decrease, and another increase, respectively, during storage (Figure 11). Yacon tubers stored at 10°C had generally higher radical scavenging activity, indicating that antioxidant activity is better retained at lower temperatures. Modified atmosphere packaging resulted in higher radical scavenging capacity, although this was not significant during most of the storage periods. The lower radical scavenging capacity of yacon tubers in MAP 1 was possibly due to higher levels of headspace CO_2 in the package than in MAP 2, which could have prevented the action of antioxidants. This result is similar to the findings of Rai et al (2011) in Jamun or Indian blackberry.

Meanwhile, the significant interaction effect of storage temperature and packaging was observed only in the last week of storage. The significantly lower radical scavenging activity of room-temperature MAP 1 yacon tubers during the last few weeks of storage was likely due to the high CO_2 and ethylene in the package, which could prevent or reduce the action of antioxidants.

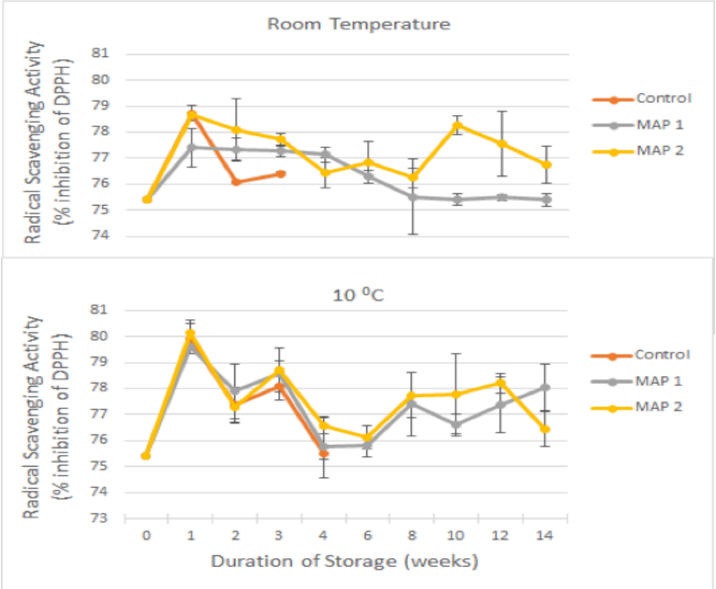

Figure 11. Effect of storage temperature and packaging combinations on the DPPH radical scavenging activity (% inhibition) of yacon tubers.

Variations in radical scavenging activity, typically between 75-79%, occurred during storage in yacon, but did not fall below the initial activity of 75.42%. Maximum radical scavenging activity in all treatments occurred during the first week of storage, and the initial increase in radical scavenging activity could be linked to the increase in TPC observed early in the storage period. Plant product antioxidants are mainly due to radical scavenging activity of phenolic compounds such as flavonoids, polyphenols, tannins, and phenolic terpenes. The efficacy of phenolic compound in scavenging free radicals is due to its ability to donate a hydrogen atom from the phenolic hydroxyl group to radicals, making it a stable molecule (Reyes, Villagen & Rodriguez, 2014). As mentioned by Qusti, Abo-Khatwa & Bin Lahwa (2010), the data on the relationship between plant polyphenol content and antioxidant activity is sometimes contradictory, as some showed a high correlation between the two, while others found no such correlation. In this study, there was no significant correlation between radical scavenging activity (DPPH) and TPC. It was observed that TPC changes in yacon during storage were mainly due to its response to stress, such as infection and wounding.

Conclusion and Recommendations

The MAP, particularly the use of 0.05 mm LDPE with pinpricks, combined with low temperature (10°C), maintained the physical quality of yacon for a period of 12 weeks. In this condition, the TPC and antioxidant activity of yacon did not decrease relative to its initial content. Rapid FOS hydrolysis was also delayed. However, since the hydrolysis of FOS was not suppressed, FOS still declined during long-term storage, while fructose, glucose, and sucrose increased. To retain high FOS content, it is recommended to store yacon tubers at this condition for only a week with a minimal loss of only 2.72%, since rapid FOS decline will occur beyond this time period.

Studies on the other storage methods that will be able to suppress or delay FOS hydrolysis and maintain the other functional properties of yacon can be explored. Also, regulation of fructan exohydrolase (FEH) activity during storage is needed.

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