

Investigating the above-ground biomass values of sweet potatoes (*Ipomoea batatas*)

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SUMMARY

The role of sweet potato tubers in human nutrition is not new. The above-ground biomass of sweet potatoes is not used for nutritional purposes in most countries, but it has a high biological value. Therefore, the aim of the present study is to investigate the production of press fibre from above ground biomass by wet fractionation. Two sweet potato varieties (purple- and white-fleshed sweet potato) and two types of irrigation system were used: bubbling water flow system (BWS) and continuous water flow system (CWS). Glucan, xylan, arabinan were analysed by HPLC and elemental content was measured by ICP-OES. Our results show that the total carbohydrate content in the pressed fibre of the leaf blades (27.64–29.88% w/w) is lower than in the stem with petiole (51.14–57.36% w/w). No significant difference in glucan, xylan and arabinan content was observed in the leaf blade. In the stem with petiole, significant differences were observed for xylan and arabinan contents. For elemental content, generally higher values were measured in the leaf blade than in the stem with petiole. This information may be relevant for the selection of the appropriate variety and treatment, even for the production of functional food.

Keywords: sweet potato; press fibre; glucan; xylan; arabinan; mineral element

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is an increasingly popular plant species of the family *Convolvulaceae* (Mohanraj and Sivasankar, 2014), which is mainly grown for its root tuber, but there are also ornamental batata varieties. The tuber has valuable nutritional value. It is rich in vitamins and minerals, has a favourable carbohydrate composition and a low glycaemic index (Allen et al., 2012; Oloniyo et al., 2021). It has a low protein content but a favourable amino acid composition. In addition to the tuber, the leaf is also suitable for human consumption. The consumption of its leaves is popular in Asia and Africa, but is less common in the United States (Ishida, 2000; Johnson and Pace, 2010; Sun et al., 2014) and is not common in Hungary. The chemical composition of the leaf is as follows: crude protein: 24.85%; fat: 4.9%; crude fibre: 7.2%; ash: 11.1%; carbohydrate content: 51.95%; moisture content: 82.21% (Antia et al., 2006; Achidi et al., 2012). Furthermore, the leaf is rich in phenols and flavonoids, as well as chlorophyll and carotenoids, which are important bioactive components for human health, as they can be an excellent preventive against many diseases such as cancer, circulatory diseases and eye diseases (Chen and Chen, 2002; Li et al., 2017; Oloniyo et al., 2021). However, these values depend on the variety and growing conditions as well (Sun et al., 2014). Furthermore, the fibre found in batata leaves is attracting more attention nowadays, as there are many studies on the effects of fibre on human health (Sun et al., 2014; Csatári and Kovács, 2022). It can be said that the leaf can make up half of the total green biomass. Sweet potato harvesting generates a large amount of green biomass as a by-product, but the green biomass (especially the leaves) has a high nutritional value (Ishida et al., 2000; Walter and Rao, 2015). One potential way of utilising green biomass as a by-product of batata production is green biorefining (Weber et al.,

2020). This involves the fractionation of green biomass to produce green juice and pressed fibre (Kromus et al., 2004; Kamm and Kamm, 2007; Walter and Rao, 2015; Xiu and Shahbazi, 2015). The green juice can be used to produce leaf protein concentrate, which is excellent for animal feed (Santamaría-Fernández and Lübeck, 2020), and brown juice, which can be used as a plant conditioner (Kisvarga et al., 2020). The pressed fibre can be an excellent raw material for many industries such as paper, pharmaceuticals, textiles, energy, and by adding it to food, it can also be used to produce functional food, which is becoming increasingly important today (Ishida et al., 2000; Xiu and Shahbazi, 2015). As we have seen above, green biomass not only offers potential uses for many industries, but by managing the by-product in a conscious way, we can also focus on circular farming.

In the present research, batata varieties that can be grown under controlled growing conditions: Purple-fleshed batata and Japanese white-fleshed batata were selected. Our objective was to study the press fibre obtained from fresh batata leaf blades and stems with petiole by wet fractionation, including structural carbohydrates (glucan, xylan, arabinan), micro- and macro elements in order to provide relevant information for the future use of green biomass, even for functional food production.

MATERIALS AND METHODS

Experimental set up

Two varieties of sweet potato (purple- and white-fleshed sweet potato) that can be grown indoors were selected. Furthermore, two types of irrigation were used: bubbling water flow system (BWS) and continuous water flow system (CWS). Each variety was produced in 3 replicates under different growing conditions in a vertical system. In the vertical system, cultivation is carried out at several levels. The batata

tubers are planted in a clay medium. The difference between the two irrigation systems is that in the continuous water flow system the liquid stream is air-free, while in the other case air is introduced into the liquid stream by means of a compressor and air bubbles appear. The commercially available Flora Series nutrient solutions Tripart Grow (NPK 3-1-6) and Tripart Micro (NPK 5-0-1) were used for the fertilization water. The EC was adjusted according to the instructions for use at each vegetative stage. The EC of the nutrient solution was 0.3–0.6 mS cm⁻¹ until rooting, 0.8–1.2 mS cm⁻¹ until the first true leaves emerged and 1.3–1.8 mS cm⁻¹ during the growth stage. The experiments lasted 40 days, after which the leaf blade and petioles with the stems were harvested separately. Subsequently, by wet fractionation, these plant parts were separated into green juice and pressed fibre fraction using a twin screw juicer (Angel Juicer 5500, Angel Ltd. Czech Republic). The resulting fibre fraction was frozen, lyophilized and then minced. Leaf blade fibre and the fibre stem with petiole were analysed separately. The following abbreviations have been used throughout the figures and text:

- Purple fleshed potato in continuous water flow system: Purple CWS
- Purple fleshed potato in bubbling water flow system: Purple BWS
- White fleshed potato in continuous water flow system: White CWS
- White fleshed potato in bubbling water flow system: White BWS

Structural carbohydrates

The carbohydrate components were determined by high performance liquid chromatography (HPLC) according to Sluiter (2008). Briefly, 0.5 grams of lyophilized sample was weighed in a laboratory flask and then placed in 72% sulphuric acid for two hours, with stirring every 30 minutes. It was then placed in an autoclave at 121 °C for two hours. Next, the sample was filtered through a G4 glass filter and the sample was filtered through a 45 µm nylon filter. The concentrations of glucose, xylose and arabinose were calculated. Detector: Shimadzu RID-10 A; Column: BioRad (Hercules, CA, USA) Aminex HPX-87H (300x7.8). The glucan, xylan and arabinan contents of the fibre samples were determined by the depolymerisation factor of the monosaccharides.

Determination of macro- and micro-elements

1 g plant sample was digested in 10 cm³ cc. HNO₃ for 30 minutes at 60 °C in a Labor MIM OE 718/A block digester. After cooling of the samples in 10 cm³ of 30% H₂O₂, digestion was continued for further 90 min at 120 °C. After cooling, the samples were made up to 50 cm³ with deionised water. Finally, the samples

were filtered with MN 640 W filter. Thermo Electron Corporation iCAP 6300 Dual Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) was used for the analytical determination of the micro- and macro-element contents (Kovács et al., 1996). The following elements were determined: Ca, S, K, Mg, Na, P, Fe, Zn.

Statistical analyses

In the statistical analysis of the data, the mean and standard deviation are shown. We analysed the effect of two irrigation systems and varieties together with one-way ANOVA. One-way ANOVAs were carried out separately on the leaf blades and stem with petiole. The normality test and Levene's test for equality of variances were performed before running the ANOVA. The means were compared by Tukey's Honestly Significant difference (HSD) test at $p \leq 0.05$. The mean values measured in the leaf blade and stem with petiole were then compared using a T test at $p \leq 0.05$ (IBM SPSS Statistics 24 (IBM Corp, Armonk, NY, USA).

RESULTS AND DISCUSSION

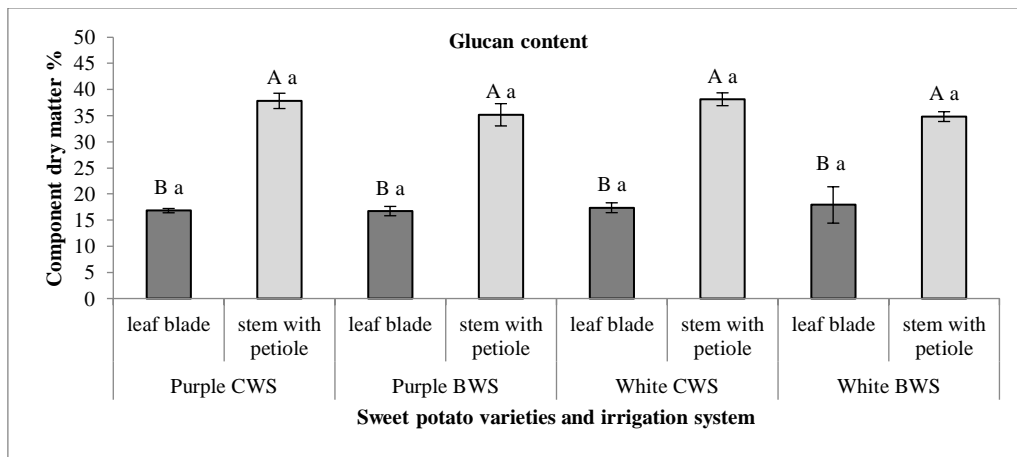
Determination of structural carbohydrates

The glucan content is shown in *Figure 1*. For the leaf blade, there was no significant difference between the varieties. The glucan content was highest in White BWS (17.91% w/w) and lowest in Purple BWS (16.73% w/w). No significant difference was also found for the stem with petiole. The glucan content was highest in White CWS (38.14% w/w) and lowest in White BWS (34.82% w/w). The *Figure 1* shows that the values measured in the stem with petiole are significantly higher than the values measured in the leaf blade.

There was also no significant difference in the xylan content of the leaf blade. Xylan was present in highest amount in Purple CWS (11.14% w/w) and lowest in White BWS (9.03% w/w). For stem with petiole, a significantly higher value was measured in Purple CWS (14.99% w/w) compared to Purple BWS (12.94% w/w). Furthermore, we can see that we measured a significantly higher xylan content in the stem with petiole compared to the leaf blade (*Figure 2*).

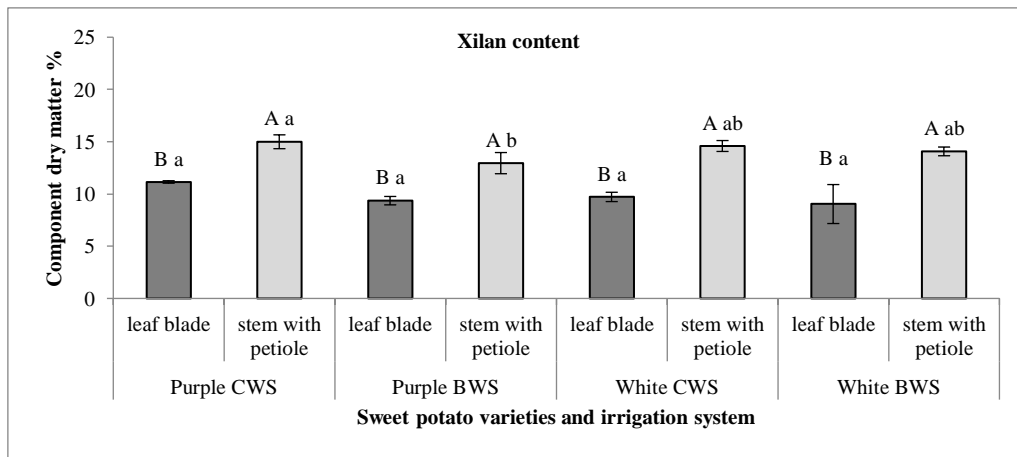
There was also no significant difference in the arabinan content of the leaf blade. The highest value was measured for Purple CWS (1.90% w/w) and the lowest for Purple BWS (1.55% w/w). For the stem with petiole, we measured a significant 1.2–1.5% higher value for Purple CWS and White CWS compared to Purple BWS and White BWS. Furthermore, a significantly higher arabinan content was observed in the stem, similar to the other two components tested previously (*Figure 3*).

Figure 1: Glucan content in leaf blade and stem with petiole of sweet potato



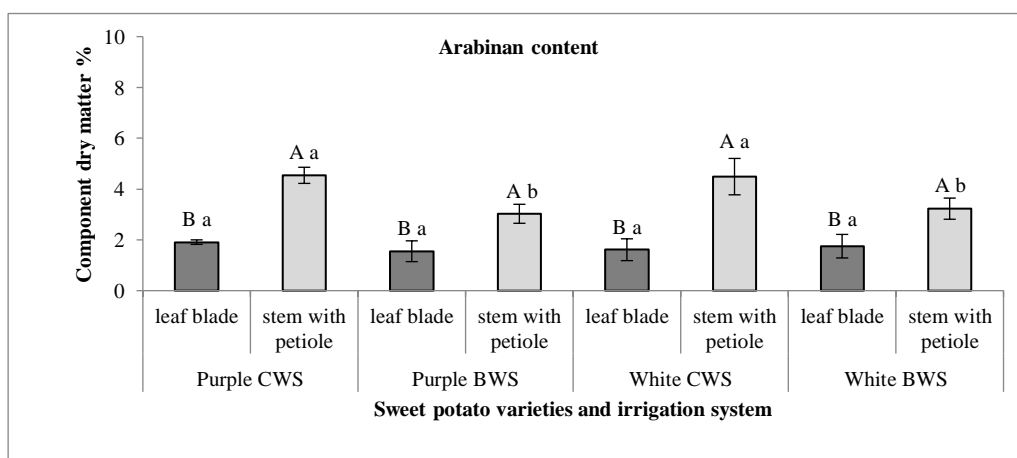
Notes: Different letters within each parameter indicate significant differences at 0.05 level ($p \leq 0.05$). Small letters indicate one-way ANOVA results, capital letters indicate T test results.

Figure 2: Xilan content in leaf blades and stem with petiole of sweet potato



Notes: Different letters within each parameter indicate significant differences at 0.05 level ($p \leq 0.05$). Small letters indicate one-way ANOVA results, capital letters indicate T test results.

Figure 3: Arabinan content in leaf blades and stem with petiole of sweet potato



Notes: Different letters within each parameter indicate significant differences at 0.05 level ($p \leq 0.05$). Small letters indicate one-way ANOVA results, capital letters indicate T test results.

Determination of macro- and micro-elements

The elemental content measured in leaf blade and stem with petiole is shown in *Table 1*. No significant differences in S, Fe, Zn in leaf blades were observed. For Ca, the highest amount was measured in White BWS (15757 mg kg⁻¹), which is significantly different from the other varieties. For K, we measured a significantly higher value for White CWS (25774 mg kg⁻¹) compared to the other cases. Mg was also significantly higher in White BWS compared to the other cases. For Na, a significantly higher value was measured for Purple BWS (269 mg kg⁻¹). For P, a significantly lower value was measured for White BWS (2978 mg kg⁻¹) compared to the other cases. Sun et al. (2014) measured Ca, K, P, Mg and Na in the leaves of 40 sweet potato varieties. Their results showed that in most cases the values are similar to ours, but there can be significant variation between varieties. It can be further stated that higher values were measured for P and Na content.

No significant differences were observed in Fe and Zn contents in the stem with petiole. The Ca content was significantly higher for White CWS and White BWS compared to Purple CWS and Purple BWS. S was also significantly higher in White CWS and White BWS. For K, a significantly higher value was obtained for White CWS (10912 mg kg⁻¹) compared to the other cases. Purple BWS had a significantly lower value (899 mg kg⁻¹) compared to Purple CWS, White CWS and White BWS. Na content was significantly higher in White CWS and White BWS than in Purple CWS and Purple BWS. For P, the highest value (976 mg kg⁻¹) was measured in White CWS, which was significantly higher than the other cases.

For S, K, Mg, Na, P, Fe, Zn, it can be said that higher values were measured in the leaf blade than in the stem with petiole. However, for Ca, significantly higher values were detected in the stem with petiole in Purple CWS and White CWS.

Table 1: Content of macro-and microelements of sweet potato leaf blades and stem with petiole

mg kg ⁻¹	Leaf blades							
	Purple CWS		Purple BWS		White CWS		White BWS	
Ca	11193	±143Bc	14153	±161Ab	11018	±110Bc	15757	±179Aa
S	2574	±60Aa	2631	±35Aa	2540	±51Aa	2524	±35Aa
K	24510	±352Ab	24601	±98Ab	25774	±236Aa	24498	±124Ab
Mg	3610	±50Ac	3510	±40Ac	3939	±93Ab	4118	±70Aa
Na	233	±11Ab	269	±6Aa	238	±7Ab	183	±11Ac
P	3212	±95Aa	3366	±58Aa	3257	±90Aa	2978	±47Ab
Fe	70	±4Aa	73	±3Aa	69	±4Aa	74	±5Aa
Zn	36	±3Aa	38	±2Aa	37	±2Aa	39	±2Aa
Stem with petiole								
Ca	12130	±241Ab	11647	±227Bb	13693	±199Aa	13144	±176Ba
S	705	±29Bb	578	±30Bc	827	±20Ba	864	±29Ba
K	9341	±257Bb	7218	±239Bc	10912	±384Ba	9743	±225Bb
Mg	1149	±44Ba	899	±37Bb	1193	±43Ba	1245	±59Ba
Na	99	±5Bb	103	±19Bb	170	±14Ba	167	±5Aa
P	852	±27Bb	669	±24Bc	976	±40Ba	892	±28Bb
Fe	20	±2Ba	17	±1Ba	19	±1Ba	21	±2Ba
Zn	19	±2Ba	18	±2Ba	22	±1Ba	21	±2Ba

Notes: Different letters within each parameter indicate significant differences at 0.05 level ($p \leq 0.05$). Small letters indicate one-way ANOVA results, capital letters indicate T test results.

CONCLUSIONS

Sweet potato produces significant amounts of green biomass, the use of which is less widespread, although it has a high biological value. The aim of the present study was to investigate the press fibre of sweet potato obtained by wet fractionation, separately examining the leaf blade and the stem with the petioles.

Our results showed that lower carbohydrate content was quantified in the leaf blade than in the stem with petiole. No significant difference in glucan, xylan and arabinan content was detected in the leaf blade. For the stem with petiole, no significant difference was detected for glucan content, but significant differences

were detected for xylan and arabinan content. In the case of elemental content, generally higher elemental content values were measured in the leaf blade. No significant difference was found for S, Fe, Zn in the case of leaf blade, while no significant difference was found for Fe and Zn content in the case of stem with petiole. For carbohydrate components, the results show that Purple CWS stands out from the others where higher values were measured. For elemental content, White CWS and White BWS stand out.

The information obtained in this study may be relevant for further studies, which may justify their future use, including in the food industry.

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