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Full Length Research Paper

Nutritional profiles of tiger Nut (*Cyperus esculentus*) plant organs during its growth cycle

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This study was carried out to determine major nutrient profiles changes of tiger nut plant during its growth period. The plant leaves, roots, tuber moisture, starch, fat and protein were analyzed by oven drying, enzymatic hydrolysis, glucose assay, soxhlet extraction and kjeldahl methods. The results show the moisture content was decreased during its growth cycle but varied with different plant organ. For leaves, the starch content was increased with reducing oil content. For roots, oil content was highest (8%) at the 100th day, and it was gradually decreased (3%) till harvest time with non-significant changes of starch content. For tuber, reducing sugar and protein content was insignificant where the starch and oil content increased significantly but the changes were irregular in the middle growing. For optimum macronutrient yields, it is recommended to harvest the plant at 142nd day for starch. The delayed harvesting may lead to increase in oil content while reducing its total starch contents. For the starch purpose, the harvest time could be around 142 days. However, harvest time could require staying longer in soil.

Key words: Tiger nut, oil, starch, growth cycle, nutrients enrichment.

INTRODUCTION

Tiger nut (*Cyperus esculentus* L.) is an edible perennial grass-like C_4 plant of the sedge family (Turesson et al., 2010). Tiger nut is tuber usable grass and also called chufa, nut grass, yellow nut sedge, earth almond, edible galingale and ground almond (Defelice, 2002; Sanchez-Zapata et al., 2012). It is widely used for human and animal consumption as a nutritious food and feed in Africa, Europe and America (Sanchez-Zapata et al., 2012).

Tiger nut is rich in starch, oil, minerals, and vitamins E and C. The starch and oil are major macronutrients in the tiger nut tuber. High starch content of this plant provide unique functional properties (Manek et al., 2012), cold storage stabilities, and preserves organoleptic properties of foods (Jing et al., 2012). The tiger nut oil also has high monounsaturated fatty acids, similar to olive, avocado and hazelnut oil (Ezeh et al., 2014). These monounstaturated oil has high unsaponifiable matter, phospholipids and other bioactive compounds such as tocopherols, phytosterols and polyphenols (Sanchez-

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Zapata et al., 2012; Ezeh et al., 2014). Although tiger nut oil fatty acid profile is similar to olive oil, nut oil has unique gold-yellow color, neutral taste properties, high in phytosterols (Sanchez-Zapata et al., 2012), and better deep frying stability (Sanchez-Zapata et al., 2012; Lasekan and Abdulkarim, 2012) .The nutritional profiles and unique functional properties have made tiger nut as unique food (Ekeanyanwu and Ononogbu, 2010) like beverage, flour (Oladele and Aina, 2007; Chinma et al., 2010), edible oil (Muhammad et al., 2011; Lasekan and Abdulkarim, 2012), and a feed source (Sanchez-Zapata et al., 2012).Although there are numerous example of plants that accumulate high amount of starch or sugars in roots and tubers, tiger nut accumulates a substantial amount of oil in such tissues. As an high oil yield and more adaptable crop, tiger nut have more potential usage as food and industrial materials. Current research focused on functional properties, organoleptic properties, biochemical actives, oil extraction and nutritional value of tiger nut but the information on changing nutrient patterns during its growing cycle is meager. Therefore, the current study was carried out to determine macronutrient profile changes of the field grown tiger nut plant parts during its full growth cycle.

MATERIALS AND METHODS

Tiger nut tubers were provided by the Karamay Huili CO., LTD (Karamay, Xinjiang, China). Before planting, the tubers were rinsed with tap water for 2 h, and then soaked at 45°C for 24 h changing the water in the middle. Then it was drained out for backup. After that the tubers were planted with spacing 20×40cm under the condition of sandy soil. The germination appeared after planting of 10days. It was watered at 10 days interval according to their real growth status. After the growth of 60 days, the tiger nut was harvested at 3 days interval. After harvest, the tubers, root and leaves were separated and wrapped in aluminium foil and stored at -80°C.

Instrument and equipment

Soil shovel, magnetic stirrer, resistivity meter, PH Meter (HANAHI98183), paraffin pan, electric oven blast, analytical balance, dryer, weighing bottle, Soxhlet extractor, constant temperature water bath, formwork units, Kjeldahl flask, adjustable electric, water bath, grinder, oven, electronic balance (0.0001 g), conical flask (250ml), volumetric flask, reflux device, acid burette, filtration device and microwave were used in this study.

Preparation of sample

Parts of tiger nuts was slowly thawed and then oven dried, and splintered with grinder.

Analyses of tiger nut

Measurement of soil physical and chemical properties

The soil physical and chemical properties were measured according to the method of Bao (2000). The quantitative analysis of water, fat, total protein, starch and sugar were determined according to the method of Jing (2012) and Nielsen (2010) without modification.

Statistical analysis

The data was replicated three times, and the mean data analyzed by statistical package for the social sciences (SPSS) 17.0.

RESULTS

Soil physical and chemical properties

Soil salt content decreased from top to bottom with soil depth, and its surface clustering. Their effect was relatively strong because the soil water soluble salt increased with the water evaporates and stays around 0 to 20 cm in the strong solar radiation. So, there was no risk of soil salinization. Considering the vertical distribution of salt ions content, the composition of the soil soluble salt ions took SO_4^{2-} relatively large proportion than K^+ and Na^+. The soil organic matter content declined from top to bottom with depth, and therefore enriched the soil. The vertical distribution of soil moisture belonged to bottom poly-type soil moisture profile. The type of soil moisture profile was characterized by its various levels of soil water content which was relatively small, and surface soil moisture was low than others. So, the soil moisture from 20 to 40 cm was a linear upward trend than 0 to 20 cm, but the changing trend decreased with increasing soil depth. Considering the surface soil water content, the soil moisture content of 20 to 40 cm increased to 95.67%, whereas the 40 to 60 cm layer increased to 10.86% (Table 1).

The moisture content (%)

The moisture content of each part of tiger nut was reduced within its growth cycle, but there were differences among the different parts of the tiger nut. The lower trend of moisture content was observed between the leaves and tuber with the increasing of harvesting time. On the other hand, the moisture content of the roots was increased before the 89th day, and was decreased with the advancement of harvesting periods after the time (Figure 1).

Oil content (%)

In growth cycle, Figure 2 shows that there was changing trend of oil content among the leaves, root and tubers of the tiger nut. The oil content increased until 98th days for both leaves and roots and after that, it gradually reduced. In roots, the oil content changed dramatically. In the

Table 1. Physical chemical properties of the tested soil.

Parameter	Salt content	pH	K^+	Na^+	Ca^{2+}	Mg^{2+}
0-20 cm	1.26	7.57	2.78E-05	3.16E-04	6.60E-05	1.55E-05
20-40 cm	0.54	7.47	2.32E-05	3.04E-04	6.60E-05	1.61E-05
40-60 cm	0.45	7.16	4.23E-05	4.18E-04	2.14E-04	3.92E-05
Parameter	Cl^-	CO_3^{2-}	HCO_3^-	SO_4^{2-}	**Soil organic matter**	**Soil moisture content（%）**
0-20 cm	6.38E-06	0.00E+00	4.88E-07	5.21E-03	52.81	21.99
20-40 cm	3.59E-06	0.00E+00	2.75E-07	3.48E-03	43.11	43.04
40-60 cm	9.38E-05	0.00E+00	1.22E-07	1.98E-02	29.46	47.71

Unit: mg/kg for ions; g/kg for soil organic matter

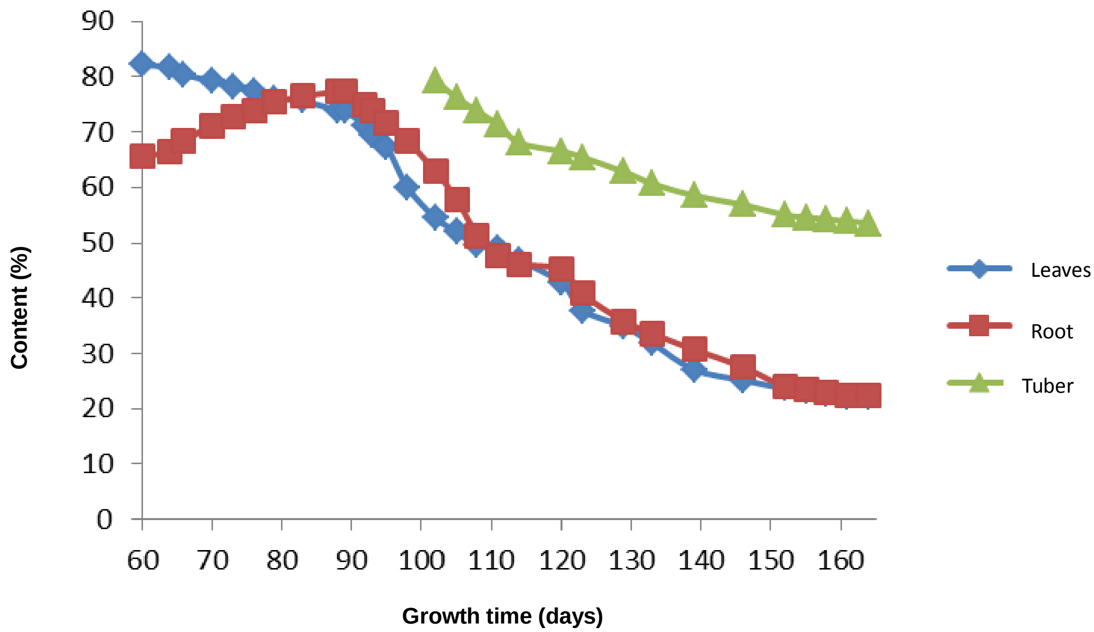

Figure 1. Moisture content of each parts of tiger nut.

tuber, the oil content increased with the growth of tiger nut. The highest oil content was also recorded in tuber (30%) followed by leaves (8.9%) and root (8.3%) respectively in the whole growth cycle of the tiger nut.

Protein content (%)

The protein content was significantly different between the leaves and tubers of the tiger nut (Figure 3). Initially, the protein content of the leaves was lower until 111 days (0.11±0.00) but after that, it increased until 120 days (2.19±0.02). In case of tuber, there was an increasing trend until 152 days (1.11±0.00) and after that, it decreased gradually with the advancement of growing periods.

Starch content (%)

There was an increasing trend of starch content at different parts of the tiger nut among the leaves, roots and tubers, but the increasing values were irregular among the leaves, roots and tubers (Figure 4). The highest content of starch was recorded before harvest, and the values were lower among the leaves, roots and tubers after harvest.

Sugar content (%)

The increasing trend of reducing sugar content of tiger nut was not very clear between leaves and tubers fluctuation was observed. This phenomenon might be

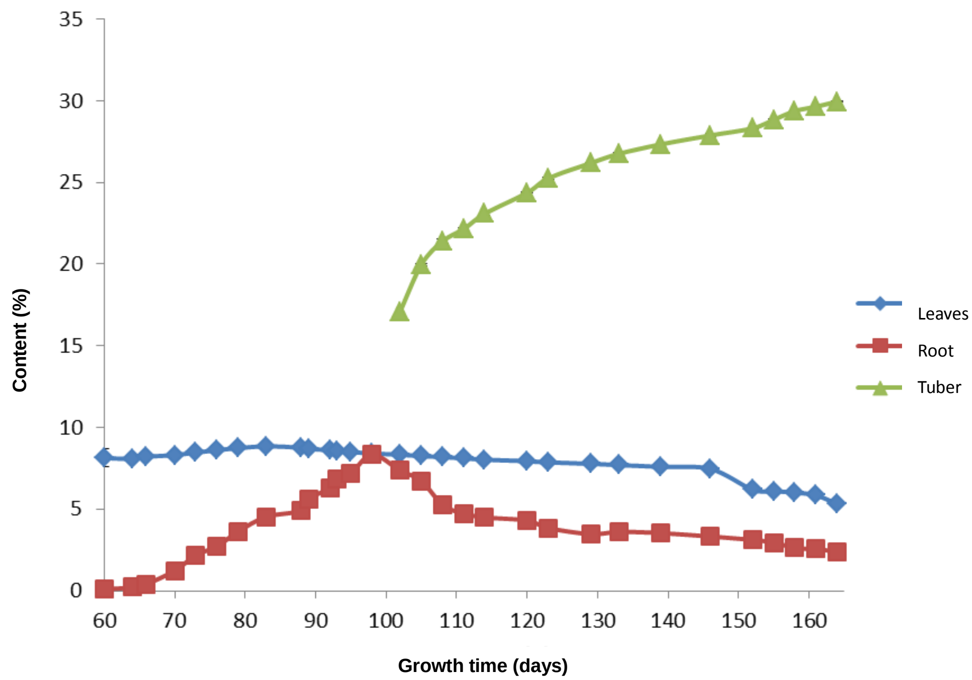

Figure 2. Oil content changes of the each part of tiger nut (dry mass).

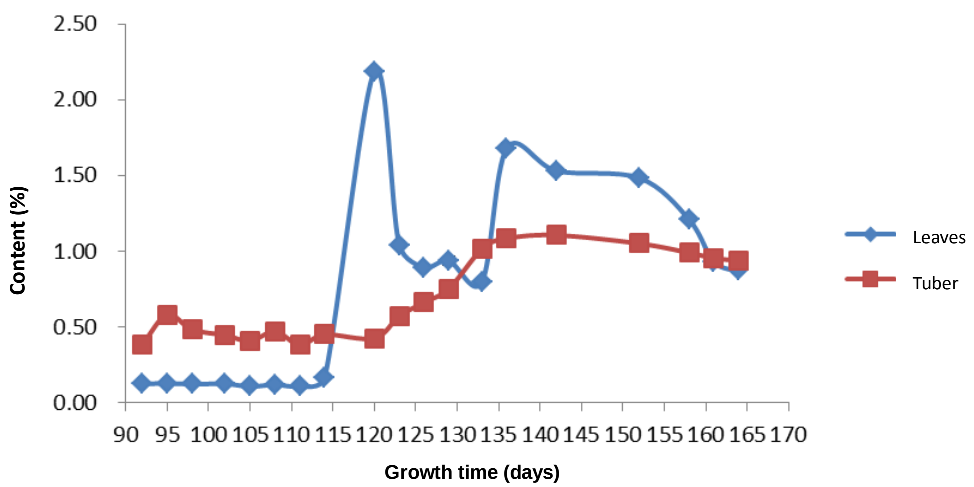

Figure 3. Protein content of the each part of the tiger nut (dry mass).

due to their irregular changes during the growing of middle time. The highest reducing sugar content (6.99±0.57) was recorded in tubers at 155 days whereas the lower one was recorded (5.73±0.27) for leaves (Figure 5).

DISCUSSION

The primary aim of this investigation was to study the biochemical changes in developing tiger nuts in field, to assess tiger nut carbon allocation into different organ and to get best harvest time.

Very interestingly, tuber is the main storage organ in tiger nut, but other organ including leaves and roots store high amount of starch. The highest starch content of the tiger nut leaves was increased gradually until 150 day, and after that the changes were irregular and reached the lowest level of 19% (Figure 6). For the oil content of leaves, it increased from the beginning of 85th day with

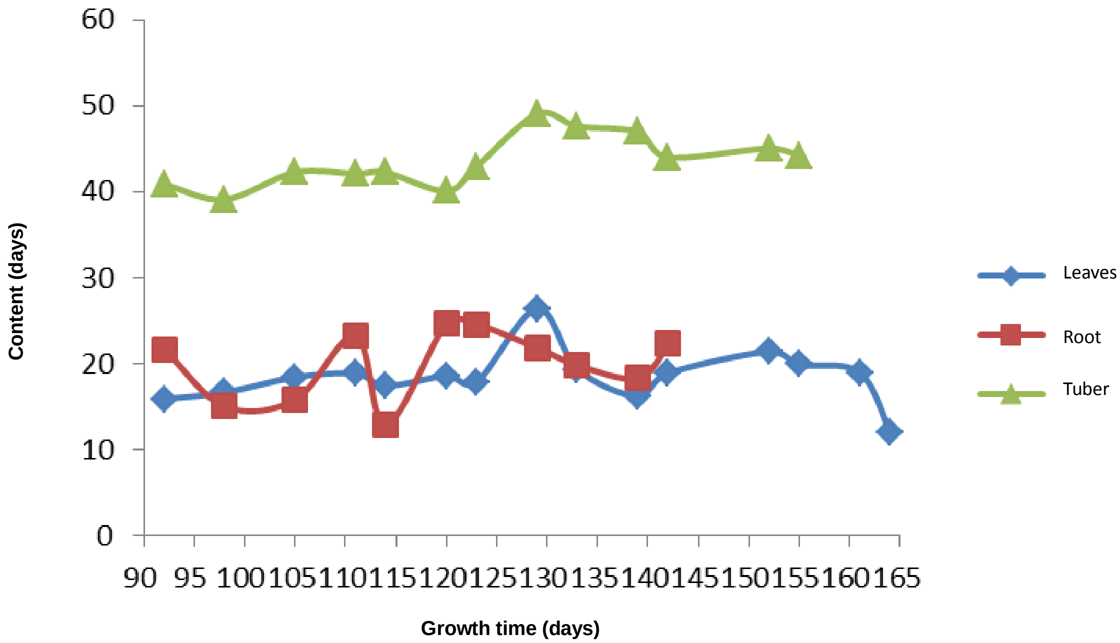

Figure 4. Starch content of the tiger nut (dry mass).

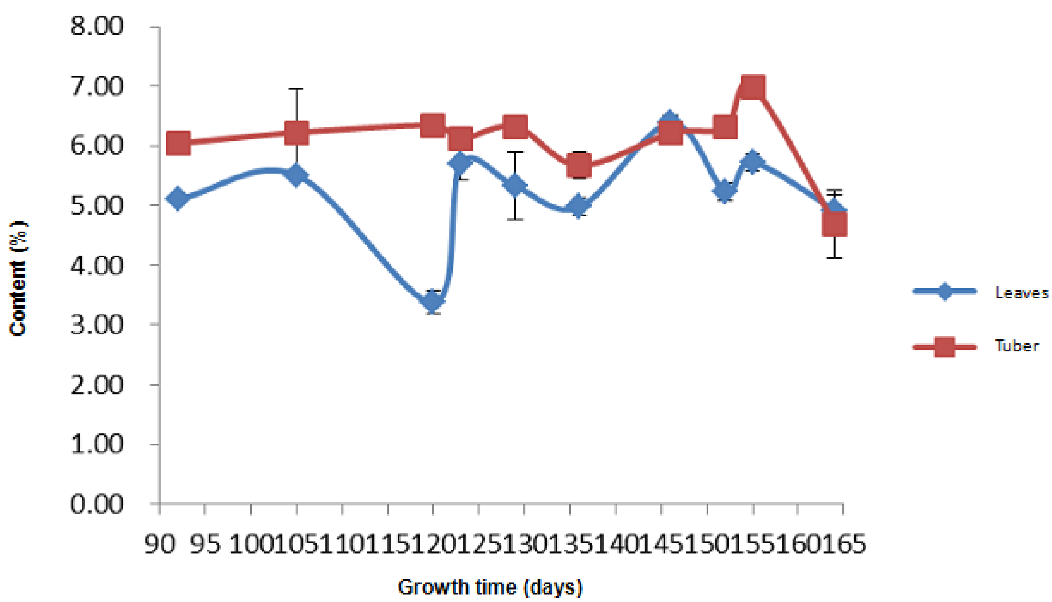

Figure 5. Reducing sugar content of the tiger nut (dry mass).

the highest level of 9%. From that time to harvest, it began to decrease and got the lowest level of 5% at the end (Figure 6) of the harvest. For sugar content of leaves, there was an increasing trend with irregular changes while the highest level was recorded at 6.4% and the lowest level was 3.4% (Figure 6). The leaves' protein content was very low until the 110th day, and reached the highest level of 2.19% at the 120th day. After that, it decreased with irregularities (Figure 6). Generally, starch, sugar and protein content of the tiger nut increased whereas the oil content decreased before the 120 to 130th day. From 130 day, the oil, sugar and protein content decreased while the changing trend of starch content was not clear. However, the starch content

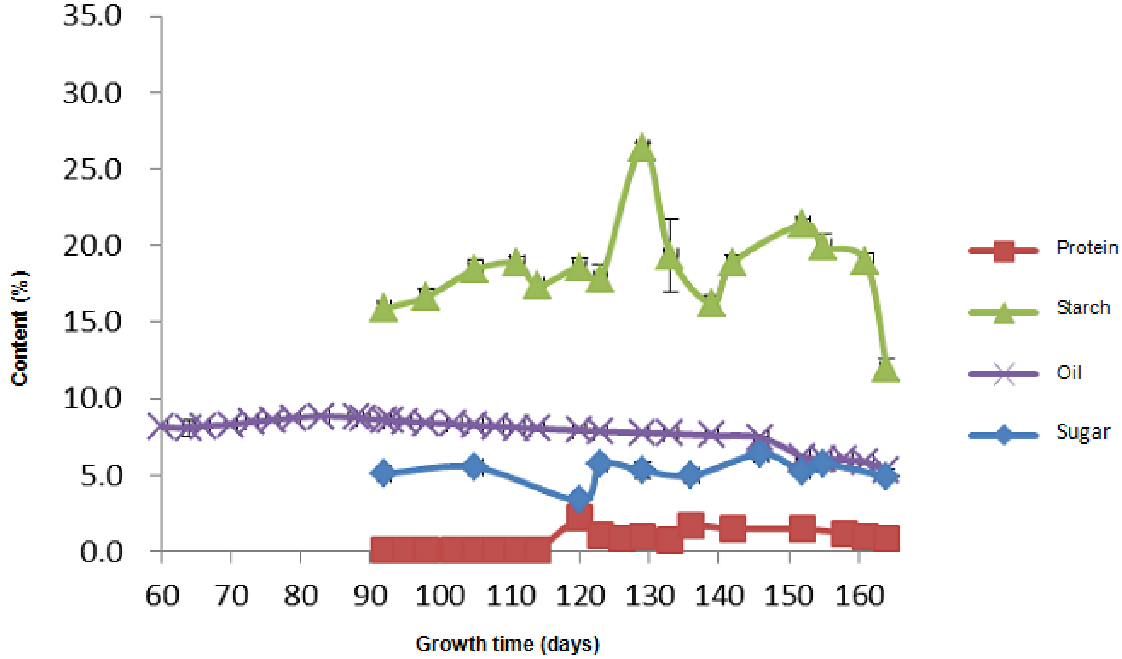

Figure 6. Nutrient contents of the tiger nut leave (dry mass).

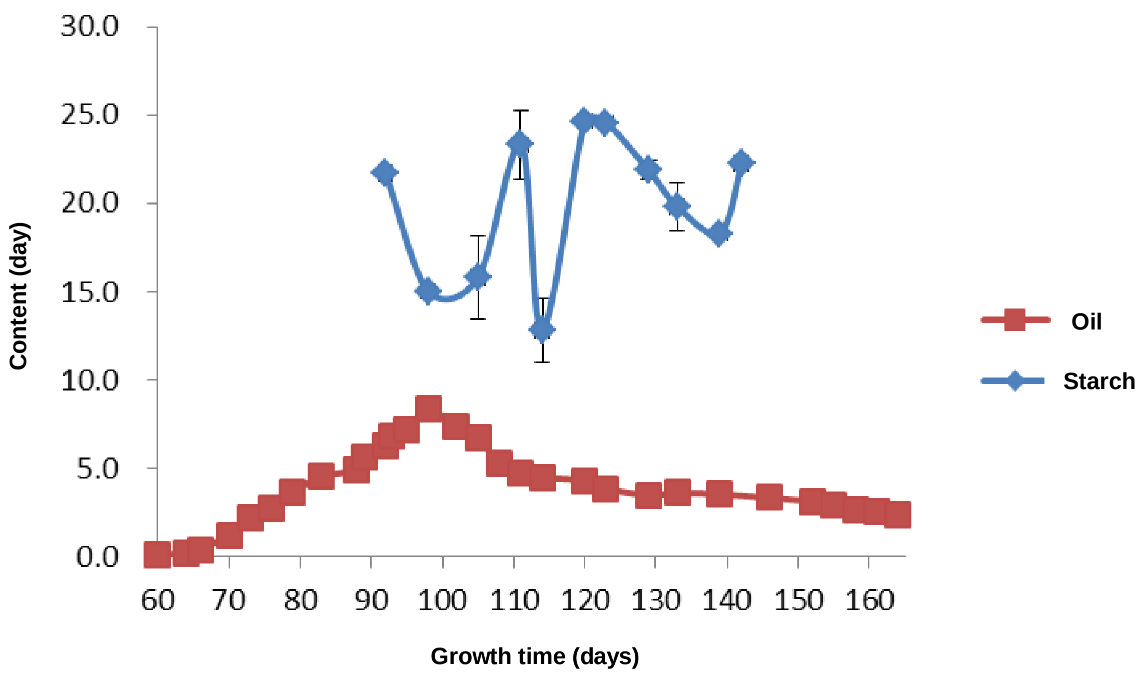

Figure 7. Oil and starch content changes of the tiger nut roots (dry mass).

increased whereas the oil content of the tiger nut decreased.

The changing trend of the root oil content was clear in whole growth cycle from the beginning of 100 day with the highest level of 8% and decreased from 100 day to the harvest time (Figure 7). During harvest, the oil content recorded 3% while the starch content has higher value of 25% with the irregular changing trend (Figure 7).

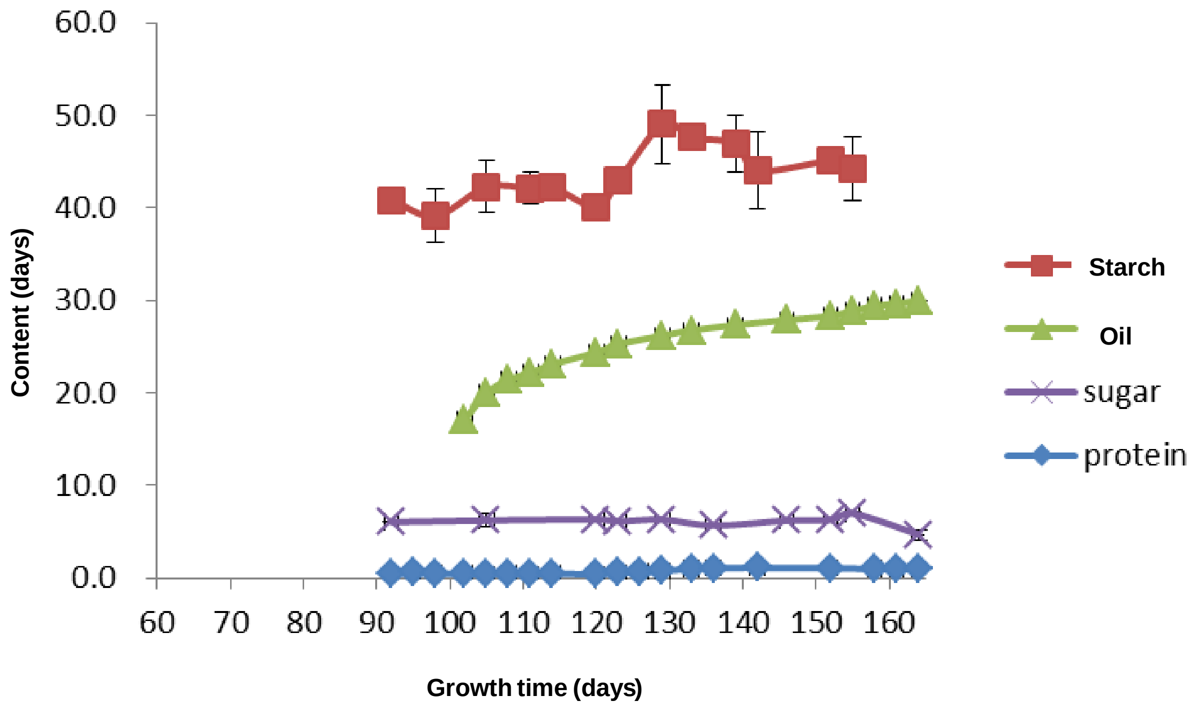

Figure 8. Nutrient content of the tiger nut tuber (dry mass).

However, the starch content of the root was higher as compared to oil content.

Tiger nut tuber development consists of at least two phases. In the first phase, root elongation ceased, and its apex started to swell and eventually developed into a tuber (Turesson et al., 2010). This development is similar to potato tuber development (Viola et al., 2001). For tuber nutrition content changes, starch and oil content accumulation pattern were same with aeroponic system (Turesson et al., 2010). The starch content increased before the 142 day with the highest level of 49% and after that day it decreased with the increasing of growing period (Figure 8). However, tuber oil content gradually increased in entire growth cycle and attained the highest level of 30% during harvesting (Figure 8).

The sugar content pattern was different from aeroponic system due to different sampling way. In the field growing system, although at the beginning sampling was same with aeroponic system, different development phase tuber occurred at the same time. So, the sugar content of the tuber was increased until the 152th days and after that, the decreasing trend was observed (with high sugar content at the early phase and low sugar content at the later phase). The protein content of tuber was very low, and remained at the same level in whole life cycle than other nutrient content (Figure 8) (Turesson et al., 2010).
For moisture content, tiger nut's leaf and tuber moisture content reduced from the beginning. However, the moisture content of roots increased before the 85th day and then began to reduce (Figure 1). Although the highest moisture content recorded were 82.25, 77.49 and 79.31% respectively for leaves, roots and tubers, the moisture content in tuber was higher than in leaves and root (Figure 1).

Conclusion

The moisture content of the tiger nut decreased throughout its growth cycle with time with different pattern in different organs. For leaves, moisture content was decreased until harvest time. And it was gradually decreasing before 90th day, and sharply decreasing after that day. The starch content was increased with reducing of fat content. There was no changing trend in sugar content, but protein content was increased around 115th day, and remaining in that level until harvest. The maximum starch, fat, total sugar, and protein percentages were 26.4, 9, 6.4, and 2%, respectively.

For root, moisture content increased till 90th day, and decreased until harvest time. The oil content showed upheaval features with the rapid increase before 100th day with the maximum value of 8% and gradually was decreased till harvest time. The starch content changed with irregularities, but always kept higher than oil content. Tuber, starch and oil content increased with the increasing of growing time but in the middle of their growth cycle, the changes were irregular. Reducing sugars and protein content of the tuber also showed no significant change. The maximum starch, fat, total sugar, and protein percentages were 49, 30, 7 and 1.1%, respectively. For tuber optimum yields, it is recommended to harvest the plant at 142nd day for starch. The delayed harvesting may lead to increase in oil content while reducing its total starch contents.

Tiger nut has the potential to provide novel information that can significantly widen understanding about the synthesis of storage reserves, regulating and directing into specific tissues and organs. This kind of information is valuable for work aimed at either increasing the oil content in presently used oil crops or searching for best ways for oil accumulation in organs or tissues that normally do not store oil. Because of this unique nutritional composition of different plant parts, it has the potential to become a model plant to study oil accumulation in non-seed tissues.

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Conflict of Interests

The author(s) have not declared any conflict of interests.

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