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Nutrients enrichment patterns of tiger nut (*Cyperus esculentus*)

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ABSTRACT

The nutrients variation patterns of the tiger nut leaves, roots and tubers was measured by oven drying, soxhlet extraction, titration and kjeldahl method in the whole growing periods. The moisture content of the tiger nut was decreased throughout its growth cycle with time, but there are differences in different organs. The starch content was increased with reducing of fat content. The root oil content of the tiger nut was upheaval features with the fast increased in the growing days of 100 with the maximum value of 8%. Gradually it was decreased and the harvest value was recorded about 3 %. Although there was no significant changes of starch content but the root starch content was always higher than the oil. Tuber starch and oil content was increased with the increasing of growing time but in the growing of middle, the changes were irregularities. Reducing sugars and protein content of the tuber also did not change significantly. The order of the tiger nut leaves composition's content was starch> oil> reducing sugar >protein with value of 26.4 %, 9 %, 6.4 %, 2% while the tuber was starch> oil> reducing sugar>protein with the value of 49%, 30%, 7% and 1.1 %. For the starch purpose, the harvest time could be around 142d. However, harvest time could require staying longer in soil.

KEYWORDS

Tiger nut;
Oil;
Starch;
Growth cycle;
Nutrients enrichment.

INTRODUCTIONS

Tiger nut (*Cyperus esculentus L.*) is an edible perennial grass-like C_4 plant of the sedge family[1]. It is also called chufa, nut grass, yellow nut sedge, earth almond, edible galingale and ground almond etal[2, 3]. It is widely used for animal and human consumption in some countries around Africa, Europe and America[3]. Its tuber is rich in energy content like starch and oil, minerals, and vitamins E and C. As the principal component of tiger nut tuber, starch has widespread availability, high yield, and the simplicity of extraction. Its starch may provide alternative for highly specific and functional excipients[4], be potentially applicable to cold storage of food, and could maintain organoleptic processing properties for longer time[5]. Its nut oil has high monounsaturated fatty acid concentration and has a similar fatty acid profile with olive, avocado and hazelnut oil[6]. Its oil also has high unsaponifiable matter, phospholipids and other bioactive compounds such as tocopherols, phytosterols and polyphenols[3, 6]. Although Its nut oil has a similarity with olive oil, it has a gold-

yellow color, neutral tasting, high content of phytosterols[3] and deep frying stability[6, 7]. Those enriches the quality and value of tiger nut oil as food source, and could be used in the same manner as olive oil[3].

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. Because of that, it has potential to become a model plant for studying oil accumulation in non-seed tissues. Therefore, the current study has been carried out to gain insights into the biochemical changes of different parts of tiger nut with whole growth cycle in the field as well as tubers and roots, and how to changes between this parts and other parts of the tiger nuts with their harvesting time.

MATERIALS AND METHOD

Material: Tiger nut

Instrument and equipment

Soil shovel; magnetic stirrer; HANAHI98188 EC, TDS, NaCl, Resistivity Meter, HANAHI98183 PH Meter, 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, conical flask (250ml), volumetric flask, reflux device, acid burette, filtration device, microwave.

Method

Tiger nut tubers were provided by the Karamay Meeting profit LLC. Before planting, the tubers were rinsed with tap water for first 2hrs and then soaked at 45°C for 24hrs with changing the water in the middle. Then it is drained out for backup. After that the tubers were planted with spacing 20×40cm in sandy soil condition. The germination was started after planting of 10days. It was watered at 10 days interval according to their actual situation. 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.

TABLE 1 : Physical chemical properties of the tested soil

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

TABLE 2 : Moisture content of tiger nut

Growth days	60	64	66	70	73	76	79	83	88	89
Leaves	82.25%	81.65%	80.40%	79.26%	78.28%	77.42%	76.06%	75.63%	73.88%	73.78%
Root	65.59%	66.55%	68.35%	71.22%	72.76%	73.79%	75.38%	76.46%	77.35%	77.49%
Tuber	-	-	-	-	-	-	-	-	-	-
Growth days	92	93	95	98	102	105	108	111	114	120
Leaves	71.16%	69.40%	67.33%	59.99%	54.46%	51.94%	49.51%	49.16%	46.87%	42.82%
Root	74.88%	73.83%	71.58%	68.44%	62.85%	57.88%	51.25%	47.72%	46.14%	45.20%
Tuber	-	-	-	-	79.31%	76.19%	73.76%	71.25%	68.07%	66.58%
Growth days	123	129	133	139	146	152	155	158	161	164
Leaves	37.74%	34.85%	31.89%	27.06%	25.14%	23.63%	23.05%	22.56%	22.12%	21.98%
Root	40.75%	35.76%	33.62%	30.72%	27.54%	23.93%	23.40%	22.98%	22.45%	22.50%
Tuber	65.46%	62.82%	60.69%	58.53%	56.83%	55.01%	54.60%	54.22%	53.86%	53.54%

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(a) Preparation of sample

Parts of tiger nuts slowly thawed and then oven dried, and splintered with a universal crushing machine.

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, S. D. [8].

Analysis of water, oil, total protein, starch and sugar: The water, oil, total protein, starch and sugar was analyzed according to the method of Jing, S. Q. [9].

RESULTS

Measurement of soil physical and chemical properties

TABLE 1 shows that soil salt content was decreased from top to bottom with soil depth, and its surface clustering. Their effect was relatively strong because the soil water soluble salt rise with the water evaporates and stays around 0 ~ 20cm in the strong solar radiation. So, there was no soil salinization risk. 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 was declined from top to bottom with depth, and therefore enriched the soil. The vertical distribution of soil moisture was belonged to bottom poly-type soil moisture profile. The type of soil moisture profile was characterized by its various levels of soil water content was relatively small, and surface soil moisture was low than others. So, the soil moisture from 20~40cm was a linear upward trend than 0~20cm, but the changing trend was decreased with increasing soil depth. Considering the surface soil water content, the soil moisture content of 20~40cm was increased 95.67% whereas the 40~60cm layer was increased only 10.86%.

The moisture content (%)

The moisture content of each nutrient part of tiger nut was reduced in 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 period. On the other hand, the moisture content of the roots was increased up to 89days and after that it was decreased with the advancement of harvesting periods (TABLE 2 and Figure 1).

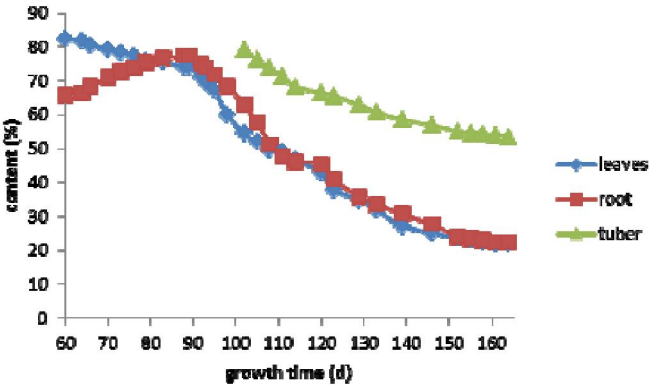

Figure 1 : Moisture content of each parts of tiger nut

Oil content (%)

In growth cycle, TABLE 3, 4&5 and Figure 2 show that there was changing trend of oil content among the leaves, root and tubers of the tiger nut. The oil content was increased up to 98 days for both leaves and roots and after that it was gradually reduced. In case of tuber, the oil content was increased with the advancement of growing time. The highest oil content was also recorded in tubers followed by leaves and root in the whole growth cycle of the tiger nut.

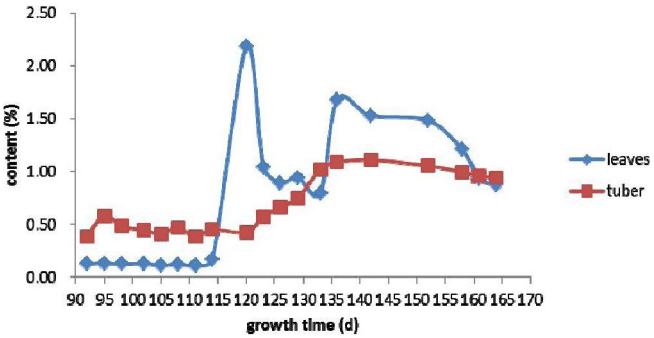

Figure 2 : Oil content changes of the each part of tiger nut

Protein content (%)

The protein content was significantly difference between the leaves and tubers of the tiger nut (TABLE 6&7 with Figure 3). Initially, the protein content of the leaves was lower up to 111 days (0.11±0.00) but after that it was dramatically increased up to 120 days (2.19±0.02). In case of tuber, there was increasing trend up to 152 days (1.11±0.00) and after that it was decreased gradually with the advancement of growing periods.

Starch content (%)

There was increasing trend of starch content at dif-

TABLE 3 : Oil content of the tiger nut leaves (X±SD%)(dry mass)

Growth days	60	64	66	70	73	76	79	83	88	89
leaves	8.14±0.57%	8.07±0.04%	8.21±0.04%	8.32±0.05%	8.47±0.04%	8.61±0.05%	8.74±0.04%	8.85±0.03%	8.76±0.05%	8.69±0.04%
Growth days	92	93	95	98	102	105	108	111	114	120
leaves	8.61±0.05%	8.58±0.05%	8.50±0.05%	8.42±0.05%	8.33±0.04%	8.25±0.06%	8.19±0.04%	8.11±0.05%	8.03±0.02%	7.93±0.04%
Growth days	123	129	133	139	146	152	155	158	161	164
leaves	7.86±0.05%	7.78±0.05%	7.70±0.06%	7.59±0.05%	7.46±0.10%	6.19±0.03%	6.10±0.04%	6.01±0.03%	5.85±0.10%	5.30±0.09%

TABLE 4 : Oil content of the tiger nut roots (X±SD%)(dry mass) (contd—)

Growth days	60	64	66	70	73	76	79	83	88	89
root	0.09±0.00%	0.21±0.00%	0.41±0.00%	1.23±0.01%	2.18±0.03%	2.72±0.04%	3.63±0.03%	4.53±0.04%	4.91±0.05%	5.62±0.05%
Growth days	92	93	95	98	102	105	108	111	114	120
root	6.30±0.05%	6.82±0.04%	7.19±0.06%	8.34±0.06%	7.36±0.09%	6.73±0.50%	5.26±0.04%	4.73±0.05%	4.50±0.05%	4.30±0.06%
Growth days	123	129	133	139	146	152	155	158	161	164
root	3.84±0.06%	3.47±0.04%	3.61±0.04%	3.53±0.04%	3.33±0.04%	3.12±0.03%	2.95±0.04%	2.63±0.04%	2.55±0.05%	2.40±0.08%

TABLE 5 : Oil content of the tiger nut tubers (X±SD%)(dry mass) (contd—)

Growth days	102	105	108	111	114	120	123	129	133	139
tuber	17.11±0.05%	19.98±0.12%	21.41±0.06%	22.16±0.08%	23.09±0.04%	24.37±0.08%	25.26±0.03%	26.19±0.07%	26.76±0.04%	27.34±0.09
Growth days	146	152	155	158	161	164				
tuber	27.89±0.04%	28.33±0.07%	28.85±0.02%	29.38±0.02%	29.65±0.02%	29.96±0.01%				

TABLE 6 : Protein content of the tiger nut leaves (X±SD%)(dry mass)

Growth days	92	95	98	102	105	108	111
leaves	0.12±0.00%	0.13±0.00%	0.12±0.00%	0.12±0.00%	0.11±0.00%	0.12±0.00%	0.11±0.00%
Growth days	114	120	123	126	129	133	136
leaves	0.17±0.00%	2.19±0.02%	1.04±0.02%	0.89±0.03%	0.94±0.02%	0.80±0.01%	1.68±0.02%
Growth days	142	152	158	161	164		
leaves	1.53±0.03%	1.48±0.00%	1.21±0.00%	0.93±0.01%	0.87±0.00%		

TABLE 7 : Protein content of the tiger nut tubers (X±SD%)(dry mass) (contd—)

Growth days	92	95	98	102	105	108	114
tuber	0.39±0.02%	0.58±0.03%	0.48±0.04%	0.45±0.03%	0.41±0.03%	0.47±0.04%	0.38±0.03%
Growth days	120	123	129	133	136	139	149
tuber	0.45±0.02%	0.43±0.02%	0.57±0.04%	0.66±0.03%	0.75±0.00%	1.02±0.00%	1.08±0.00%
Growth days	152	155	158	161	164		
tuber	1.11±0.00%	1.05±0.00%	0.99±0.00%	0.95±0.00%	0.94±0.00%		

ferent parts of the tiger nut among the leaves, roots and tubers. Although there were increasing trend of starch content with the advancement of growing time but the increasing values were irregularities among the leaves, roots and tubers (TABLE 8, 9 &10). The highest value of starch content was recorded before harvest and after harvest the values were lower among the leaves, roots and tubers.

Sugar content (%)

The changing trend of reducing sugar content of tiger nut was not very obvious between leaves and tu-

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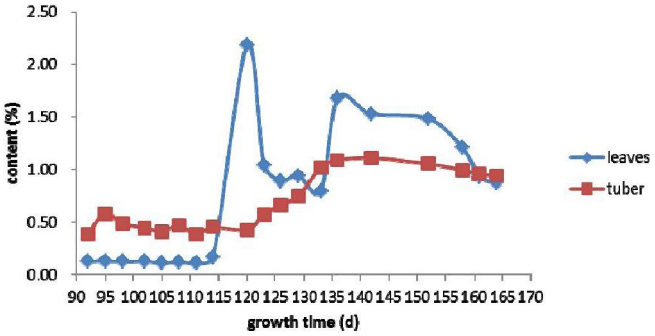

Figure 3 : Protein content of the each part of the tiger nut (dry mass)

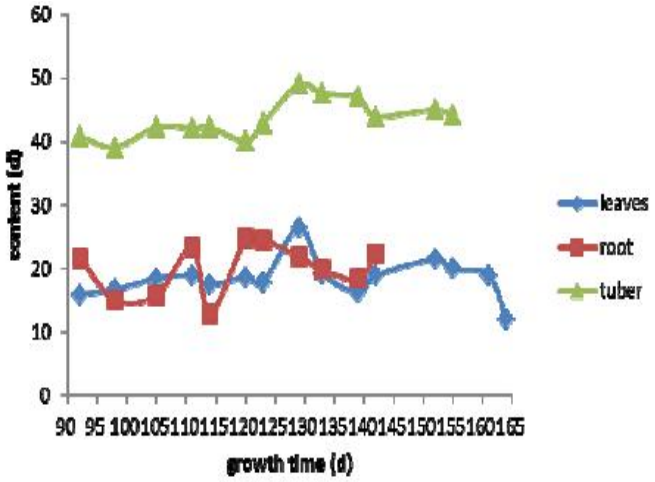

Figure 4 : Starch content of the tiger nut (dry mass)

was increased gradually up to 150d and after that the changes were irregularities and reached the lowest level of 19% (Figure 6 and TABLE 8). For the oil content of leaves, it was increased from beginning to 85d to get the highest level of 9%. From that time to harvest, it began to decrease and got lowest level of 5% at the end (Figure 6 and TABLE 3). For sugar content of leaves, there was increasing trend with irregular changes while the highest level was 6.4% and the lowest level was 3.4% (Figure 6 and TABLE 11). The leaves' protein content was very low level up to 110d, and reached the highest level of 2.19% at 120d. After that, it was decreased with irregularities (Figure 6 and TABLE 6). Generally the starch, sugar and protein content of the tiger nut was increased whereas the oil content was decreased before 120~130d. From 130d the oil, sugar and protein content were decreased while the changing trend of starch content was not clear. However, the starch content was increased whereas the oil content decreased.

The changing trend of the root oil content was clear in whole growth cycle from beginning to 100d with highest level of 8% and decreased from 100d to the harvest time (Figure 7 and TABLE 4). During harvest the oil content was recorded 3% while the starch content was higher value 25% with the irregular changing trend (Figure 7 and TABLE 4). However, the starch content of the root was higher as compared to oil content.

In case of tuber, the starch content was increased before 142d with highest level of 49% and after that it was decreased with growing period (Figure 8 and TABLE 10). However, tuber oil content was gradually increased in entire growth cycle and attained the highest level of 30% during harvesting (Figure 8 and TABLE 5). The sugar content of tuber was increased before

TABLE 8 : Starch content of the tiger nut leaves (X±SD%)(dry mass)

Growth days	92	98	105	111	114	120	123	129
leaves	15.90±0.51%	16.65±0.64%	18.44±0.49%	18.85±0.15%	17.41±0.64%	18.59±0.85%	17.85±0.32%	26.41±2.33%
Growth days	133	139	142	152	155	161	164	
leaves	19.34±0.50%	16.22±0.53%	18.91±0.28%	21.40±0.84%	19.92±0.47%	18.99±0.72%	11.94±0.16%	

TABLE 9 : Starch content of the tiger nut roots (X±SD%)(dry mass)

Growth days	92	98	105	111	114	123
root	21.69±0.11%	15.03±2.36%	15.81±1.94%	23.30±1.84%	12.83±0.11%	24.64±0.21%
Growth days	133	139	142	155	161	
root	24.56±0.54%	21.85±1.38%	19.81±0.03%	18.30±0.25%	22.26±0.38%	

bers. This might be 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 155days whereas it was recorded lower (5.73±0.27) for leaves (TABLE 11&12).

DISCUSSIONS

The highest starch content of the tiger nut leaves

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TABLE 10 : Starch content of the tiger nut tubers (X±SD%)(dry mass)

Growth days	105	114	120	123	129	136	139
tuber	40.84±2.87%	39.10±2.84%	42.26±1.68%	42.09±0.28%	42.23±0.33%	40.08±0.57%	42.94±4.21%
Growth days	142	149	152	155	161	164	
tuber	49.03±0.45%	47.61±3.09%	46.95±4.13%	44.01±1.05%	45.04±3.42%	44.16±1.97%	

TABLE 11 : Reducing sugar content of the tiger nut leaves (X±SD%)(dry mass)

Growth days	92	105	120	123	129
leaves	5.10±0.01%	5.51±0.20%	3.37±0.28%	5.70±0.56%	5.32±0.15%
Growth days	136	146	152	155	164
leaves	4.97±0.13%	6.39±0.15%	5.23±0.16%	5.73±0.27%	4.92±0.08%

TABLE 12 : Reducing sugar content of the tiger nut tubers (X±SD%)(dry mass)

Growth days	92	105	120	123	129
tuber	6.04±0.73%	6.22±0.06%	6.34±0.13%	6.12±0.13%	6.32±0.23%
Growth days	136	146	152	155	164
tuber	5.67±0.09%	6.21±0.05%	6.30±0.08%	6.99±0.57%	4.69±0.14%

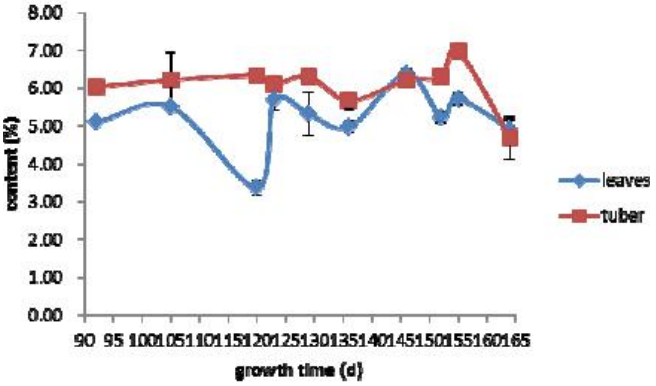

Figure 5 : Reducing sugar content of the tiger nut (dry mass)

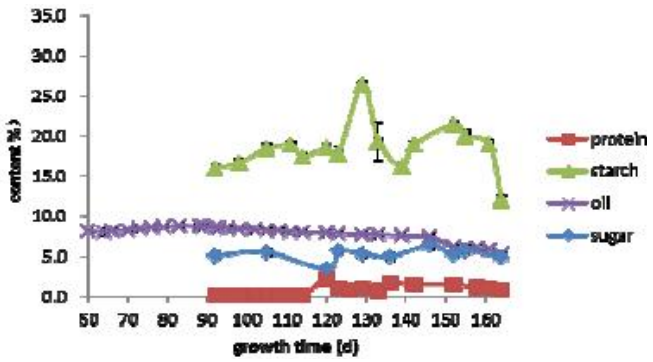

Figure 6 : Nutrient contents of the tiger nut leave (dry mass)

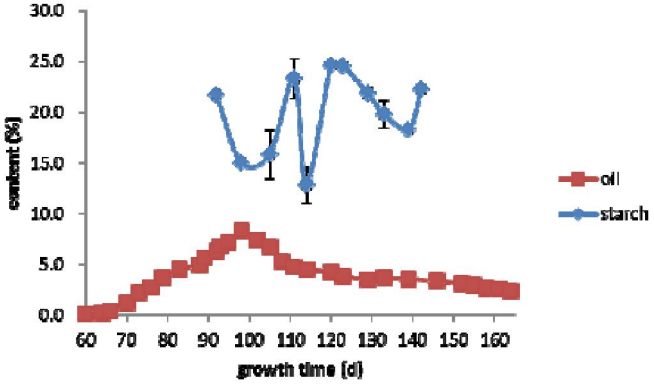

Figure 7 : Oil and starch content changes of the tiger nut roots (dry mass)

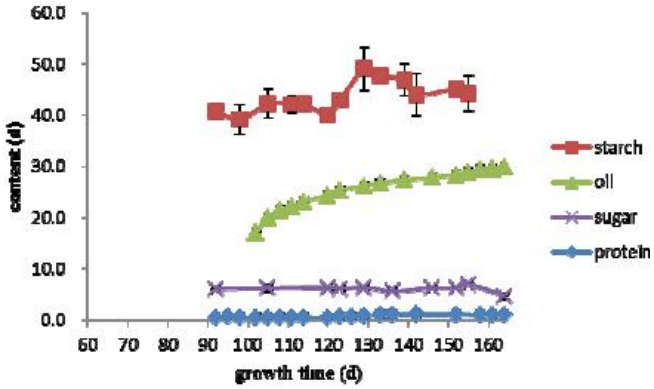

Figure 8 : Nutrient content of the tiger nut tuber (dry mass)

152d with the highest level of 7% but at the end it was decreased (Figure 8 and TABLE 12). The protein content of tuber was very low and was remained almost same level in whole life cycle then other nutrient content (Figure 8 and TABLE 7).

For moisture content, tiger nut's leaf and tuber moisture content reduced from the beginning. However, the moisture content of roots was increased before 85d and then began to reduce. The tuber moisture content was higher than leaves and root. The moisture content was recorded 82.25%, 77.49% and 79.31% for leaves, roots and tubers which indicates that the highest mois-

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ture content was higher in leaves as compared to roots and tubers.

CONCLUSION

The moisture content of the tiger nut was decreased throughout its growth cycle with time. The starch content was increased with reducing of fat content. The root oil content of the tiger nut was upheaval features with the fast increased in the growing days of 100 with the maximum value of 8% and gradually it was decreased Tuber starch and oil content was increased with the increasing of growing time but in the growing of middle, the changes were irregularities. Reducing sugars and protein content of the tuber also did not change significantly. The order of the tiger nut leaves composition's content was starch> oil> reducing sugar >protein with value of 26.4 %, 9 %, 6.4 %, 2% while the tuber was starch> oil> reducing sugar>protein with the value of 49%, 30%, 7% and 1.1 %. For the starch purpose, the harvest time could be around 142d. However, harvest time could require staying longer in soil.

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