NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 51 Number 1, April 2020 Pg. 142-150
Available online at: http://www.ajol.info/index.php/naj

EFFECT OF *Phytophthora* LEAF BLIGHT DISEASE OF TARO [*Colocasia esculenta*(L.) Schott] ON PROXIMATE AND PHYTOCHEMICAL CONSTITUENTS OF INFECTED CORMS

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Abstract
Leaf-blight and corm rot of taro [*Colocasia esculenta* (L.) Schott] incited by *Phytophthora colocasiae* hampers production, storage and utilization of taro in Nigeria. This study evaluated the effect of leaf blight disease on proximate and phytochemical constituents of infected corm varieties: NCe001, NCe011, NCe012 and BLS/158 obtained from National Root Crops Research Institute (NRCRI) Umudike, and grown under natural leaf blight disease conditions during the 2016/2017 planting season. The experiment was laid out in Randomized Complete Block Design and replicated thrice. Corm samples were obtained from the infected and uninfected crop after harvest and analyzed for proximate and phytochemical constituents by standard procedures. Data were subjected to Analysis of Variance (ANOVA). Results showed significant ($P< 0.05$) reduction in carbohydrate, dry matter, crude fibre, ash, crude fat and energy value in the diseased samples of the varieties compared to the healthy samples. However, significant ($P< 0.05$) higher moisture and crude protein contents were observed across the diseased taro varieties. Oxalate, Flavonoids and Tannins had significant ($P < 0.05$) higher values for non-diseased samples over the diseased samples and varied among the varieties. Alkaloids and Saponins were higher in the diseased samples and varied significantly. The significant reduction in proximate and phytochemical constituents of infected corms demonstrated in this experiment suggests that taro leaf blight (TLB) caused significant reduction in the chemical composition of taro corms and may limit the industrial potentials of corms. Hence, taro based industries are by this findings informed of the magnitude of nutrient depletion in infected taro corms due to blight and the need to make necessary adjustments to avoid the production of sub-standard products.

Keywords: Healthy Tissues, Diseased Tissues, Taro Corms, Proximate, and Phytochemical

Introduction

Taro (*Colocasia esculenta* (L.) Schott.), commonly referred to as cocoyam is a herbaceous perennial and a major tropical root crop of the monocotyledonous family Araece. It is an invaluable dietary staple with underground starchy corms (Nwachukwu and Osuji, 2008), highly nutritive leaves, petioles and flowers that constitute important staple food in Nigeria (Amusa *et al*., 2011; Chukwu, 2015) and other parts of the world (Onwueme, 1999, Mishra *et al*., 2008; Tumuhimbise *et al*., 2009; Mannar and Taylor, 2011; Alcantara *et al*., 2013). Its underground stems (corms) provide 98.8% highly digestible starch (FAO, 2004; Aboubakar *et al*., 2008; Anon, 2011; Adane *et al*., 2013; Eneh, 2013) which qualifies taro as a composite in the manufacture of infant meals, in the management of patients with digestive and coeliac disorders and in the management of gluten allergies in adults. The potentials of taro as carbohydrate adjunct in energy food drinks(Eneh,2013), and as agro-industrial raw material for pharmaceutical , confectionery and livestock industries (Mweta *et al* 2008; Mandal *et al*., 2015) have been established (Mandal *et al*., 2013). Taro can be eaten in a variety of ways: the soft white-fleshed tubers (corms) can be boiled, fried, roasted, pounded into *fufu* or made into porridge, chips, crisps and flour (Ukpabi *et al*., 2013; Manner and Taylor, 2011; Ecoport, 2010). In some localities, they are also used as adjunct in soup thickening. Also, corm processed into flour is used for various forms of confectioneries.

The Oomycetes phyto-pathogen, *Phytophthora colocasiae* Raciborski, is the causal agent of the most infectious and devastating disease of *Colocasia esculenta* known as Taro Leaf Blight(TLB) (Brunt *et al*., 2001; Brook, 2008; Mishra *et al*., 2008; Shakywar *et al*.,

2008; Tarla *et al*.,2014). The swift development of infections has had catastrophic consequences both for small, medium and large scale production of taro. These ranges from mild, heavy to total loss of the crop in the entire zone where taro is grown (Mishra *et al*., 2008), postharvest deterioration of corms resulting to nutrient depletions in the infected corm(Brooks, 2005; Mbong*et al*., 2011),scarcity and exorbitant prices of corms among others.

The effect of the scourge could be likened to the potato late blight epidemic which wiped out potato crops of Ireland and Western USA in 1840, and caused severe famine which led to death of two million people and migration of many (Mehrothra and Agarwal, 2003).The epidemic of TLB occurred in Nigeria in 2009, and ravaged taro crops (Ugwuja and Chiejina, 2011; Bandyopadhyay *et al.*, 2011) leading to drastic decline of production by 60%. Similar outbreaks were reported in Cameroon in 2010 (Fontem and Mbong, 2011), Ghana, Ethiopia, Ivory Coast, and many other African countries.These gave rise to serious hunger as there were not enough produce to eat or sell and many taro farmers abandoned their farms (Fontem and Mbong, 2011).

Symptoms typical of TLB are initially expressed on the leaf as small, water-soaked, dark brown, round to irregular necrotic lesions on the ad axial leaf lamina (Chiejina and Ugwuja, 2013), which rapidly become enlarged to 2.5-5.0cm within few days. As the disease progresses, secondary infections occur even on the petiole and adjacent lesions on the lamina coalesce to cover extensive leaf area and quickly destroy it. Concentric colour patterns with whitish band of mycelia round the lesion and yellowing of the leaf are conspicuous pattern of the disease. Orange or reddish brown exudates also ooze out from the spot and infected leaf dies within 7-14 days causing yield losses of up to 50% (Brunt *et al.,*2001;Misra, 2008) in severe cases and more than 70% in extreme severe cases (Nelson *et al*.,2011).The impact of this disease has already been felt in various cocoyam growing zones due to the attendant scarcity and leading to hunger(Ugwuja and Chiejina, 2011).Due to the ubiquitous nature of this pathogen (Brooks, 2000; Brooks, 2005; Strange and Scott, 2005) and the rapid rate of spread of infections through wind-blown rain, it is very rare to find uninfected plants in a TLB infested field. Underground infection of corms takes place from zoospores washed down from the leaves of infected plants (Brooks, 2005) and virtually all the corms harvested from such crop have latent infections in various degrees. Consequently, the deterioration of such corms after harvest and during storage is inevitable.

Knowledge of chemical constituents and nutritional values of crops is important for the utilization of its products as food or raw material for industries. Due to plant disease problems and changing environmental conditions which affect qualities of agricultural products (Agrios, 2005), routine monitoring of these products has becomes important to ascertain whether they can still provide the expected quantity and quality of nutrients before they are used in industries for large scale production. Many industrialists /local consumers do not consider the state of nutrient of diseased crop; whether it has increased beyond consumable standard or has decreased to a value below the "Required Daily Allowance" (RDA) for a particular food nutrient. There are speculations that due to TLB infections, the nutritional value of corms might have drastically declined. However, there are no scientific data to confirm the validity of these speculations or the contrary. Despite the magnitude of research done on TLB and the yield losses attributed to the disease, there is dearth of information on the amount of nutrient depletion in corms due to TLB. This study therefore, is aimed at determining the extent of proximate and phytochemical depletion in taro corms grown under taro leaf blight condition.

Materials and Methods

Plant Growth and harvesting of Corms: This study was carried out at the National Root Crop Research Institute (NRCRI) Umudike, located within Longitude 07° 34"E, Latitude 05° 29" N and at elevation of 122m above sea level. The soil was predominantly sandy-loam with pH range of5.5 to 6.5. The average rainfall of the region is 2500mm with 108 rainy days and major rainfall was observed during the months of June, July, August and September which coincides with the growth stage and intensity of Taro. The relative humidity during the days ranged from 83% to 100%, with temperature around 20°C-22°C. The climatic conditions were highly favorable for TLB symptoms development and spread of the pathogen. The study consist of 8 treatment combinations comprising 4 taro varieties NCe011 – V1, NCe012 –V2, NCe001-V3 and BLS/158 and 2 disease levels (infected and uninfected) replicated thrice in a ranomized complete block design (RCBD). The size of each plot was 3m x 3m with plant spacing of 0.5cm within row giving a density of 18plants per plot. Prior to planting, corms were treated by soaking in 5% Ridomil solution for one hour in order to eliminate postharvest pathogens especially *P. colocasiae* which might have survived during the previous season according to the method of Shakywar *et al* (2007). Natural inoculation occurred in the field at 8 weeks after planting. The uninfected treatment was achieved by spraying with Ridomil at the rate of 0.67mg/ml on bi-weekly intervals throughout the six month duration of the experiment. The crops were harvested at maturity at the end of the growth season. Harvesting was done plot by plot according to the various treatments and replications for laboratory analysis.

Laboratory analysis of corm quality: The corms from each field plot were pulled and a 4kg corm sample from each plot used for the laboratory analysis of the proximate contents following the procedure developed by the Association of Official Analytical Chemist (AOAC, 2000) viz:

a. Moisture content

Two (2) grammes of the sample (in stainless oven dishes previously washed, dried, cooled and weighed) were weighed with the aid of analytical balance. Then dried in a Genlab moisture extraction oven set at 105^{0}C until constant weight was attained. The samples together with the dishes were transferred into a desiccator with the aid of a laboratory tong and then allowed to cool for 30 minutes. After cooling in the desiccator, it was weighed again and recorded. The difference in weight was calculated as a percentage of the original sample thus:

$$\text{Percentage moisture content} = \frac{(W2 - W3)}{(W2 - W1)} \text{x} \frac{100}{1}$$

Where,
W_1 = Initial weight of the empty dish
W_2 = Weight of the dish + undried sample and
W_3 = Weight of the dish + dried sample

b. Ash content

Two (2) grammes of the sample (in a dried, cooled and weighed dish) were weighed with the aid of an analytical balance. The sample was charred by placing them on a Bunsen flame inside a fume cupboard to ward off smoke for 30 minutes. The sample was thereafter transferred into a pre-heated muffle furnace already at 550^{0}C with the aid of a laboratory tong. It was allowed to stay in the furnace for 3 hours until a white or light grey ash was observed. Sample that remained black or dark in colour after this time elapsed was moistened with small amount of water to dissolve salts, dried in an oven and then the ashing processes repeated again. After ashing, the dishes were transferred into a dessicator with a laboratory tong. When cooled, it was weighed again and recorded thus:

$$\text{Percentage ash content} = \frac{(W3 - W1)}{(W2 - W1)} \text{X} \frac{100}{1}$$

Where,
W_1= Weight of Empty Crucibles
W_2 = Weight of Crucible + Food Sample before ashing and
W_3 = Weight of crucible + ash

c. Crude Fibre Content

Five grams (5g) of the sample was used for determination. The sample was boiled in a 500 ml flask containing 200 ml of 1.25% H_2SO_4 solution under reflux for 30 minutes. When this time elapsed, the sample was washed with several portions of hot boiling water using a two-fold muslin cloth to trap the residual particles. The residual particles were carefully transferred quickly back to the flasks and 200ml of 1.25% NaOH solution was added into the flask. Again, the sample was boiled for 30 minutes and washed as before in hot water. Then, carefully transferred into a weighed crucible and dried in a Genlab oven set at 100^{o}C for about 20 minutes before being weighed again. After weighing, it was transferred into a muffle furnace set as 550^{o}C for 2 hours (until ashed). Finally, it was cooled in a dessicator and weighed again. The crude fibre content for the sample was calculated thus:

$$\text{Percentage crude content} = \frac{(W2 - W3)}{(W1)} \text{x} \frac{100}{1}$$

Where,
W_2 = Weight of crucible + Sample after washing and drying in the oven
W_3 = Weight of crucible + Sample as ash and
W_1 = Weight of the original sample

d. Crude Protein Content

Half gram (0.5) of the sample was mixed with 10ml of concentrated H_2SO_4 in a Kjeldahl digestion flask. A tablet of selenium catalyst was added to the sample which was digested (heated) inside a fume cupboard until a clear solution was obtained in a separate flask. Also, a blank was made by digesting the above reagents without any sample in it. Then, the digest was carefully transferred into a 100ml volumetric flask and was made up with distilled water. A 100ml portion of the digest was mixed with equal volume of 45% NaOH solution in a Kjeldahl distilling unit. The resulting mixture was distilled and the distillate collected into 10ml of 4% boric acid solution containing three (3) drops of mixed indicators (bromocresol green and methyl red). A total of 50ml of the distillate was obtained and titrated with 0.02molar H_2SO_4 solutions. Titration was done from the initial green colour to a deep red end-point. The nitrogen content of the sample was calculated thus:

$$\text{Percentage Nitrogen} = \frac{(100 \text{ x } N \text{ x } 14 \text{ x } Vf)T}{W \text{ x } 1000 \text{ x } Va}$$

Where,
W = Weight of sample analyzed
N = Concentration of H_2SO_4 titrant
Vf= Total volume of digest
Va= Volume of digest distilled and
T = Titrate value of the sample minus titre value of the blank

The results for each sample were multiplied with the factor of 6.25 to obtain the crude protein content of each sample.

e. Fat Content

Two hundred and fifty milliliters (250ml) of boiling flasks were washed with water, dried in a Genlab oven set at 105^{o}C for 30 minutes, cooled in a desiccator and then used for sample. The flask was first labeled, weighed with an analytical balance and filled with 300ml of petroleum ether in each case. Then, 5gof the sample was weighed out with an analytical balance into a labeled thimble. The extraction thimble was tightly plugged with cotton wool. The Soxhlet apparatus was then assembled and allowed to reflux for 6 hours. When this time elapsed, the thimble was removed and the petroleum ether collected on the top of the container in the set up, and drained into another container for re-use. The flask was removed and then dried in a Genlab oven at 105^{o}C for 1 hour. After drying, they were transferred into a desiccator, allowed to cool, and weighed. The percentage fat was calculated for sample thus:

$$\text{Percentage fat} = \frac{C - A}{B} \times \frac{100}{1}$$

Where,
A= Weight of empty flask
B= Weight of the sample
C = Weight of oil after drying

f. Carbohydrate Content

Carbohydrate content of the samples was determined by difference using the formula thus:
Carbohydrate (%) = 100 – (% Moisture + Ash + % Crude fibre + % Crude protein + Fat)

g. Quantitative Phytochemical Screening

The amount of phytochemicals present in the healthy and diseased corm samples were determined according to the standard procedures described by Edeoga *et al* (2005). The phytochemicals tested for include: alkaloids, tannins, saponin, flavonoids, terpenoids, steroids and glycosides.

h. Statistical Analysis

One-way Analysis of Variance was performed for the proximate and phytochemical profiles of the healthy and diseased samples of each taro variety using SPSS (IBM SPSS Statistics 22) analytical package. Means separation was done using t-Test. Results for the analyzed parameters were presented in tables as mean plus or minus standard error.

Results and Discussion

Proximate Composition

The results of the proximate analysis revealed significant variations in moisture, dry matter, crude protein, crude fibre, ash, and carbohydrate and energy value contents of the diseased and healthy samples of the 4 varieties. (Tables 1 to 4). There was highly significant reduction (P<0.05) in dry matter (DM), fat (FT) crude fiber (CF),ash,(AS) carbohydrate (CHO) and energy value (EV) of the diseased samples. These components were consistently higher in the healthy samples and varied significantly (P <0.05) with those of the diseased samples. DM, FT, CF, AS, CHO and EV recorded for the healthy samples were 38.79±0.05, 0.61±0.017, 1.20±0.023, 1.92±0.012, 30.78±0.01 and 145.74±0.146Kcal compared to32.98±0.012, 0.45±0.012, 1.20±0.012, 1.67±0.012, 24.32±0.035 and 122.71±0.52Kcal recorded for the diseased samples respectively. However moisture content (MC) and crude protein CP were higher in the diseased corm samples than in the healthy samples. With respect to varieties, ANOVA indicated differences across the varieties in the proximate profiles as shown. BLS/158 was significant (P < 0.05), highest contents of DM (47.44%), CHO (40.02%) and EV (181.50%), with lowest MC (52.57%) and appreciable amounts of CP (4.39%) compared to the other varieties. Similarly, NCe001 had appreciable amount of DM (39.90%), and EV (150.38 %). The highest moisture and ash contents were recorded in NCe011 while the highest crude protein (4.83%) and fiber (1.68%) were recorded in NCe012.

Phytochemical Profiles of Healthy and Diseased Corm Samples

The anti-nutrient profiles of the healthy and diseased corm samples of the four varieties of taro are presented in Table 5. The concentration of Oxalate (OX), Alkaloid (AL), Saponin (SP), Favonoids (FL) and Tannins (TA) differed per variety. OX, FL and TA were significantly (P<0.05) and consistently reduced in the diseased samples than in the healthy samples, whereas, AL was consistently higher in the diseased than in the healthy samples. Saponin was higher in the diseased sample of V1 and V2 and lower in the diseased samples of V3 and V4. The highest OX content for both healthy and diseased samples (235.08 ± 0.07%; 215.08±0.01%) was found in V2 followed by V4, V3 and V1 had the least, 145.35±0.05% and 145.09±0.02%. The differences in the OX concentration between the diseased and healthy samples of these varieties were highly significant (P < 0.05) for V2, V3, and V4 and significant for V1.Similar trend was observed with SA, FL and TA. The highest FL contents for healthy and diseased samples (6.32±0.012%; 5.37±0.012%) was recorded by V2 while the lowest (4.72±0.012; 2.04± 0.012) was recorded by V4.The highest value of TA (1.84±0.012; 1.47±0.012) was recorded by V4 while the lowest (0.78±0.012; 0.62±0.012) was found in V1.

Table 1: Proximate composition of healthy and diseased corm samples of NCe011 variety

Proximate	Healthy sample	Diseased sample	Mean
DM (%)	38.79 ± 0.05^{a}	32.98 ± 0.01^{b}	**35.89**
MC (%)	61.21 ± 0.01^{b}	67.02 ± 0.01^{a}	**64.12**
CP (%)	4.28 ± 0.01^{b}	5.35 ± 0.01^{a}	4.82
FAT(%)	0.61 ± 0.02^{a}	0.45 ± 0.01^{b}	0.53
CF (%)	1.20 ± 0.03^{a}	1.20 ± 0.02^{a}	1.2
ASH (%)	1.92 ± 0.01^{a}	1.67 ± 0.012^{b}	1.8
CHO (%)	30.7 ± 0.01^{a}	24.32 ± 0.035^{b}	**27.55**
EV (Kcal)	145.74 ± 0.14^{a}	122.71 ± 0.52^{b}	134.23

Values are means of 3 replicates plus or minus standard error Means with the same superscript within a given row are not significantly different (P < 0.05)

Table 2: Proximate composition of healthy and diseased corm samples of NCe012 variety

Proximate	Healthy sample	Diseased sample	Mean
DM (%)	40.54 ± 0.012[a]	34.54 ± 0.012[b]	37.54
MC (%)	59.46 ± 0.012[b]	65.46 ± 0.012[a]	62.46
CP (%)	4.28 ± 0.012[b]	5.38 ± 0.038[a]	4.38
FAT(%)	0.46 ± 0.012[a]	0.39 ± 0.06[b]	0.43
CF (%)	1.69 ± 0.012[a]	1.66 ± 0.012[b]	1.68
ASH (%)	1.65 ± 0.012[a]	1.51 ± 0.012[b]	1.58
CHO (%)	31.33 ± 0.010[a]	26.71 ± 0.026[b]	29.02
EV (Kcal)	151.10 ± 0.090[a]	127.48 ± 153[b]	139.29

Values are means of 3 replicates plus or minus standard error Means with the same superscript within a given row are not significantly different (P <0.05)

Table 3: Proximate composition of healthy and diseased corm samples of NCe001 variety

Proximate	Healthy sample	Diseased sample	Mean
DM (%)	43.25± 0.006[a]	36.54± 0.031[b]	39.9
MC (%)	56.75± 0.06[b]	63.48± 0.012[a]	60.12
CP (%)	3.98± 0.012[b]	4.07± 0.012[a]	4.03
FAT(%)	0.51± 0.012[a]	0.49± 0.012[b]	0.5
CF (%)	1.36± 0.012[a]	1.15± 0.012[b]	1.26
ASH (%)	1.73± 0.012[a]	1.59± 0.010[b]	1.66
CHO (%)	35.66± 0.017[a]	29.21± 0.035[b]	32.44
EV (Kcal)	163.19±0.050[a]	137.56± 0.020[b]	150.38

Values are means of 3 replicates plus or minus standard error. Means with the same superscript within a given row are not significantly different(P< 0.05)

Table 4: Proximate composition of healthy and diseased corm samples of BLS/158 variety

Proximate	Healthy sample	Diseased sample	Mean
DM (%)	54.94 ± 0.012[a]	39.93 ± 0.012[b]	47.44
MC (%)	45.06 ± 0.012[b]	60.073 ± 0.012[a]	52.57
CP (%)	4.13 ± 0.013[b]	4.66 ± 0.017[a]	4.39
FAT(%)	0.45 ± 0.025[a]	0.41 ± 0.012[b]	0.43
CF (%)	1.10 ± 0.006[a]	1.01 ± 0.012[b]	1.06
ASH (%)	1.67 ± 0.012[a]	1.40 ± 0.012[b]	1.54
CHO (%)	47.59 ± 0.050[a]	32.44 ± 0.021[b]	40.02
EV (Kcal)	210.93 ± 0.097[a]	152. 07 ± 0.042[b]	181.5

Values are means of 3 replicates plus or minus standard error Means with the same superscript within a given row are not significantly different (P < 0.05)

Table 5: Phytochemical composition of healthy and diseased corm samples of four varieties of taro

Variety	Treatment	Oxalate	Alkaloids	Saponin	Flavonoids	Tanins
NCe011	**Healthy**	145.35 ± 0.052^{b}	1.78 ± 0.020^{a}	3.34 ± 0.032^{a}	5.45 ± 0.012^{b}	0.78 ± 0.012^{b}
	Diseased	145.09 ± 0.015^{a}	1.81 ± 0.012^{a}	3.43 ± 0.017^{b}	4.07 ± 0.012^{a}	0.62 ± 0.012^{a}
	Total	**145.22^{a}**	**1.80^{c}**	**3.38^{c}**	**4.76^{b}**	**0.70^{a}**
NCe012	**Healthy**	235.08 ± 0.07^{b}	1.11 ± 0.012^{a}	2.92 ± 0.012^{b}	6.32 ± 0.012^{b}	1.55 ± 0.012^{b}
	Diseased	215.08 ± 0.01^{a}	1.21 ± 0.012^{b}	3.02 ± 0.012^{a}	5.37 ± 0.012^{a}	1.31 ± 0.012^{a}
	Total	**225.08^{d}**	**1.16^{a}**	**2.97^{a}**	**5.85^{d}**	**1.43^{b}**
NCe001	**Healthy**	185.67 ± 0.01^{b}	1.41 ± 0.012^{a}	4.26 ± 0.012^{b}	6.81 ± 0.012^{b}	1.66 ± 0.012^{b}
	Diseased	166.37 ± 0.01^{a}	1.55 ± 0.006^{b}	3.34 ± 0.012^{a}	3.97 ± 0.012^{a}	1.21 ± 0.012^{a}
	Total	**176.02^{b}**	**1.48^{b}**	**3.80^{d}**	**5.39^{c}**	**1.44^{b}**
BLS/158	**Healthy**	195.51 ± 0.01^{b}	1.38 ± 0.012^{a}	4.67 ± 0.012^{b}	4.72 ± 0.012^{b}	1.84 ± 0.012^{b}
	Diseased	172.22 ± 0.012^{a}	1.61 ± 0.012^{b}	2.65 ± 0.012^{a}	2.04 ± 0.012^{a}	1.47 ± 0.012^{a}
	Total	**183.86^{c}**	**1.50^{b}**	**3.66^{b}**	**3.38^{a}**	**1.66^{c}**

Data of healthy and diseased samples of each variety were presented with standard error. Means with the same superscripts are not significantly different ($P < 0.05$)

Means for variety is presented in bold character and values are means of 3 replicates

Results of the proximate analysis showed significant reduction ($P \leq 0.05$) in the contents of carbohydrates, crude fibre, ash, dry matter, fat, ether extract and energy value of the diseased corm samples compared to the healthy one. This therefore, suggests that TLB caused significant reduction in the nutritional profile of taro corms and may limit the industrial potentials of infected corm .Hence, in the processing of taro based products; the manufacturers should not compromise standards by making use of unwholesome taro raw materials. If they do, the result would be the production of substandard inferior products which cannot meet the required daily allowance prescribed by the World Health Organization (WHO). The reduced concentration of these nutrients in the diseased samples supported the findings of some authors who reported that during pathogenesis, glucose, fructose, maltose and starch which are the major sources of carbon are utilized by most pathogenic fungi for metabolism (Graham and Graham 1991; Huber and Graham 1999).

However, the diseased corms contain higher moisture and crude protein. The higher moisture content in the diseased corm tissues reflects the maceration of tissues and the dissolution of cell walls and middle lamellae by hydrolytic and pectolytic enzymes in the course of pathogenesis resulting to the watery effects in the diseased tissues (Mehrotra and Agarwal, 2003). On the other hand, the higher crude protein in the diseased sample could be attributed to what many researchers in the field of Phytopathology have termed effector proteins (Wawra *et al*., 2012; Stassen and Ackerveken, 2011.). According to these authors, a common strategy shared by oomycetes pathogens with most of other cellular disease agents is the secretion of effector proteins. Effectors are molecules that alter host physiology by initiating and allowing infection to develop. The accumulation of the effector proteins in the infection matrix with the additional primary protein in the corm tissues might have resulted to higher protein in the diseased tissues. Our results also corroborate the findings of Oladele and Osipitan (2006) who reported that as fungal deterioration advances in grains, and carbohydrate is used up in the respiratory processes, protein content increases. Proteolytic enzymes produced by the pathogen and other secondary (infection) pathogens modify the proteins by hydrolyzing them into polypeptides and amino acids which are subsequently converted into fungal proteins. Despite the high level of disease recorded in BLS/158 in the field trials, it retained significantly, the highest amount of DM, CHO, EV and appreciable amounts CP with the lowest level of MC among the varieties. The high content of these nutrients in the diseased corms of BLS/158 indicated tolerance to TLB and its suitability for the production of starch and food supplements of high energy value.

Phytochemical analyses of the corm samples have shown that oxalate content was predominantly higher than other anti-nutrients among the varieties, and in the diseased samples, the concentrations were reduced. Researchers have established that high oxalate content is typical of members of the Araceae family due to the presence of calcium oxalate crystals known as raphides in their tissues (Onwueme, 1999; Duncan *et al*., 2000; Wong, 2007; Malavanh *et al*., 2008; Agu*et al*., 2014). However, the reduction of calcium oxalate concentration among diseased corms suggests that it might have been used up during pathogenesis either as a defense tool against the pathogen or a nutrient source. Graham and Graham (1991) reported that the activities of Pectolytic enzymes which dissolves the middle lamella is strongly inhibited by Ca^{2+} and this explains the positive correlation between Ca concentration of tissues and their resistance to fungal and bacterial diseases. Similarly, the significant and consistent reduction of FL and TA in the diseased samples might probably be due to their use as defense arsenals. Results also revealed consistent higher concentrations of AL in diseased samples. Alkaloid is a nitrogenous compound and its increase in the diseased samples might be linked to the high protein concentration among diseased samples. Higher saponins were found in diseased samples of NCe011 and NCe012 than those of NCe001 and BLS/158. The higher saponins in these varieties might be related to their relative ability to resist the scourge of TLB in the field trials than their counterparts. The reduction of phenolic compounds in the diseased tissues reflects their use as precursors of lignin and suberin biosynthesis for the strengthening of cell wall and inhibiting pathogen invasion (Graham and Graham, 1991). The presence of higher phenolic compounds in the healthy corms affirms the antioxidant potentials of taro. Crude extracts of plants rich in phenolics are increasingly of interest in the food industry because they retard oxidative degradation of lipids and thus improve the quality and nutritional values of food (Javanmardia *et al*., 2003). Flavonoids and phenolic acids are known to possess antioxidant activities due to the presence of hydroxyl groups in their structures and their redox properties (Zahid *et al*., 2015). In conclusion, remarkable depletion in proximate and phytochemical constituents of taro corms due to TLB infection has been established, therefore, the need to tackle this disease problem before and after harvest.

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