IN-VITRO EVALUATON OF ANTI-NUTRIENT, ANTI-OXIDANT AND PROXIMATE PROPERTIES OF CABBAGE *(BRASSICA OLERACEA)* SPECIES IN JOS PLATEAU STATE NIGERIA

[1*]OGBU K. I., [2]NWITE P. O., [3]OLAIYA D. O., [1]ENOCH V. A., [2]IGUISI U. M., [2]OLARENWAJU D. O., [4]CHUKWUDI I. C.

[1]Department of Animal Health, Federal College of Animal Health and Production Technology, National Veterinary Research Institute Vom, Plateau State, Nigeria

[2]Department of Agricultural Technology, Federal College of Animal Health and Production Technology, National Veterinary Research Institute Vom, Plateau State, Nigeria

[3]Department of Animal Production, Federal College of Animal Health and Production Technology, National Veterinary Research Institute Vom, Plateau State, Nigeria

[4]Department of Veterinary Medicine, Faculty of Veterinary Medicine, University of Nigeria Nsukka, Enugu State, Nigeria

[*]**Corresponding author**: drken2016@gmail.com; ogbu.kenneth@fcahptvom.edu.ng; +2348030852357; ORCID: 0000-0003-0924-1604

ABSTRACT

This study was carried out to determine and compare the proximate, anti-nutrient and antioxidant properties of 3 Brassica oleracea varieties (green, red and chinese) cabbage respectively. Fresh samples of the 3 Brassica oleracea peviridis, (green cabbage), Brassica oleracea rupetris (red cabbage) and Brassica oleracea rupa (chinese cabbage) were collected from Bukuru market of jos south LGA, Gwol market of Barikin ladi LGA and Qui market of Riyom LGA, the samples were identified and processed according to the method of Thompson, (2003) of which it was taken to the Biochemistry laboratory of the National Veterinary Research institute vom. Each of the 3 varieties were analyzed for proximate composition, anti-nutrient and antioxidant scavenging activity. The proximate analysis showed that Brassica oleracea rupa (chinese cabbage) has more dietary nutritional properties such as high crude protein (C.P) and high crude fiber (C.F) while Brassica oleracea peviridis (green cabbage) has more mineral properties such as Ash, Phosphorus, Nitrogen free extract (NFE) and Metabolizable energy (M.E). The anti-nutrient analysis showed that both Brassica oleracea rupa (chinese cabbage) and Brassica oleracea

rupetris (red cabbage) have higher concentration of phytic acid, tannin and oxalate compared to Brassica oleracea peviridis (green cabbage). Equally the antioxidant analysis showed that Brassica oleracea peviridis (green cabbage) has the highest antioxidant scavenging activity. In conclusion, Green cabbage (Brassica oleracea peviridis) consist of high mineral properties, less anti-nutrient compounds and high antioxidant scavenging activity making it the most suitable variety for both animal and human consumption out of the 3 Brassica oleracea species.
Keywords: *Cabbage Species, In-Vitro, Anti-Nutrient, Anti-Oxidant, Proximate Properties, Jos Plateau State*

INTRODUCTION

Cabbage *(Brassica oleracea)* is one of the most important vegetables grown worldwide. It belongs to the family *Cruciferae,* which includes broccoli, cauliflower, and kale. Vegetables have a wide area of application and nutritional values. Each however, requires certain minimum quality of nutrition because the principle of nutrition for all animals is anchored on the whole content of balanced diet (Hall, 1998). *Brassica oleracea* (cabbage) is a plant of *Brassicacea (or Cruciferae).* It is an herbaceous, biennial and dicotyledonous flowering plant with leaves forming a characteristic compact cluster. The most commonly grown varieties of *Brassica oleracea* on Jos, Plateau are the Green, Red and Chinese cabbage respectively in their order of demand. The favorable climatic condition of Jos, Plateau contributes immensely to the commercial and subsistence production of these three varieties (Osagie, 1998).Increasing the nutritional contents of vegetables with agricultural practices is one of the ways of improving the micronutrient contents in food crops (Bernacchia *et al.,* 2016). This can be through the manipulation of factors governing soil nutrient availability. Soil pH is part of the main factors that govern the solubility and bioavailability of soil elements leading to the accumulation of nutrients in plants (Clemente *et al.,*2005). Other factors include soil physical, chemical, and biological properties, as they condition plant growth and survival in soil (Bernacchia *et al.,* 2016).

Brassica oleracea has both nutritional and medicinal benefits. The nutritional benefits among others include it's been a rich source of nutrients such as Minerals (Ca, K, P, Fe, Mg and Zn), Vitamins such as B-complex vitamins and ascorbic acid, Carbohydrates, fats, proteins and water (Rosa, 1997).The medicinal health benefits are a function of the nutritional properties some of which include lower risk of heart attack, birth defects, lung cancer, obesity and intestinal un-comfortability (Osagie, 1998).

Several studies have indicated that vegetable such as cabbage has good nutritive value and has potential for use as livestock feed (Wadhwa *et al.,* 2006; Tobias *et al.,* 2010; Wadhwa *et al.,* 2013). Cabbage may be fed freshly chopped or processed, such as when dried, composited in feed. Vegetable such as cabbage could be transformed into value added products (Laxmi *et al.,* 2015). This non-conventional feed is highly sought after in arid regions, especially as maintenance feed during the dry season. Cabbage and cauliflower leaves have been reported to serve as excellent sources of nutrients for ruminants and can economize the production of animals (Wadhwa *et al.,* 2006). Also Gupta *et al*., (1993) and Miller-Cebert *et al*., (200) have confirmed that cabbage contains 86 - 140 g dry matter (DM)/kg, 137 - 280 g crude protein (CP)/kg DM, 9 - 17 g ether extract (EE)/kg DM and 186 g crude fibre (CF)/kg DM. In addition, 10.2 MJ

metabolizable energy (ME)/kg DM, an 80.4% *in vitro* dry matter digestibility (IVDMD) (Mekasha *et al*., 2002) and 84% total digestible nutrients (TDN) (NRC, 2007) were reported for cabbage, making it a good source of nutrients for ruminants.

However, *Brassica oleracea* varieties also contains corresponding high amount of anti-nutrients such asS-methyl-L-cysteine, sulphoxide and glucosinolates that depress intake by ruminants (Ahmadiani *et al.,* 2014). Phytic acid, cyanides, oxalate, tannins and glycosides have also been discovered which makes some of the mineral nutrients bio-unavailable due to process of chelation. Prolonged bio-unavailability of essential nutrients can result to metabolic derangement and consequently leads to dietary deficiency diseases (Chipman, 1978). The liver is one of the largest delicate and complex organs in the body with enormous functions among which includes osmo-regulation, detoxification and metabolism. Some of the normal roles of the liver may be altered if tissue injury occurs at specific sites. This is the case with prolonged use of the immuno-suppressive plant extract of *Brassica oleracea*for nutritional and medicinal purposes.

Due to its antioxidant, anti-inflammatory and antibacterial properties, cabbage has widespread use in traditional medicine, in alleviation of symptoms associated with gastrointestinal disorders (gastritis, peptic and duodenal ulcers, irritable bowel syndrome) as well as in treatment of minor cuts and wounds and mastitis. Fresh cabbage juice, prepared either separately or mixed with other vegetables such as carrot and celery, is often included in many commercial weight-loss diets (Samec, 2011), diets that improve the bioavailable content of non-heme iron (Chiplonkar *et al.,* 1999), as well as alternative therapies for cancer patients (Maritess *et al.,* 2005). Clinical research has shown positive effects of cabbage consumption in healing peptic ulcers (Cheney, 1949), and facilitating the reduction of serum LDL levels (Suido *et al.,* 2002). There are many reports about the phenolic substances and antioxidant activity of cabbage, many of them have focused on the Chinese cabbage or the red cabbage (Ahmadiani *et al.,* 2014). Seong *et al.,* (2016) studied the antioxidant capacities and polyphenolics of Chinese cabbage leaves, Watanabe *et al.,* (2011) investigated the polyphenol content and antioxidant activity of orange colored Chinese cabbage. Mizgier *et al.,* (2016) reported the characterization of phenolic compounds and antioxidant properties of red cabbage. Leja *et al.,* (2010) found phenolic compounds as the major antioxidant in red cabbage. Nonetheless, the systematic analysis of phytochemicals in cabbages and the comparisons between the different cabbage varieties were limited.

Chemical components analysis has shown that the main constituents of cabbage are carbohydrates, comprising nearly 90% of the dry weight, where approximately one third is dietary fiber and two thirds are low-molecular-weight carbohydrates (LMWC). Other characteristic components are glucosinolates (Wennberg *et al.,* 2006). Interest in the role of free radical scavenging-antioxidants in human health has prompted research in the fields of horticulture and food science to assess the antioxidant phytochemicals in fruits and vegetables.

Some studies have been conducted to quantify the phenolic compounds, carotenoids, vitamin C, and antioxidant potential Nilsson *et al.,*(2006) and Kusznierewicz *et al.,*(2008). The antioxidant properties were tested in many studies by using different approaches (Liu *et al.,* (2008) and Zanfini *et al.,*(2010). The content of antioxidants depends on a lot of factors, especially on cultivars, stage of maturity and growing conditions (Hart and Scott, 1995). These antioxidants exist in nature in

combination, and in combination they certainly cooperate on total antioxidant activity. The functional quality and antioxidant constituents of cabbage heads are strongly influenced by environmental factors and genetics.

The ferric reducing antioxidant power (FRAP), Trolox equivalent antioxidant capacity (TEAC) and Free radical scavenging activity (DPPH) assays are the three most frequently used for assessing the antioxidant activities (Magalhaes *et al.,* 2008).

The absence of antioxidant in dietary foods and vegetables is the primary causes of oxidative stress build up in the body which has been the root cause of the development and progression of several diseases by damaging vital molecules in animal cells including DNA and proteins which are responsible for many body processes (Kasote *et al.,* 2013)

MATERIALS AND METHOD

Study area/study location

The experiment was conducted in the toxicology laboratory of the National Veterinary Research Institute NVRI Vom, Vom a village on the out skirts of Jos Plateau state, the capital of Plateau state Nigeria, Vom lies on Longitude 8˚45E and Latitude 9˚48N and has an altitude of about 1280m above sea level.

Collection and preparation of plant material

Fresh samples of each of the 3 commonly grown varieties of *Brassica oleraceapeviridis, Brassica oleracearupetris,* and *Brassica oleracea nepa* (green, red, and Chinese cabbage) respectively was collected from Bukuru market of Jos south L.G.A, gwol market of Barikin ladi L.G.A and Qui market of Riyom L.G.A. The samples were identified and processed according to (Thompson, 2003), washed with distilled water, dried in hot air oven at 35ºC, grinded and stored in a polyethylene bags at 4ºC which was then taken to the Biochemistry laboratory of National Veterinary Institute (N.V.R.I) vom Jos Plateau state for analysis according to Association of Official Analytical Chemists (AOAC, 1990).

Proximate Analysis

Proximate composition (moisture, ash, fat, protein, crude fiber and carbohydrate of *Brassica oleracea spp* was determined using the method of Association of Official Analytical Chemists (1990).

Determination of moisture content

A crucible was thoroughly washed and dried in the oven at 100 °C for 30 minutes and allowed to cool inside desiccator. After cooling, it was weighed and the weight recorded as (W1). 1 gram of the sample were poured into crucible and weighed, the weight recorded as (W2). Then, the sample plus the crucible were placed in an oven at 100 °C for 2 hours, cooled in a desiccator and weighed for 30 minutes. The process was repeated until a constant weight was obtained as (W3). The values obtained were used to calculate the percentage of moisture content.

Determination of crude fiber

1 g of the sample was hydrolyzed in a beaker with petroleum ether after which it was refluxed for 30 minutes with 200 ml of a solution containing 1.25% H2SO4 per 100 ml of solution. The solution was filtered through filter paper. After filtration, the sample was washed in the boiled water until the sample was no longer acidic. The residue was transferred through filter crucible and dried at 100 °C for 2hours. The percentage crude fiber was thus calculated from the weight after drying and the weight of the sample.

Determination of ash content

1 g of the sample was weighed into a previously ignited and weighed crucible. The crucible and content were ignited in a preheated muffle furnace at 650 °C for 2 hours. The crucible was cooled in a

desiccator to a constant weight, weighed and percentage ash content was calculated.

Crude fat determination

This was done by soxhlet extraction method. 250 ml clean flask was dried in an oven at 105-110 °C for about 30 minutes. 1g of the dried sample was weighed accurately into labelled thimble then corresponding labelled cooled boiling flask was weighed. The boiling flask was filled about 100 ml of petroleum ether (Boiling point 40-60 °C). Extraction thimble was plugged lightly with cotton wool while the soxhlet extractor apparatus was assembled and reflux for about 3 hours. The thimble was removed with care and petroleum ether collected on the top container of the set up and drained into flask for re-use. When the flask was free of petroleum ether, it was removed and dried at 105-110 °C for 1 hour. The flask was transferred from the oven into a desiccator and allowed to cool, and then weigh. The weight obtained were used to calculate the percentage fat.

Determination of protein

This was done by Kjeldah method which remains the most popular method of protein determination.

(a) Protein digestion: 1g of sample was weighed into a Kjeldah flask. 5g of anhydrous sodium sulphate was added. This was followed up with the addition of 1g of copper sulphate and 1 tablet of Kjeldah catalyst. Into the mixture, 25 ml of concentrated sulphuric acid and 5 glass beads were introduced. In the fume cupboard, heating was done gently at first and then increased in heat with occasional shaking till solution assumes a green colour. The black particle showing at the tip and neck of the flask was cooled and washed with the distilled water. Reheating was done gently at first until the green colour disappeared and then allowed to cool. After the cooling, the digest was transferred with several washings into a 250 ml volumetric flask and filled to the mark with distilled water. Distillation was done using distillation apparatus.

(b) Protein distillation: The distillation apparatus was steamed for about 15minutes before usage. Under the condenser, 100 ml conical flask containing 5 ml of boric acid indicator was placed such that the condenser tip was under the liquid. 5 ml of the digest was pipette into the body of apparatus through a small funnel aperture; the digest was washed down with distilled water followed by 5 ml of 60% NaOH solution. The mixture was steamed thoroughly for about 5-7 minutes to collect enough ammonium sulphate. Then receiving flask and the condensed water were removed. Titration of the solution was made in the receiving flask using (0.1 M) sulphuric acid and calculation of the nitrogen content was done.

Determination of carbohydrate

The total carbohydrate content of the sample was obtained from the relation; percentage carbohydrate = 100% - (moisture + ash + fat + crude fiber + protein) %

Anti-nutritional Analysis

Oxalate determination

In the determination of total oxalate, 1g of the sample, 75cm3 of 15N H_2SO_4 was added. The solution was carefully stirred intermittently with a magnetic stirrer for 1hr and filtered using what-man No1 filter paper. 25cm3 of the filtrate was then collected and titrated against 0.1N $KMnO_4$ solution until a faint pink color appeared that persisted for 30sec (Umar *et al.,* 2007).

Phytate determination

For determination of phytate, 4g of the sample were soaked in 100cm3 of 2% HCl for 5hours and filtered. To 25cm3 of the filtrate, 5cm3 of 0.3% ammonium thiocyanate solution was added. The mixture was then titrated with iron (III) chloride solution until a brownish-yellow color that persisted for 5minutes was obtained (Reddy*et al.,* 1999).

Tannin determination

The tannin content was determined using Folin Denis reagent, in that method, a standard calibration curve was prepared and the Absorbance (A) against concentration of tannins at specific wave length was estimated as follows: Suitable aliquots of the tannin-containing extract (initially: 0.05, 0.2 and 0.5cm3) were pipetted in test tubes, the volume was made up to 1.00cm3 with distilled water, then 2.5cm3 of sodium carbonate reagent were added. The tubes were shaken and the absorbance was recorded at 725nm after 40 min. The amount of tannin was calculated as tannic acid equivalent from the standard curve (Abdel *et al.,* 2007).

Antioxidant analysis

2, 2-Diphenyl-1-picrylhydrazyl (DPPH) Assay was used for this analysis which is popular in natural product antioxidant studies (Liu *et al.,* 2008).

Study design

The data obtained was expressed in replicates of mean + standard error of the means (mean + SEM). Significant differences between means was determined by the student t-test (Bailey, 1992). The value of $p<0.05$ was regarded as significant for statistical comparison in all cases. Graph Pad Prism, Version 5.0, San Diego, CA was the statistical package used.

RESULT

Table 1: Proximate composition of *B. oleracea* species (Green, Red and Chinese) cabbage

Sample	Chinese cabbage	Green cabbage	Red cabbage	P-value
Moisture	7.13±3.43	5.25±0.00	6.33±0.00	0.541
C.P	5.67±1.16	5.47±0.90	5.11±0.20	0.736
C.F	11.80±3.11	7.00±3.04	7.06±2.54	0.147
Lipid	0.10±0.00	0.40±0.00	2.15±0.00	0.020
Ash	2.25±0.00	6.15±0.00	5.10±0.17	0.000
N.F.E	6.37±2.27	9.35±1.11	8.26±2.20	0.242
M.E	48.4±2.71	62.9±22.40	56.85±31.42	0.739
Calcium	2.28±0.49	0.33±0.00	0.76±0.00	0.000
Phosphorus	0.04±0.00	0.05±0.00	0.02±0.01	0.017

The result in Table 1 showed that the moisture content in the chinese cabbage is higher compared to green and red cabbage with 7.13±3.43 in chinese cabbage, red cabbage 6.33±0.00 and green cabbage 5.25±0.00 with($P>0.05$) which indicate there is no significance difference between them. The crude protein C.P showed that chinese cabbage has the highest C.P with 5.67±1.16, green cabbage 5.47±0.90 and red cabbage 5.11±0.20 with ($P> 0.05$) which indicate there is no significant difference between them. The crude fiber C.F showed that the chinese cabbage has the highest C.F with 11.80±3.11, red cabbage 7.06±2.54 and green cabbage 7.00±3.04 with ($P>0.05$) which indicate there is no significant difference between them. Lipid showed that the red cabbage has the highest 2.15±0.00, green 0.40±0.00 and chinese cabbage 0.10±0.00 with ($P<0.05$) which indicate there is significant difference between them. The Ash content showed that green cabbage has the highest with 6.15±0.00, red cabbage 5.10±0.17 and chinese cabbage 2.25±0.00 with ($P<0.05$) indicating there is significant difference between them. The nitrogen free extract NFE showed that the green cabbage

has the highest with 9.35±1.11 and red cabbage 8.26±2.20, chinese cabbage 6.37±2.27 with (P>0.05) which indicate there is no significant difference between them. The metabolizable energy M.E was seen to be high in the green cabbage with 62.9±22.40, red cabbage has 56.85±31.42 and chinese cabbage 48.4±2.71 with (P>0.05) which indicate that there is no significant difference between them. Calcium showed that there was significant difference between the 3 varieties with (P<0.05) chinese cabbage having the highest with 0.33±0.00. Phosphorus also showed that there was significant difference between the 3 varieties with (P<0.05) green cabbage having the highest 0.05±0.00, chinese cabbage having 0.04±0.00 and red cabbage having 0.02±0.01.

Table 2: Anti-nutrient analysis on*B. oleracea*species (Green, Red and Chinese) cabbage

Anti-Nutrient (mg/100g)	Green cabbage	Red cabbage	Chinese cabbage	P-values
Phytic acid	10.12 ± 1.52	15.88 ± 0.75	18.26 ± 1.32	0.108
Tannins	1.72 ± 0.54	2.63 ± 0.41	2.55 ± 0.35	0.678
Oxalate	112.50 ± 4.56	130.00 ± 3.48	220.00 ± 5.74	0.009

The result in Table 2 showed that the amount of phytic acid in chinese cabbage is higher 18.26±1.32 than red cabbage 15.88±0.75 and green cabbage being the lowest 10.12±1.52 with (P>0.05) which indicate there is no significant difference between them. Tannins was seen to be in high concentration in the red cabbage 2.63±0.41 compared to chinese cabbage 2.55±0.35 and green cabbage being the lowest 1.72±0.54 with (P>0.05) indicating that there was no significant difference between them. Lastly oxalate was seen to be in high concentration in the chinese cabbage 220.00±5.74 compared to red cabbage 130.00±3.48 and green cabbage been the lowest 112.50±4.56 with (P<0.05) which indicate there is significant difference.

Table 3: Antioxidant analysis on *B. Oleracea* species (Green, Red and Chinese) cabbage using DPPH assay

Average /µg/ml/2mg/ml Std Vit. C	Chinese cabbage	Green cabbage	Red cabbage	P- value
200ml	28.33±6.65	24.33±9.81	26.66±2.88	0.791
150ml	26.33±6.35	20.33±8.8	25.33±4.50	0.517
100ml	25.00±5.00	19.33±1.15	24.66±5.50	0.276
75ml	17.66±4.04	16.33±2.30	22.66±4.04	0.150
50ml	10.00±0.00	14.33±1.15	20.33±8.08	0.092
25ml	8.33±2.88	14.66±8.08	7.66±4.04	0.298
15ml	4.33±1.15	9.33±1.15	6.66±2.88	0.050
5ml	3.00±0.00	7.33±2.51	3.33±0.59	0.021

Using vitamin C at 2mg/ml as a standard antioxidant in DPPH assay according to Liu et al., (2008), the result was expressed in various concentration levels and assed for

scavenging radicals. At 200ml, chinese cabbage has the highest 28.66±2.88 and green cabbage having the lowest 24.33±9.81 with (P>0.05) which indicate no significant difference between them. At 150ml also chinese cabbage has the highest 26.33±6.35, Red cabbage having 25.33±4.50 and green cabbage having the lowest 20.33±8.80 with (P>0.05) which indicate there is no significant difference between them. At 100ml, there is also no significant difference between them (P>0.05 with chinese cabbage having the highest 25.00±5.00, red cabbage having 24.66±5.50 and green cabbage having the lowest value 19.33±1.15. At 75ml, red cabbage having the highest value of 22.66±4.04 and green cabbage having the lowest value 16.33±2.30 with (P>0.05) which indicate there is no significant difference between them. At 50ml, red cabbage has the highest value with 20.33±8.08, green cabbage having 14.33±1.15 and chinese cabbage having the lowest with 10.00±0.00 with (P>0.05) which indicate no significant difference between them. At 25ml, green cabbage has the highest value of 14.66±8.08 and chinese cabbage 8.33±2.88 and red cabbage having the lowest value of 7.66±4.04 with a (P>0.05) which indicate there is no significant difference between them. At 15ml green cabbage was seen to have the highest value of 9.33±1.15 and red cabbage has 6.66±2.88 and chinese cabbage has the lowest with (P<0.05) which indicate there is significant difference between the 3 varieties. At 5ml, there is also a significant difference between the 3 varieties with green cabbage having the highest value of 7.33±2.51 and red cabbage having 3.33±0.59, chinese cabbage having the lowest value of 3.00±0.00 (P<0.05).

DISCUSSION

The result in Table 1 showed that moisture content in *Brassica oleracea rupa* (chinese cabbage) is higher compared to *B. oleracea rupetris* and *B. oleracea peviridis* (red and green) cabbage of which there was no significant difference between them (Tunde, 1998). High moisture content above 15% in fruit and vegetables was reported by Rumeza *et al.,* (2006) to favour microbial activity during storage. There was no significant difference between the crude fiber (CF), crude protein (CP), ash, nitrogen free extract (NFE), metabolizable energy (ME), phosphorus and calcium with (P>0.05). this research disagrees with the study of Mohammed and Luka, (2013) who stated that there was significant difference between the proximate parameters of the 3 varieties of *Brassica oleracea species* (green, red and chinese) cabbage in his study. This could be attributed to the location and environmental factors such as Temperature, humidity, rainfall, soil nutrient and soil pH in which the samples where obtained from (Bernacchia *et al.,* 2016). Soil pH is part of the main factor governing the solubility and bioavailability of soil element leading to accumulation of nutrient in plant (Clemente *et al.,* 2005). The age and stage of harvesting the Brassica species could also influence the nutrient availability of the plant (Bohinc *et al.,* 2012).

The result in Table 2 showed a high level of phytic acid in *B. oleracea rupa* (chinese cabbage) compared to *B. oleracea rupetris* and *B. oleracea peviridis* (red and green cabbage) with (P>0.05) indicating that there is no significant difference between them. Tannin was also observed to be higher in both *B. oleracea rupa* and *B. oleracea rupetris* (chinese and red cabbage) with (P>0.05) indicating no significant difference between them. This result agrees with the study of Mohammed and Luka, (2020) that both phytic acid and tannin were observed to be in high concentration in both *B. oleracea rupa* and *B. oleracea rupetris* (chinese and red cabbage). Oxalate on the other hand was observed to be significantly low in the green cabbage *B. oleracea peviridis* compared to

the chinese and red cabbage (*B. oleracea rupa* and *B. oleracea rupetris*) with (P<0.05).

The result in table 3 showed the scavenging activities of free radicals using DPPH assay at different level of concentrations using vitamin C as a standard (Malencic *et al.,* 2000). the result starting from 200ml-25 ml at the range of 10µg - 20µgshowed that there was no significant difference with (P>0.05). This result is in line with Ayushi *et al.,* (2017) who stated that *B. oleracae*leave exhibited high scavenging activity at IC_{50} (20µg/ml). At 15ml and 5ml there was significant difference between the 3 variety of *B. oleracae*with green cabbage showing a high level of scavenging activity. This agrees with the study of Woolley, (2015) that maximum DPPH scavenging activities were found in aqueous extract of *B. oleracae peviridis* (green cabbage).

CONCLUSION

The result from the proximate analysis showed that *B. oleracae rupa* (chinese cabbage) has more dietary nutritional properties such as high crude protein and crude fiber while *B. oleracae peviridis* (green cabbage) has more vitamins and mineral properties such as Ash, Phosphorus, Nitrogen free extract (NFE) and Metabolizable energy (ME). The Anti-nutrient analysis showed that both *B. oleracea rupa* and *B. oleracea rupetris* (chinese and red cabbage) have higher concentration of phytic acid, Tannin and Oxalate than *B. oleracae peviridis* (green cabbage) while the Antioxidant analysis showed the green cabbage (*B. oleracae peviridis)* has the highest scavenging activities making green cabbage the most suitable variety for both animal and human consumption among the 3 varieties of *B. oleracae*species.

RECOMMENDATIONS

- *Brassica oleracea peviridis*(green cabbage) could be used as feed supplement to feed animals conveniently
- Further research should be carried out on how to improve the dietary nutrient such as crude protein CP, and crude fiber CF of *Brassica oleracea peviridis*(green cabbage)
- Method and techniques on how to lower the Anti-nutrient should be adopted to reduce the risk factor of chronic health disorder associated with plant Anti-nutrient

REFERENCE

Abdel, M.S, Fatima, MI, Elamin, AE. (2007). Quantitative determination of tannin content in some sorghum cultivars and evaluation of its antimicrobial activity. *Research Journal of Microbiology*, **2:** 284 - 288.

Ahmadiani, N., Robbins, R. J., Collins, T. M., & Giusti, M. M. (2014). Anthocyanins contents, profiles, and color characteristics of red cabbage extracts from different cultivars and maturity stages. *Journal of Agricultural and Food Chemistry,* 62(30), 7524–7531.

AOAC. (1990). Official methods of analysis, 14th edition, *Association of Official Analytical Chemists,* Washington DC.

Ayushi Agarwal, Nishtha Raj and Neelam Chaturvedi. (2017). A Comparative Study on Proximate and Antioxidant Activity of *Brassica oleracea* (Kale) and *Spinacea oleracea* (Spinach) Leaves. *International Journal of Advance Research Biological Science* 4(4): 22-29.

Bernacchia, R., Preti, R. & Vinci, G. (2016). Organic and conventional foods: Differences in nutrients. *Italian Journal ofFood Science*, *28*(4), 565 – 578.

Bohinc, T and Trdan, S. (2012). Environmental factors affecting the glucosinolate content in Brassicaceae. *Journal of Food Agriculture and Environment*, **10:** 357–360.

Cheney G (1949). Rapid healing of peptic ulcers in patients receiving fresh cabbage juice. *California Medicine*, **70**, 10-5.

Chiplonkar SA, Tarwadi KV, Kavedia RB, (1999). Fortication of vegetarian diets for increasing bioavailable iron density using green leafy vegetables. *Food Research International journal*, **32**, 169-74.

Chipman E.W and E. Thorpe. Effects of maturity and frost on the leaf colour of storage cabbage.*Canadian journal of plant science.1978, 59: 429-435*

Clemente, R., Walker, D.J. & Bernal, M.P. (2005). Uptake of heavy metals and as by Brassica juncea grown in a contaminated soil in Aznalcóllar (Spain): The effect of soil amendments. *Environmental Pollution*, *138*(1), 46 – 58.

Gupta, R. K., Gangoliya, S. S., & Singh, N. K. (2015). Reduction of phytic acid andenhancement of bioavailable micronutrients in food grains. *Journal of Food Science and Technology*, 52(2), 676–684.

Hall,R.*Brassicaoleraceae*(AcephalaGroup). USDA Database for Standard Reference,Release 12 (March, 1998). *about.com. Nutrition guide. http://www.nutrition.about.com. Accessed10/4/2009*.

Hart DJ, Scott KJ (1995). Development and evaluation of an HPLC method for the analysis of carotenoids in foods, and the measurement of the carotenoids content of vegetables and fruits commonly consumed in the UK. *Food Chemistry*, **54**, 101-11.

Kasote DM, Hegde MV, Katyare SS. Mitochondrial dysfunction in psychiatricand neurological diseases: cause(s), consequence(s), and implications of antioxidant therapy. Bio-factors 2013; 39: 392-06.

Kusznierewicz B, Bartoszek A, Wolska L, (2008). Partial characterization of white cabbages (Brassica oleracea var. capitata f. alba) from different regions by glucosinolates, bioactive compounds, total antioxidant activities and proteins. *LWT – Food Science Technology*, **41**, 1-9.

Laxmi, G., Chaturvedi, N., & Richa, S. (2015). The impact of malting on nutritionalcomposition of foxtail millet, wheat and chickpea. *Journal of Nutrition and Food Sciences*, 5(5), 1–3.

Leja, M., Kamińska, I., & Kołton, A. (2010). Phenolic compounds as the major antioxidants in red cabbage. *Folia Horticulture*, 22(1), 19–24.

Liu D, Shi J, Ibarra AC, (2008). The scavenging capacity and synergistic effects of lycopene, vitamin E, vitamin C, and b-carotene mixtures on the DPPH free radical. *LWT - Food Science Technology*, **41**, 1344-9.

Magalhaes LM, Segundo MA, Reis S, (2008). Methodological aspects about in vitro evaluation of antioxidant properties. *Analytical Chemistry Act,* **613**, 1-19.

Malencic, D., Gasic, O., Popovic, M., Boza, P. (2000). Screening for antioxidant properties of *Salvia reflexa hornem. Phytochemical Research*. 5:546-548.

Maritess C, Small S, Waltz-Hill M (2005). Alternative nutrition therapies in cancer patients. *Sem Oncol Nursing*, **21**, 173-6.

Miller-Cebert, R., Sistani, N and Cebert, E. (2009). Comparative protein and folate content among canola cultivars and other cruciferous leafy vegetables. *Journal of Food Agricultureand Environment*, **7:** 46–49.

Mizgier, P., Kucharska, A. Z., Sokół-Łętowska, A., Kolniak-Ostek, J., Kidoń, M., &Fecka, I. (2016). Characterization of phenolic compounds and antioxidant and anti-inflammatory properties of red cabbage and purple carrot extracts. *Journal of Functional Foods,* 21, 133–146.

Mohammed, Abdulrashid & Luka, C. (2020). Comparative Analysis of the Different Brassica OleraceaVarieties Grown on Jos, Plateau Using Albino Rats. *Journal of Applied Life Sciences International*6. 85-88.

Nilsson J, Olsson K, Engqvist G, (2006). Variation in the content of glucosinolates, hydroxycinnamic acids, carotenoids, total antioxidant capacity and low-molecular-weight carbohydrates in Brassica vegetables. *Journal of Science Food Agriculture*, **86**, 528-38.

Osagie, A.U,*Anti-nutritional factors in nutritional quality of plant food*,1998,Pg 221-244

Rosen, C.J., Fritz, V.A., Gardner, G.M., Hecht, S.S., Carmella, S.G. and Kenney, P.M. (2005).Cabbage yield and glucosinolate concentrations as affected by nitrogen and sulfur fertility. *Horticulture Science*, **40:** 1493–1498.

Samec D, Piljac-Zegarac J, Bogovi M, (2011). Antioxidant potency of white (Brassica oleracea L. var. capitata) and Chinese (Brassica rapa L. var. pekinensis (Lour.)) cabbage: The influence of development stage, cultivar choice and seed selection. *Science Horticulture*, **128**, 78-83.

Seong, G.-U., Hwang, I.-W., & Chung, S.-K. (2016). Antioxidant capacities and polyphenolics of Chinese cabbage (Brassica rapa L. ssp. Pekinensis) leaves. *Food Chemistry*, 199, 612–618.

Suido H, Tanaka T, Tabei T, (2002). Mixed green vegetable and fruit beverage decreased the serum level of low-density lipoprotein cholesterol in

hypercholesterolemic patients. *Journal of Agricultural Food Chemistry*, **50**, 3346-50.

Watanabe, M., Musumi, K., & Ayugase, J. (2011). Carotenoid pigment composition,polyphenol content, and antioxidant activities of extracts from orange-colored Chinese cabbage. LWT - *Food Science and Technology*, 44(9), 1971–1975.

Wennberg M, Ekvall J, Olsson K, (2006). Changes in carbohydrate and glucosinolate composition in white cabbage (Brassica oleracea var. capitata) during blanching and treatment with acetic acid. *Food Chemistry*, **95**, 226-36.

Westerveld, S.M., McKeown, A.W., Scott-Dupree, C.D. and McDonald, M.R. (2003). How welldo critical nitrogen concentration work for cabbage, carrot and onion crops? *Horticulture Science*, **38:** 1122–1128.

Zanfini A, Corbini G, La Rosa C, (2010). Antioxidant activity of tomato lipophilic extracts and interactions between carotenoids and atocopherol in synthetic mixtures. *LWT - Food Science Technology*, **43**, 67-72.