EFFECT OF *AMARANTHUS MOSAIC VIRUS* (AMV) AND BITTER LEAF MOSAIC VIRUS (BMV) ON GROWTH, PROXIMATE, NUTRIENT CONTENT AND SENSORY ACCEPTABILITY OF GREEN AMARANTH (*Amaranthus hybridus* L.)

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ABSTRACT
A greenhouse experiment was conducted to evaluate the effect of Bitter leaf mosaic virus (BMV) and Amaranthus mosaic virus (AMV) on growth response, proximate, nutrient composition and sensory acceptability of green amaranth (Amaranthus hybridus L.). The treatments comprised single and double inoculations of A. hybridus with AMV and BMV while buffer inoculated plants served as control. Data were collected from 1st to 8th week after inoculation (WAI) for plant height, number of leaves, and number of leaves with viral disease symptoms. Standard methods of the Association of Official Analytical Chemist were used for determining the proximate composition and sensory acceptability were carried out on the leaves at harvest. The results showed that the significantly highest percentage disease severity at 8 WAI was recorded in plants inoculated with AMV (19.3%) followed by BMV (16.2%) and BMV + AMV (15.1%). The growth parameters from the 5th to the 8th WAI indicated that AMV inoculated plants were the shortest plants (22.6 to 33.7cm) with the significantly lowest number of leaves (6.9 to 23.6cm) compared to the control plants which were the tallest. The analysis showed a depletion of the proximate and mineral contents of the leaves by the viruses. However, the sensory evaluation revealed overall general acceptability of the virus infected plants despite an aversion to the colour.

Key words: *Amaranthus* species, inoculation, mineral content, proximate analysis, vegetables, virus.

INTRODUCTION
Vegetable is an important contributor to human well being (Mepha *et al.,* 2007). They are usually responsible for more subtle feeling of daily well being and for protection from long term degenerated diseases (Raheena, 2007). African leafy vegetables are increasingly recognized as possible contributors of both micronutrients and bioactive compounds to the diets of populations in Africa (Smith and Eyzaguirre, 2007). The continent is rich of vegetable species including amaranths which are among the most popular leafy vegetables on the continent (Maundu *et al.,* 2009).

Amaranths consist of 60–70 species and include at least 17 species with edible leaves and three grain amaranths grown for their seeds (Grubben and Denton, 2004). Several amaranth species are often considered to be weeds, even though many people around the world consume it as leafy vegetables and cereal crop (Xu and Sun, 2001; Grubben and Denton, 2004; Trucco and Tranel 2011). *Amaranthus hybridus* is cultivated in several areas of the world including South America, Africa, India, China and the United States (He *et al*., 2002). It grows well in semi arid region such as southern Africa and its commercial production is increasing throughout the world as an important alternative food source (Rawate, 1983; Kauffma, and Weber, 1990).

In Africa amaranths are among the most important leafy vegetables, a fact attributed to their easy of cultivation, wide occurrence, low pests and diseases incidence, low labour input, ease in cooking and high nutritional value (Maundu *et al.,* 2009). Cultivation occurs in all agro-ecological zones of West Africa, from the coastal sector in the Guinean zone to the dry forests and herbaceous savannahs in the Sudanian zone. In Benin Republic, *Amaranthus* species are the most commonly cultivated and consumed African leafy vegetables throughout the country. (N'Danikou *et al.,* 2010).

Amaranthus hybridus is grown on a commercial scale in Southern Nigeria and constitutes a major part of the diet of the people of Nigeria, where they are mostly used in soups, because of their rich source of protein, minerals and vitamin C (Oke, 1980). It was reported that *A. hybridus* seed oil contained squalene which has important beneficial effects on cancers (Rao and Newmarj, 1998) and reduces cholesterol level in the blood (Miettinen and Vanhanen, 1994; Smith, 2000). *Amaranthus hybridus* production has been reduced by pest and disease attack. It is mostly affected by fungal diseases like, damping off caused by *Pythium* spp., stem canker by *Rhizoctonia* spp., *Alternaria* leaf spot, wet rot caused by *Choanephora cucurbitarum* (PROTA, 2004). The wet rot of *Amaranthus* causes a lot of damage if ignored, especially in the

endemic areas (Robert *et al.,* 2003). *C. cucurbitarum* affects portions of the stem which are cut during harvesting (Messiaen, 1994). In Africa, the high incidence of the disease adversely affects the cultivation of *Amaranthus* (Odebunmi-Oshilanu, 1977). In the humid tropics of Nigeria especially, the wet rot of *Amaranthus* reduces productivity of the crop (Awurum and Ogbonna, 2013).

Worldwide, diseases caused by virus have been recognized to constitute one of the major factors limiting vegetable production (Grogan, 1980). In most African countries, viruses are a major limiting factor to vegetable production and also serve as hosts to a number of other viruses (Nono-Womdim, 2003; Nyamupingidza and Machakaire, 2003). In 1988, a virus disease of *A. hybridus* named *Amaranthus mosaic virus* (AMV) was reported for the first time in Nigeria (Taiwo *et al.,* 1988). Since then, AMV has been found to be highly prevalent with an incidence rate of 19.7% (Taiwo and Owolabi, 2004). A recent study by Aliyu *et al.* (2014) showed the vulnerability of *Celosia argentea* to BMV virus infection with consequential reduction in the development of the vegetable.

The persistence of natural and recombinant virus genotypes depends on their competitive interactions at the individual and the ecosystem level (Hoover *et al.,* 1995). The distribution of any single virus within host plants is influenced by interaction of the virus and host, the environment, fitness of the virus strain, and grower management practices (William *et al.,* 2010). Virus distribution within plants is also influenced by interaction of the virus with other viruses or pathogens. The frequency with which two viruses are found occupying the same niche is a measure of the affinity for coexistence (Ludwig and Reynolds, 1988).

*Amaranthus mosaic virus*s has a restricted host range confined to a few species of the *Amaranthaceae, Chenopodiaceae* and *Solanaceae* families and there is no evidence of AMV transmission by seeds. The viral coat protein had a relative molecular mass (M(r)) of about 30.2 K. Electron microscopy of purified virus preparations revealed flexuous rod shaped particles of about 750 nm in length (Owolabi *et al.,* 1998). The virus isolated from *Vernonia amygdalina* Del. (bitterleaf) is mechanically transmissible but had a narrow host range restricted to *Nicotiana benthamiana, Chenopodium quinoa* and *C. amaranticolor.* The virus was purified from N. benthamiana and about 750 nm long flexuous rod-shaped particles were observed in purified preparations as well as in leaf-dips of *Vernonia* sp. Inclusion bodies in the form of pinwheels and scrolls were observed in ultrathin sections of Vernonia leaves by electron microscopy. M(r), of the viral coat protein was estimated to be about 34 K (Taiwo and Dijkstra, 2004). The objective of this study therefore was to document the effect of *Amaranthus mosaic virus* (AMV) and Bitter Leaf mosaic virus (BMV) on the growth, proximate/nutrient content and sensory acceptability of *Amaranthus hybridus.*

MATERIALS AND METHODS

Experimental design and plant propagation: The experiment was conducted at the Faculty of Agriculture, University of Ilorin and Biosciences Limited, Ibadan-Nigeria. *Amaranthus hybridus* seeds (NHAM/114) were obtained from the National Horticultural Research Institute (NIHORT), Ibadan. The viral inoculums (*Bitter leaf mosaic* virus and *Amaranthus mosaic virus*) were sourced from the Department of Crop Protection, University of Ilorin.

Ninety six (50 cm diameter) plastic pots were filled with sandy loam soil that was previously steam sterilized at 120°C for 240 minutes. The *A. hybridus* seeds were sown at the rate of ten seeds per bucket and later thinned to four stands per pot seven days thereafter The buckets were arranged in the greenhouse in a completely randomized design with 3 replications per treatment.. The treatments were as follows:

(i) Plants inoculated with *Bitter leaf mosaic virus* comprised of 24 pots and 96 plants.
(ii) Plants inoculated with *Amaranthus mosaic virus* comprised of 24 pots and 96 plants.
(iii) Plants inoculated with *Amaranthus mosaic virus and Bitter leaf Mosaic virus* comprised of 24 pots and 96 plants.
(iv) Buffer inoculated plants which served as control for the experiment comprised of 24 pots and 96 plants.

Inoculation procedure: The viral isolates were extracted from the infected leaves by homogenization, using mortar and pestle in 0.05M Phosphate buffer (2.72g KH_2PO_4 14.20g Na_2HPO_4 x $2H_2O$ 800 ml demineralised water set pH to 7.4 with NaOH and demineralised water to 1000 ml total volume) at the rate of 1g leaf sample to 5 ml of buffer. In all cases, the four plants in each pot were mechanically inoculated. Inoculation was done by mechanical transmission of virus through sap when the plants were at the four leaf stage. The sap was applied on the surface of the leaves previously sprinkled with carborundum (800 mesh), by gently rubbing the leaves with a cotton wool dipped in the sap. The control plants were buffer inoculated alone, after which all the plants were rinsed with water to reduce inoculation stress on them. Thereafter, all the necessary agronomic

practices were equally observed on all the treatment pots. This included hand weeding with hoes when needed and daily watering of plants twice daily at 7am and 5pm.

Data Collection: Data were collected from the 1st to the 8th week after inoculation (WAI) on plant height, number of leaves per plant, and number of leaves with virus disease symptoms. The percentage disease severity was measured by the number of diseased leaves relative to the total number of leaves on any given plant and this value was expressed as a percentage.

Preparation of samples for proximate and mineral analysis: The leafy vegetables were harvested at 9th WAI, and thoroughly washed differently with distilled water and air dried. The dried leaves were ground into powder using pestle and mortar. The ground portion was kept in a plastic bottle in a freezer prior analysis.

Proximate Analyses: Standard Methods of the Association of Official Analytical Chemists (AOAC, 1997) were used for determining the proximate composition of the leaves. Moisture content was determined by oven drying 10g each of virus inoculated and buffer inoculated leaf samples at 50^0 C to constant weights. Ash content was obtained by incinerating leaf samples in a muffle furnace at 550^0C for 30 minutes. Nitrogen was determined by the micro-kjeldahl method (Pearson, 1976) and the percentage of nitrogen was converted to crude protein by multiplying by 6.25. Fat content was determined gravimetrically after extraction with diethyl ether from an ammonical solution of the samples. The Crude fibre content was determined by acid – base digestion using 1.25% H_2SO_4 and 1.25% NaOH (w/v) solution, while carbohydrate value was calculated by difference.

Mineral Analysis: The minerals in the leafy vegetables were analysed from solution obtained when 2.0g of the samples were digested with concentrated nitric acid and concentrated per chloric acid in ratios 5:3, the mixtures were placed on a water bath for three hours at 80^oC as outlined by Asaolu *et al.* (2012). The resultant solution was cooled and filtered into 100ml standard flask and made to mark with distilled water (Asaolu, 1995). Atomic absorption spectro-photometer (Buck scientific model 200A by Beijing Beifen-Ruili Analytical Instrument Company limited) was then used for the analysis.

Sensory evaluation: Twenty panel members consisting of staff and students of the University of Ilorin were randomly selected for the sensory evaluation of the boiled fresh *Amaranth* leaves harvested at 9th WAI. Samples from each of the treatment pots were cooked in the same sauce preparation and determined for colour, taste, and overall acceptability as described by Ihekoronye and Ngoddy (1985). The samples were evaluated on a 7–point hedonic scale (1=disliked very much, 2=disliked much, 3=disliked moderately, 4=neither liked nor disliked, 5=like moderately, 6=like and 7=like very much) in the mid morning (11.00 a.m.) in a sensory evaluation laboratory under white light. Samples were presented in 3 digits code in plates. The order of presentation of the sample to the judges was randomized and the buffer inoculated *Amaranth* leaves cooked with the same sauce were used as control.

Data Analysis

All the data generated were subjected to analysis of variance (ANOVA) and where necessary, treatment means were separated using Duncan's Multiple Range Test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Effect of Viral Inoculation on plant height: Table 1 shows the effect of viral inoculation on plant height at different times after inoculation. It indicates there were no significant differences among the treatments at 1st week after inoculation. By the 2nd WAI however, the most significantly affected plants were those inoculated with AMV (11.2 cm) and combination of AMV + BMV (11.9 cm). At 3rd WAI the significantly affected plants were with the AMV inoculation (14.1 cm) followed by BMV (16.3 cm) and combination of AMV + BMV (18.6 cm). The result from the 5th - 8th WAI indicated that AMV inoculated plants were the shortest with the range of 22.6 - 33.7 cm, followed by BMV (25.4 - 38.5 cm) and AMV + BMV (31.3 - 46.6 cm). This result shows that virus inoculation caused a reduction in *Amaranth* plant heights overtime. This reduction was however most significant in AMV inoculated plants and the least in AMV + BMV inoculations. The finding is indicative of the pathogenic effect of the viruses on *A. hybridus* and is suggestive of the antagonistic effect of AMV and BMV considering its influence in this regard. Pazarlar *et al.* (2013) and Aliyu *et al.* (2014) reported stunting of some vegetables as a result of virus infection but the perceived antagonistic effect of AMV + BMV on plant height of *A. hybridus* as observed in this study is novel.

Effect of Virus Inoculation on percentage disease severity: The effect of virus inoculation on percentage disease severity is presented in Table 2. The effect of the treatment on the plants became apparent from the 3rd WAI. The significantly highest percentage disease severity was observed in plants inoculated with AMV (6.6%) followed by BMV (5.8%) and AMV + BMV (5.6%). At 4th WAI the significantly highest percentage disease

severity (11.2%) was reported in the AMV inoculated plants while AMV + BMV had the significantly lowest value (8.1%) among the virus inoculated. A consistent trend was observed such that at 8th WAI, the disease severity indicated AMV (19.3%), BMV (16.2%) and AMV + BMV (15.1%). The buffer inoculated plants which served as control also showed some level of infection although very minimal, probably be due to seed-borne infection. This is a confirmation of the work of Leisner and Howell (1993) who reported that many plant viruses move from cell to cell along with the flow of photoassimilates with increasing severity. The fact that AMV and BMV were more severe singly inoculated compared to AMV + BMV on *A. hybridus* suggest an antagonistic effect of the two viruses and is in tandem with the views of Oku (1994) that the interaction between two or more viruses could be synergistic, additive or antagonistic.

Effect of virus infection on average number of leaves per plant: The effect of virus inoculation treatments on the mean number of leaves per plant is shown in Table 3. The effect of the virus inoculated at 2nd WAI was significantly highest in the AMV inoculated plants which produced the lowest mean number of leaves per plant (6.9). The BMV and AMV + BMV inoculated plants were not significantly different from each other with values of 7.4 and 7.8, respectively. At the 3rd WAI the effect was also more pronounced in AMV (8.3) which was significantly different from BMV (10.1) and AMV + BMV (12.4) inoculated plants. This same trend of was observed at the 8th WAI with significantly lowest number of leaves per plant in AMV (23.6), followed BMV (27.4) and AMV + BMV (29.2). The significant reduction in the number of leaves observed in AMV inoculation could diminish the photosynthetic ability of the plants and reduced yield as noted by Stampar *et al.* (1999). The reduction in the number of leaves observed in the present study is attributed to higher infection severity of AMV as compared to BMV and AMV + BMV. Aliyu *et al.* (2014) also assessed the pathogenicity of *Cucumber mosaic virus* and *Bitter leaf mosaic virus* on *Celosia argentea* and reported similar findings.

Table 1: Effect of Viral Inoculation on plant height (cm) of *Amaranthus hybridus* at different times after inoculation

Treatment	1 WAI	2 WAI	3 WAI	4 WAI	5 WAI	6 WAI	7 WAI	8 WAI
BMV	5.3	12.6^{b}	16.3^{c}	19.6^{c}	25.4^{c}	31.0^{c}	34.7^{c}	38.5^{c}
AMV	5.4	11.2^{c}	14.1^{d}	18.9^{c}	22.6^{d}	27.4^{d}	30.3^{d}	33.7^{d}
BMV + AMV	5.5	11.9^{c}	18.6^{b}	25.5^{b}	31.3^{b}	37.4^{b}	42.2^{b}	46.6^{b}
BUFFER	5.2	14.8^{a}	21.2^{a}	28.9^{a}	36.1^{a}	44.2^{a}	49.9^{a}	54.1^{a}
S E M	0.012	2.126	1.006	3.826	1.652	2.805	2.227	1.876

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test. Key: BMV = *A. hybridus* inoculated with *Bitter leaf putative virus;* AMV = *A. hybridus* inoculated with *Amaranthus mosaic virus;* BMV + AMV = *A. hybridus* inoculated with *Bitter leaf mosaic virus* and *Amaranthus mosaic virus;* BUFFER = *Amaranthus* inoculated with buffer (control); WAI = week after inoculation.

Table 2: Effect of Viral infection on percentage disease severity at different times after inoculation

Treatment	1 WAI	2 WAI	3 WAI	4 WAI	5 WAI	6 WAI	7 WAI	8 WAI
BMV	0.1	2.2	5.8^{b}	8.9^{b}	10.1^{b}	12.9^{b}	15.4^{a}	16.2^{b}
AMV	0	2.8	6.6^{a}	9.4^{a}	11.2^{a}	13.6^{a}	16.7^{a}	19.3^{a}
BMV + AMV	0.1	2.6	5.6^{b}	8.1^{b}	9.9^{b}	11.6^{b}	13.1^{b}	15.1^{b}
BUFFER	0	2.6	2.7^{c}	3.0^{c}	3.1^{c}	3.3^{c}	3.4^{c}	3.6^{c}
S E M	0.001	0.121	0.397	0.665	0.712	0.662	1.12	1.321

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Table 3: Effect of virus infection on average number of leaves per plant at different times after inoculation

Treatment	1 WAI	2 WAI	3 WAI	4 WAI	5 WAI	6 WAI	7 WAI	8 WAI
BMV	4.4	7.4^{b}	10.1^{c}	12.6^{bc}	14.2^{c}	16.9^{c}	21.0^{c}	27.4^{c}
AMV	4.6	6.9^{c}	8.3^{d}	10.2^{d}	12.6^{c}	14.5^{cd}	17.9^{d}	23.6^{d}
BMV+ AMV	4.3	7.8^{b}	12.4^{b}	14.4^{b}	18.1^{b}	20.1^{b}	24.6^{b}	29.2^{bc}
BUFFER	4.4	8.9^{a}	15.3^{a}	18.6^{a}	24.7^{a}	26.8^{a}	34.4^{a}	37.7^{a}
S E M	0.011	1.221	2.021	1.332	2.983	3.732	2.322	3.614

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Table 4: Proximate analysis of virus and buffer infected *Amaranthus hybridus*

Proximate Composition (g/100g)	BMV	AMV	BMV + AMV	BUFFER
Protein	8.4^{c}	7.6^{cd}	10.2^{b}	16.8^{a}
Crude Fibre	3.6^{bc}	3.3^{c}	4.3^{b}	11.5^{a}
Fat	1.3^{c}	1.4^{c}	1.6^{b}	3.2^{a}
Carbohydrate	10.2^{ab}	11.1^{a}	8.4^{c}	6.1^{d}
Ash	14.0^{b}	13.9^{c}	14.6^{b}	16.6^{a}
Moisture	86.3^{b}	90.4^{a}	85.7^{b}	83.5^{c}

In each row, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Proximate analysis of virus and buffer infected *Amaranthus hybridus*: Table 4 is result of analysis of the virus infected and buffer infected *Amaranthus* leaves. The result indicated that the percentage protein content was significantly lowest in the AMV inoculated plants (7.6%), followed by BMV (8.4%) and 10.2% in the AMV + BMV inoculated plants, while the buffer inoculated plants had the highest value of 16.8%. The low protein values in the virus inoculated plants may be due to changes in the metabolic activity of the plants as a result of virus infection since viruses depend on the protein synthesis machinery of host cells for survival. This is in agreement with Yardimci *et al.* (2007) while determining the effects of AMV on the nutrient content of alfalfa plants but contrasts the work of White and Blakke (1982) that reported increased protein in barley infected with *Wheat spindle mosaic virus* (WSMV) and *Barley strip mosaic virus* (BSMV).

Crude fibre content ranged from 3.3% in the AMV inoculated plants to 4.3% in the AMV + BMV inoculated plants. The BMV and buffer inoculated plants were 3.6% and 11.5% respectively. The fat content was significantly highest in the buffer inoculated plants (3.2%), followed by AMV plus BMV inoculated plants (1.6%). The percentage fat content were not significantly different for AMV (1.4%) and BMV (1.3%) inoculated plants. The carbohydrate content was significantly highest in AMV inoculation (11.1%), followed by BMV inoculation (10.2%) and AMV + BMV inoculation (8.4%). The least carbohydrate content was in the buffer inoculated plants (6.1%). This finding is in agreement with Mofunanya *et al.* (2015) who reported that *A. hybridus* reaction to virus infection revealed marked reductions in the nutritional quality of the vegetable.

The ash content was significantly lowest in AMV inoculation (13.9%), followed by 14.0% in BMV and 14.6% in AMV plus BMV inoculation. The highest value was 16.6% in the buffer inoculated plants. These findings are in line with those of Mofunanya *et al.* (2008) and were attributed to higher levels of antioxidants in virus inoculated plants. The moisture content level was significantly highest in the AMV inoculated plants (90.4%), followed by BMV (86.3%) and AMV plus BMV (85.7%). The lowest moisture content was in the buffer inoculated (control) plants (83.5%). The high water content in the virus infected plants might be as a result of reduction in permeability of cell membrane. This is also the view of Tinklin (1970) while studying the effects of aspermy virus infection on water relations of tomato leaves.

Mineral composition of virus and buffer infected leaves of *Amaranthus hybridus*

Table 5 shows the mineral composition of virus and buffer infected leaves of *A. hybridus* at harvest. The Sodium content was significantly lowest in AMV inoculated (1.3mg/100g) followed by BMV inoculated plants (2.9mg/100g) and AMV plus BMV inoculation (3.3mg/100g). The potassium value ranged from the significantly highest value of 27.3mg/100g in AMV to 33.6mg/100g in the AMV + BMV.

The potassium value was 29.4mg/100g in BMV infected and significantly highest at 40.4mg/100g in the buffer inoculated plants. Calcium content was lowest at AMV inoculated plants (18.6mg/100g), followed by BMV inoculated plants (19.4mg/100g) and AMV plus BMV inoculated plants 22.4 mg/100g. The magnesium mineral content as expected was significantly highest in the control (223.6 mg/100g), followed by AMV plus BMV (100.2 mg/100g). The magnesium values for AMV (89.4 mg/100g) and BMV (88.6 mg/100g) were not significantly different. Iron content was also significantly lowest in BMV inoculated (3.6 mg/100g), while AMV (4.0 mg/100g) and AMV plus BMV (4.8 mg/100g) had statistically similar values. The Zinc content was not significantly different for the three inoculations but ranged from 1.0 mg/100g in AMV inoculation to 1.7 and 1.8 mg/100g in BMV and AMV + BMV inoculation. These results are similar to reports by Owolabi *et al.* (2010) but slightly differ from Shattuck (1987). Zinc has been found to have a number of different effects as in some cases it decreased, in others increased, and in

others had no effect on plant susceptibility to disease (Graham and Webb, 1991; Grewal *et al.,* 1996). It was however confirmed by Dmitriev *et al.* (2009) that Zinc induced a significant (more that 2-fold) increment of virus content in tomato plants. This therefore suggests that BMV and AMV both singly and in combination did not significantly affect Zinc content and disease severity in *A. hybridus.*

Table 5: Mineral composition of virus and buffer infected leaves of *Amaranthus hybridus*

Mineral Composition (mg/100g)	BMV	AMV	BMV + AMV	BUFFER
Sodium (Na)	2.9[c]	1.3[d]	3.3[b]	5.6[a]
Potassium (K)	29.4[c]	27.3[d]	33.6[b]	40.4[a]
Calcium (Ca)	19.4[c]	18.6[d]	22.4[b]	44.1[a]
Magnesium (Mg)	88.6[c]	89.4[c]	100.2[b]	223.6[a]
Iron (Fe)	3.6[c]	4.0[b]	4.8[b]	12.1[a]
Zinc (Zn)	1.7[b]	1.6[b]	1.8[b]	2.9[a]

In each row, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test.

Sensory acceptability of *Amaranthus hybridus* inoculated with viruses and buffer: Table 6 represents the results of the sensory acceptability in terms of colour, taste and overall acceptability of *A. hybridus* samples cooked after inoculation with AMV, BMV, AMV + BMV and buffer solution (Control). The significantly lowest colour ratings of 6.8 to 6.9 were in the virus inoculated and this showed that the panellist preferred the colour of the control as it appeared to be the most acceptable having recorded the score of 9.6. The unlikeable colour of the virus inoculated plants was probably due to the action of the viruses resulting in an unattractive mosaic presentation.

The result of the rating as regards taste and overall acceptability showed that there was no significant difference among the samples. Taste perception has been suggested to play a key role in determining individual food preferences and dietary habits. This finding suggests that virus infection does not affect the taste and overall acceptability of *A. hybridus* by consumers.

Table 6: Mean sensory scores of acceptance of *Amaranthus hybridus* inoculated with viruses and buffer after harvest

Sample	Colour	Taste	Overall Acceptability
AMV	6.9[b]	7.2	7.5
BMV	6.6[b]	7.6	7.3
AMV + BMV	6.8[b]	7.4	7.6
BUFFER	9.6[a]	7.7	8.1

In each column, means followed by the same letter are not significantly different (P = 0.05) according to Duncan's multiple range test

CONCLUSION

The infection of *A. hybridus* with AMV and BMV either singly or in combination of both resulted in growth parameter distortions. However, AMV inoculated singly appeared to be the more pathogenic of the two viruses. There seem to be an antagonistic effect between the two viruses as the combination was less infectious compared to single inoculations. The infection of *A. hybridus* with the viruses resulted in the depletion of the nutrients and minerals present in the leaves. Sensory evaluation revealed that although there was marked effect on leaf colour, this did not influence taste or overall acceptability by consumers.

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