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Research Article
Comparative Effect of *Acanthoscelides obtectus* (Say) Infestation on Nutrients of *Phaseolus vulgaris* (Linn.) and *Phaseolus acutifolius* (Gray)

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Abstract

Background and Objective: *Acanthoscelides obtectus* is a destructive post-harvest pest of beans. The destructions caused by this beans weevil are of economic and nutritional importance. This study was carried out to compare the effect of *A. obtectus* infestation on the nutrients of *Phaseolus vulgaris* L. and *Phaseolus acutifolius* G. **Materials and Methods:** A mix of infested and non-infested seeds of *P. vulgaris* and *P. acutifolius* was purchased from the Watt Market Calabar, Nigeria. The infested seeds were sorted from the non-infested ones into 3 groups (slight (SLI), moderate (MI) and severe (SI)) according to their levels of infestation. The seeds were kept for 3 months, sundried for 1 week, ground separately into powder and analyzed for nutrients using standard methods. **Results:** Results revealed a progressive decrease in some nutrients of *P. vulgaris* and *P. acutifolius* and increase in others according to the severity of *A. obtectus* infestation. Infestation led to significantly ($p = 0.05$) higher reduction/increase in nutrients of *P. vulgaris* than *P. acutifolius*. Effect of *A. obtectus* infestation on proximate nutrients revealed a reduction in moisture, protein, fat and carbohydrate with an increase in ash content. Percentage reduction in carbohydrate had values of 27.6, 28.1 and 30.5% for infested *P. vulgaris* at SLI, MI and SI levels compared to values of 10.2, 13.3, 22.2%, respectively for *P. acutifolius*. Effect of *A. obtectus* infestation on mineral nutrients showed a decrease in Na, Mg, Fe, Co with an increase in K and Zn for both *P. vulgaris* and *P. acutifolius*. In *P. vulgaris*, the beans weevil engendered reduction in Ca, Cu, Mn but caused an increase in Ca, Cu, Mn and Ni content in *P. acutifolius*. Reduction/increase in mineral nutrients due to infestation was higher in *P. vulgaris* compared to *P. acutifolius* except for Co and Mn which was higher in *P. acutifolius*. Reduction in Mg was higher for infested *P. vulgaris* with values of 12.5, 15.4 and 20.8% compared to values of 7.5, 9.8 and12.5%, respectively for *P. acutifolius* at SLI, MI and SI. Increase in Zn content of infested *P. vulgaris* had values of 21.4, 37.1 and 41.8% as against values for infested *P. acutifolius* of 19.6, 23.3 and 23.7%, respectively. Effect of infestation on vitamins depicted higher reduction in vitamin A and B_1 with an increase in vitamin E in both species at all levels of infestation. **Conclusion:** Comparatively, *A. obtectus* infestation caused higher significant reduction in some nutrients with an increase in others in infested *P. vulgaris* when compared to *P. acutifolius* resulting in nutrients fluctuation.

Key words: *Acanthoscelides obtectus* infestation, *Phaseolus vulgaris*, *Phaseolus acutifolius*, nutrient composition

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Phaseolus vulgaris L. (Fabaceae) is widely consumed throughout the world[1]. The bean is one of the important food for both the rural and urban dwellers in Nigeria as it is the main source of protein. *Phaseolus vulgaris* is a high nutritional food considered as a staple grain in the diet of the Nigerian people and in other developing countries of the world. Globally, the bean is the most important food legume for nearly 300 million people, what, most of them live on in developing countries, the crop is also known as "the meat of the poor". The bean is considered as the second source of protein in eastern and southern Africa and the fourth in America, it is especially important in the nutrition of women and children; in addition, it has great economic importance, as it generates income for millions of small farmers to such a degree that the world annual production is US $11 billion[2]. Dry beans (*Phaseolus vulgaris* L.) or common beans, have been characterized as a nearly perfect food because of their high protein, fiber, prebiotic, vitamin B and chemically diverse micronutrient composition[3,4]. The beans contain high levels of chemically diverse components (phenols, resistance starch, vitamins, fructooligosaccharides) that have shown to protect against such conditions as oxidative stress, cardiovascular disease, diabetes, metabolic syndrome and many types of cancer, thereby positioning this legume as an excellent functional food[5].

Phaseolus acutifolius (Gray) constitutes one of the most popular and widely cultivated species among the genus Phaseolus. They are among the most important grain legumes for direct food use[6]. *Phaseolus acutifolius* is highly medicinal owing to its rich source of nutrients. The beans have high antioxidant properties, thus enabling the body to fight the natural signs of aging (lines and wrinkles). It provides energy that the body needs throughout the day and stave off the onset of hunger pangs, thereby slowing the release of sugars and preventing blood glucose level spikes. This aids in regulating metabolism and lessening the chances of developing diabetes. *Phaseolus acutifolius* are perfect weight-watchers. They leave a feeling of being full, thus ensuring that one do not resort to eating huge amounts of food during the next meal. The beans possess cancer-fighting elements. They lower the risk of different types of cancers (colon, breast, gastric, prostrate and renal cancers). It also stimulates red blood cell production as well as fetus development during the early stages of pregnancy. The folic acid content of the beans aids in preventing neural tube defects from afflicting the infant in the womb[7]. Beans also support the body systems. They are good for the cardiovascular system. They prevent the proliferation of low-density lipoproteins or bad cholesterols that stick to the walls of blood vessels, causing inflammation and plaque buildup leading to a plethora of heart ailments (heart attacks and strokes). The fibre content of *P. acutifolius* prevents absorption of cholesterol in the gut. *Phaseolus acutifolius* are good for the nervous system. They aid in the regulation of blood pressure which is good for proper functioning of the nerves. The high B-complex vitamins in this beans provide for proper functioning of the brain cells and boost cognitive skills and memory. *Phaseolus acutifolius* are good for the digestive system. They prevent digestive disorders such as constipation and irritable bowel movement. *P. acutifolius* supports the immune systems. They neutralize free radicals preventing damage to healthy body cells. In the skeletal system, they stave off onset of osteoporosis characterized by loss of bone mass preventing fractures[7]. *Phaseolus vulgaris* and *P. acutifolius*) are well utilized in Nigeria.

The beans weevil *Acanthoscelides obtectus* Say (Coleoptera: Bruchidae) commonly known as bruchids is a significant pest of legumes, especially beans, in some part of the world attacking crops in the field and in warehouses. Ahmed *et al.*[8] reported that *A. obtectus* is a serious Neotropical origin insect pest on kidney beans, *Phaseolus vulgaris* L. and other legumes seeds. It is a destructive pest of stored *P. vulgaris* and *P. acutifolius*. The insect larvae begin feeding from the embryo and eventually consumes the entire seed, making the grain hollow and leaving only the seed coat. Mofunanya and Namgbe[9] documented a reduction in protein, moisture and carbohydrate with increase in ash, fiber and fat due to *C. maculatus* infestation of *V. unguiculata*. Different levels of infestation abound (slight, moderate and severe infestation). In severe infestation, the infested seeds are filled with frass, cast skins and excreta, which adversely deteriorate the quality of the grain. Hence, a common trend of zero-tolerance by buyers is increasing. Infestation by insect produces unpleasant odors, dirty appearance and abhorrent taste due to contamination by insect fragments and excretion. Severe infestation also makes seeds unpalatable. The quality of the grain may decrease due to nutrient depletion[10]. Because of the damaging effect of this weevil on stored beans, farmers are indirectly forced to sale post-harvest grain rapidly thereby shortening storage periods in granaries, thus, causing post-harvest price collapse, marked seasonal price fluctuation and reduction in market value. The quality deterioration potentials of *A. obtectus* have assigned them a status of noxious pest and a bridge to trade.

Reports of storage pest infestation on nutrients content of stored beans are inconsistent. Variation (decrease and

increase) in nutrients composition of stored products due to infestation have been observed. Mbah and Silas[11] reported a decrease in moisture with an increase in protein, carbohydrate, ash and fat content of cowpea infested by *Callosobruchus maculatus*. In another study, Oke *et al*.[12] reported a decrease in moisture, ash, fat, free fatty acid and protein content with an increase in fibre and carbohydrate in cowpea infested by *C. maculatus*. A decrease in moisture, ash, fibre, carbohydrate and fat with an increase in protein content of *Phaseolus lunatus* sequel to *A. obtectus* infestation has been documented[10]. Infestation of *V. unguiculata* by *C. maculatus* caused an increase in Zn, Mn, K, Ca, Na and Co with a decrease in Ni, Fe, Cu and Mg[9]. A reduction in K, Na, Fe, Zn, Cu, Mn and Co with increase in Ca, Mg and Ni content of *Phaseolus lunatus* sequel to *A. obtectus* infestation has been observed[10]. Mofunanya[10] documented a reduction in niacin (vit. B_3), vitamin E and biotin with increase in vitamin B_1, B_2, A and C for infested *P. lunatus* by *A. obtectus* when compared to the non-infested seeds. Mofunanya[13] published a decrease in vitamin C, A, B_1, B_2, B_3, B_5, B_6, B_9 and biotin except for vitamin E which showed increase after *C. maculatus* infestation of *V. aconitifolia*. Variation in nutrients composition of these important stored food due to infestation is worrisome. Keeping in view the destructive nature of *A. obtectus* and its significance in global food security and safety and the significant contribution of *P. vulgaris* and *P. acutifolius* in nutrient supply and income generation, the present study investigates the comparative effect of *A. obtectus* (Say) infestation on the nutrients composition of *P. vulgaris* and *P. acutifolius*.

MATERIALS AND METHODS

Location and duration of study: The study was carried out in the Department of Botany, University of Calabar, Calabar, Nigeria between March and June, 2018.

Seed collection: Seeds of *P. vulgaris* and *P. acutifolius* were bought from the Watt Market, Calabar, Nigeria. On purchase, infested seeds were sorted from the non-infested ones and taken to the Department of Zoology and Environmental Biology, University of Calabar for pest identification. The non-infested seeds with no emergence hole were designated as: 1 and 2: infested seeds, were sorted into 3 levels of infestation: slight infestation (SLI) with 1-3 holes designated, 3: moderate infestation (MI) with 4-5 holes designated, 4: severe infestation (SI) with 6 holes, above per seed. Each group of seeds sorted was placed in a transparent glass jar covered with a net 1 cm by 1 cm mesh size to enhance infestation continuity at 25±2°C and 70±5% relative humidity. The non-infested (control) group was tightly sealed with a metallic lid. The non-infested and infested seeds were kept for months.

Samples preparation for analysis: At 3 month's post-storage, the non-infested seeds designated 1 and the infested with different levels of infestations designated 2, 3 and 4 were removed from their storage containers, the seeds were properly checked and dissected to remove, larvae, pupae and adults of *Acanthoscelides obtectus*. Seeds from the 2 groups were sundried for one week, ground into powder and used to analyze the effect of *A. obtectus* infestation on proximate, mineral and vitamin contents of *P. vulgaris* and *P. acutifolius*. Non-infested and infested samples at different levels of infestation were analyzed for moisture, ash, protein, fibre, fat and carbohydrate using standard methods of Association of Analytical Chemist[14]. Fe, Mg, Ca, Cu, Zn, Mn, Co, Ni were analyzed by atomic absorption spectrophotometer[14]. Na and K were analyzed using flame photometry and vitamins[15].

Statistical analysis: Data analysis differences in mean values of non-infested and infested *P. vulgaris* and *P. acutifolius* obtained in the present study were tested by analysis of variance (ANOVA) at ($p = 0.05$). Percentage difference was obtained by expressing the difference between the mean values for non-infested and infested as a percentage of the non-infested.

RESULTS

Comparative effect of *Acanthoscelides obtectus* infestation on proximate nutrient of *Phaseolus vulgaris* and *P. acutifolius*: Proximate nutrients of *P. vulgaris* and *P. acutifolius* were severely affected by *A. obtectus* infestation. Results revealed a progressive decrease/increase in values which varied according to infestation levels. *Acanthoscelides obtectus* infestation caused a significant ($p = 0.05$) decrease in moisture, protein, fat and carbohydrate with an increase in ash content of *P. vulgaris* and *P. acutifolius*. Reduction in carbohydrate induced by infestation at all levels was higher for *P. vulgaris* with values of 27.6, 28.1 and 30.5% compared to values for *P. acutifolius* of 10.2, 13.3 and 22.2%, respectively. Increase in ash content induced by infestation revealed higher percentage values of 7.6, 12.8 and 23.2% for *P. vulgaris* at slight, moderate and severe levels of infestation compared to values of 2.8, 7.2 and 10.7%, respectively for *P. acutifolius*. Protein was significantly reduced but reduction did not differ statistically for both *P. vulgaris* and *P. acutifolius* (Table 1).

Table 1: Comparative effect of *Acanthoscelides obtectus* infestation on proximate nutrients of *Phaseolus vulgaris* and *P. acutifolius*

Proximate nutrients	Dry matter (g/100 g)													
	P. vulgaris NIF 1	*P. vulgaris* INF 2	*P. acutifolius* NIF 1	*P. acutifolius* INF 2	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)	*P. vulgaris* INF 3	*P. acutifolius* INF 3	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)	*P. vulgaris* INF 4	*P. acutifolius* INF 4	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)
Moisture	67.10±0.10	66.04±0.01	64.40±0.10	62.40±0.10	1.6	3.1	64.21±0.02	61.02±0.01	4.3	5.2	60.53±0.02	59.98±0.02	9.9	6.7
Ash	3.83±0.01	4.12±0.20	2.90±0.10	2.98±0.10	7.6	2.8	4.32±0.01	3.11±0.02	12.8	7.2	4.72±0.04	3.21±0.02	23.2	10.7
Protein	27.13±0.02	22.38±0.01	25.38±0.01	21.69±0.02	17.5	14.5	22.10±0.06	20.99±0.20	18.5	17.3	20.50±0.02	20.59±0.02	24.4	18.9
Fibre	3.90±0.01	3.30±0.01	3.18±0.01	2.75±0.02	15.3	13.5	322.81±0.10	2.68±0.10	17.4	15.7	3.18±0.03	2.66±0.10	18.7	16.4
Fat	1.89±0.02	1.91±0.12	1.67±0.02	1.70±0.01	1.1	1.8	1.98±0.03	1.73±0.01	4.8	3.6	2.01±0.02	1.75±0.01	6.3	4.8
Carbohydrate	48.46±0.02	35.20±0.20	46.28±0.02	41.56±0.02	27.6	10.2	34.82±0.02	40.12±0.10	28.1	13.3	33.67±0.03	36.01±0.20	30.5	22.2

Values are means of 3 replicates±SE, p = 0.05, NIF: Non-infested (1), INF: Infested (2), Infestation levels: 2: Slight infestation (SLI), 3: Moderate infestation (MI), 4: Severe infestation (SI)

Comparative effect of *Acanthoscelides obtectus* infestation on mineral nutrients of *Phaseolus vulgaris* and *Phaseolus acutifolius*: *Acanthoscelides obtectus* infestation caused a significant (p = 0.05) decrease in Na, Mg, Fe, Co with an increase in K and Zn for both *P. vulgaris* and *P. acutifolius*, In *P. vulgaris* the pest engendered decrease in Ca, Cu, Mn while in *P. acutifolius* it caused an increase in Ca, Cu, Mn and Ni respectively at slight, moderate and severe infestation levels. Percentage increase/decrease in some mineral nutrients orchestrated by *A. obtectus* was higher in *P. vulgaris* compared to *P. acutifolius* except for Co and Mn which had higher reduction/increase in *P. acutifolia* than in *P. vulgaris*. Results revealed a trend of progressive percentage increase/decrease in mineral nutrients which varied according to infestation levels with slight infestation (SLI) exhibiting the lowest infestation manifested by the lowest percentage increase/decrease in mineral nutrients followed by moderate infestation (MI) while severe infestation (SI) had the highest percentage increase/decrease. Results of decrease in Na for *P. vulgaris* were 2.6, 7.9 and 15.7% as against values of 1.8, 2.8 and 3.6%, respectively for *P. acutifolius*. While results of increase in Zn revealed significantly higher values of 21.4, 37.1 and 41.8% for *P. vulgaris* compared to values of 19.6, 23.3 and 23.7% for *P. acutifolius*, respectively at SLI, MI and SI levels. Manganese content of *P. acutifolius* was significantly increased by infestation with values of 47.6, 52.4 and 57.1% while Mn content of *P. vulgaris* was decreased due to infestation with values of 9.5, 14.3 and 19.0%, respectively (Table 2).

Comparative effect of *Acanthoscelides obtectus* infestation on vitamins of *Phaseolus vulgaris* and *Phaseolus acutifolius*: The beans weevil caused a significant (p = 0.05) reduction in vitamin A and B_1 with an increase in vitamin E in both *P. vulgaris* and *P. acutifolius* at all levels of infestation. A trend of progressive decrease/increase in vitamins with severity of infestation was also observed. The pest caused more damage to vitamins of *P. vulgaris* than *P. acutifolius*. *Acanthoscelides obtectus* infestation caused a significant increase in vitamin C content of *P. acutifolius* with a decrease for *P. vulgaris*. Percentage reductions for vitamin A at SLI, MI and SI levels were 27.8, 29.1 and 29.2% for *P. vulgaris* compared to *P. acutifolius* values of 11.7, 15.0 and 16.3%, respectively. Increase in vitamin E content of *P. vulgaris* due to infestation had a higher percentage increase in values of 16.5, 23.8, 27.3% compared to *P. acutifolius* values of 11.1, 14.2, 17.3% at SLI, MI and SI levels respectively (Table 3).

Table 2: Comparative effect of *Acanthoscelides obtectus* infestation on mineral nutrients of *Phaseolus vulgaris* and *Phaseolus acutifolius*

	Dry matter (g/100 g)													
Elements	*P. vulgaris* NIF 1	*P. vulgaris* INF 2	*P. acutifolius* NIF 1	*P. acutifolius* INF 2	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)	*P. vulgaris* INF 3	*P. acutifolius* INF 3	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)	*P. vulgaris* INF 4	*P. acutifolius* INF 4	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)
Potassium (K)	3.80±0.10	4.10±0.10	2.30±0.10	2.39±0.02	7.9	3.9	4.39±0.02	2.50±0.10	15.5	8.7	4.96±0.01	2.84±0.01	30.5	23.5
Sodium (Na)	23.41±0.01	22.80±0.10	21.10±0.10	20.73±0.01	2.6	1.8	21.56±0.01	20.50±0.01	7.9	2.8	19.73±0.10	20.33±0.02	15.7	3.6
Calcium (Ca)	90.18±0.03	81.10±0.10	67.20±0.10	70.20±0.20	10.1	4.5	68.11±0.02	70.29±0.01	24.5	4.6	67.10±0.01	70.36±0.01	25.6	4.7
Magnesium (Mg)	70.21±0.02	61.43±0.20	75.14±0.20	69.47±0.01	12.5	7.5	59.39±0.10	67.81±0.20	15.4	9.8	55.61±0.20	65.72±0.02	20.8	12.5
Iron (Fe)	41.52±0.02	40.17±0.20	39.66±0.10	38.35±0.02	3.3	3.3	39.01±0.20	37.37±0.01	6.0	5.7	36.98±0.03	37.17±0.01	10.9	11.3
Zinc (Zn)	2.80±0.10	3.40±0.06	2.19±0.10	2.62±0.02	21.4	19.6	3.84±0.01	2.70±0.02	37.1	23.3	3.97±0.01	2.73±0.01	41.8	23.7
Copper (Cu)	7.15±0.01	5.67±0.20	11.19±0.20	12.20±0.10	20.7	9.0	4.85±0.01	12.39±0.01	32.2	10.7	4.02±0.10	12.50±0.01	42.8	17.7
Manganese (Mn)	0.21±0.02	0.19±0.01	0.21±0.01	0.31±0.01	9.5	47.6	0.18±0.02	0.32±0.02	14.3	52.4	0.17±0.01	0.33±0.02	19.0	57.1
Cobalt (Co)	0.37±0.02	0.35±0.01	0.21±0.01	0.13±0.01	5.4	38.1	0.34±0.10	0.12±0.01	8.1	42.9	0.33±0.02	0.11±0.01	10.8	47.6
Nickel (Ni)	1.50±0.02	1.41±0.01	0.81±0.01	0.85±0.01	6.0	4.9	1.33±0.02	0.85±0.01	11.3	4.9	0.26±0.02	0.87±0.01	16.0	7.4
Lead (Pb)	ND	ND	ND	ND			ND	ND			ND	ND		

Values are means of 3 replicates±SE, p = 0.05, NIF: Non-infested (1), INF: Infested (2), Infestation levels: 2: Slight infestation (SLI), 3: Moderate infestation (MI), 4: Severe infestation (SI), ND: Not detected

Table 3: Comparative effect of *Acanthoscelides obtectus* infestation on vitamins of *Phaseolus vulgaris* and *Phaseolus acutifolius*

	Dry matter (g/100 g)													
Elements	*P. vulgaris* NIF 1	*P. vulgaris* INF 2	*P. acutifolius* NIF 1	*P. acutifolius* INF 2	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)	*P. vulgaris* INF 3	*P. acutifolius* INF 3	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)	*P. vulgaris* INF 4	*P. acutifolius* INF 4	*P. vulgaris* Diff. (%)	*P. acutifolius* Diff. (%)
β-carotene (Vit. A) (μg dL^{-1})	145.53±0.03	105.12±0.02	145.92±0.02	128.80±0.10	27.8	11.7	103.12±0.01	124.09±0.01	29.1	15.0	103.07±0.01	122.11±0.10	29.2	16.3
Thiamine (Vit. B_1) (μg dL^{-1})	218.55±0.02	157.84±0.02	204.30±0.02	179.55±0.10	27.9	12.1	150.38±0.20	176.25±0.01	31.2	13.7	148.69±0.20	170.16±0.01	31.9	16.7
Ascorbic acid (Vit. C) (mg/100 g)	7.28±0.02	6.83±0.03	7.73±0.01	8.74±0.01	6.6	13.1	6.72±0.01	8.86±0.02	7.7	14.6	6.60±0.02	8.91±0.01	9.3	15.3
Tocopherol (Vit. E) (mg/100 g)	2.60±0.10	3.03±0.02	3.18±0.02	2.83±0.03	16.5	11.1	3.22±0.01	2.73±0.01	23.8	14.2	3.31±0.01	2.64±0.02	27.3	17.0

Values are means of 3 replicates±SE, p = 0.05, NIF: Non-infested (1), INF: Infested (2), Infestation levels: 2: Slight infestation (SLI), 3: Moderate infestation (MI), 4: Severe infestation (SI)

DISCUSSION

Comparative effect of *A. obtectus* infestation on the nutrients of *P. vulgaris* and *P. acutifolius* was studied. Results of proximate analysis showed a significant ($p = 0.05$) reduction in moisture, protein, fibre and carbohydrate content of *P. vulgaris* and *P. acutifolius* with an increase in ash and fat content. Effect of *A. obtectus* infestation was more in *P. vulgaris* depicted by higher percentage decrease/increase in nutrients than in *P. acutifolius*. Oyeyinka *et al.*[16] reported a variation in the proximate composition of infested cowpea flours by *Callosobruchus maculatus* resulting in a decrease in moisture, ash, protein and fat content with increase in the duration of storage period while carbohydrate and crude fibre increased. Keskin and Ozkaya[17] reported a decrease in fat with increase in ash and protein content of wheat samples infested by *Sitophilus granarius*. Mofunanya and Namgbe[9] documented a reduction in protein, moisture and carbohydrate with increase in ash, fiber and fat due to *C. maculatus* infestation of *V. unguiculata*. Mofunanya[13] published a decrease in moisture, fat, fibre and carbohydrate with an increase in protein content of *Vigna aconitifolia* as a result of *C. maculatus* infestation. The moisture content of seeds is an important factor in storage. The lower the temperature and relative humidity, the longer the seeds can be safely stored. The decrease in these proximate nutrients may be attributed to metabolic activities of the pest as it utilizes these nutrients for growth and other activities[13]. Reduction in these proximate nutrients due to *A. obtectus* infestation reduces the medicinal value of these legumes. Adequate intake of dietary fibre can lower the serum cholesterol level, risk of coronary heart disease, hypertension, constipation, diabetes, colon and breast cancer[18]. Protein functions in support, as catalysts, in regulation, as a transport substance, in storage of amino acids, in movement and protection[19].

The present study has revealed that *A. obtectus* infestation caused a significant ($p = 0.05$) decrease in Na, Mg, Fe, Co with increase in K and Zn for both *P. vulgaris* and *P. acutifolius*, *Acanthoscelides obtectus* engendered decrease in Ca, Cu and Mn for *P. vulgaris* while it caused an increase in Ca, Cu, Mn and Ni content of *P. acutifolius* at different levels of infestation (SLI, MI and SI). The effect of infestation led to either higher reduction or increase in the mineral nutrients of *P. vulgaris* compared to *P. acutifolius*. In a similar study Mofunanya[13] reported an increase in K, Ca, Mg, Fe, Zn, Co and Mn with a decrease in P, Na, Cu and Ni content of *V. aconitifolia* due to *C. maculatus* infestation. Increase in nutrients due to infestation may be attributed to large waste generation and eggs, egg cases, excretory products left after removal of larval, pupal and adult stages of *A. obtectus* before analysis.

Results on vitamins revealed that *A. obtectus* infestation of *P. vulgaris* and *P. acutifolius* depicted a progressive reduction in vitamin A and B_1 and increase in vitamin E with severity of infestation. Vitamin C content of *P. acutifolius* increased while that of *P. vulgaris* decreased with severity of infestation. *Callosobruchus maculatus* infestation of *V. unguiculata* was observed to reduce vitamin A and B in infested seeds with an increase in vitamin C and E[9]. Reduction in vitamin A, B_1 for *P. vulgaris* and *P. acutifolius* and E for *P. acutifolius* may be attributed to their use by the pest as food to sustain the life of the pest and to enable the pest complete its larval development and metamorphosis[20]. Srivastava and Subramanian[21] also attributed decrease in nutrients studied to the fact that stored grain pests infest grains to fulfill their food and shelter requirements resulting in qualitative as well as quantitative losses. Reduction in these vitamins implied that *A. obtectus* infestation had a large effect on depleting *P. vulgaris* and *P. acutifolius* nutrients during storage. Deficient amount emanating from reduction and excess amount from increase present serious health problems. The importance of mineral nutrients and vitamins; their deficiencies and excesses have been extensively discussed[22].

Results of this research have showed that *Phaseolus vulgaris* and *Phaseolus acutifolius* are both rich in nutrients supply. These nutrients are plant-based that is, components in food of plant origin that an organism uses for survival and growth. Some nutrients can be stored in the body while others are required more or less continuously. These plant-based nutrients are the basis for more than forty percent medications today and have become a great resource in the treatment of a wide range of diseases such as pulmonary and cardiovascular diseases, diabetes, high blood pressure, obesity and cancer etc. Experts have suggested that people can reduce their risk of cancer significantly by eating food that contains phytonutrients according to American Cancer Society[23]. Life is gradually returning to plants (nature)[24]. Decrease/increase amount of these phytonutrients orchestrated by *A. obtectus* infestation of *P. vulgaris* and *P. acutifolius* is problematic since poor health in humans is caused either by lack of the required nutrients or in extreme cases, by too much of a required nutrient[13,22]. It is worthy of note that excessively high nutrients in food can be harmful or toxic. When beans seeds are infested with weevil, they do not appeal to the eye as quality is compromise reducing their marketability. Though *P. vulgaris* and *P. acutifolius* are

cheap and commonly consumed legumes in Nigeria, many people detest buying and consuming them when infested. These 2 beans species though members of the same family varied in their degree of tolerance to *A. obtectus* infestation as seen with higher reduction/increase in nutrients of *P. vulgaris* when compared to *P. acutifolius*. Further studies are encouraged to investigate reasons for the variation in nutrients reduction/increase in *P. vulgaris* when compared to *P. acutifolius* as a result of infestation by *A. obtectus*.

SIGNIFICANCE STATEMENT

This study discovered that *A. obtectus* infestation of *P. vulgaris* and *P. acutifolius* caused significant reduction/ increase in phytonutrients. That reduction/increase in phytonutrients varied according to levels of infestation. Effect of *A. obtectus* infestation was significantly higher in *P. vulgaris* as manifested by higher reduction/increase in nutrients compared to *P. acutifolius* except for Co and Mn which were higher in *P. acutifolius*. Severe infestation resulted in more significant reduction/increase in nutrients than moderate and slight infestation. A balance in nutrients remain the ultimate for optimal benefits. The findings of this study provides the need for routine check of *P. vulgaris* and *P. acutifolius* in storage to enhance quality and nutrients stability.

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