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Vitamin contents of cereal grains as affected by storage and insect infestation

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Abstract. There were substantial losses in thiamine, riboflavin and niacin contents of wheat, maize and sorghum grains at three infestation levels (25, 50 and 75%) caused by releasing two insect species viz., *Trogoderma granarium* and *Rhizopertha dominica* separately and mixed population. Losses were to the extent of 65 to 69% (thiamine), 50 to 67% (riboflavin) and 10 to 32% (niacin) due to *T. granarium* and 23 to 29% (thiamine), 13 to 18% (riboflavin) and 4 to 14% (niacin) due to *R. dominica* at 75% level of infestation in three cereal grains. Storage of grains (1–4 months) in insect free conditions did not show appreciable changes in the vitamin contents.

Introduction

Cereal grains are major sources of B-vitamins like thiamine, riboflavin and niacin in India and several other developing countries. Wheat, maize and sorghum are among the important cereal grains consumed in many Asian and African countries. These food grains are attacked by several insect pests under varied storage conditions which adversely affect nutritional composition of the grains [1–3]. Insect infested grains are generally consumed in rural and urban areas by poor section of people.

Insect pests like *Sitophilus oryzae* and *Ephestia cautella* have been reported to decrease thiamine in cereal grains [3–6] but information is lacking with regard to key insect pests like *Trogoderma granarium* and *Rhizopertha dominica* which are more prevalent in tropical and subtropical climates [2, 7, 8]. However, loss of vitamins has been reported as marginal under uninfested storage conditions [5, 9]. This paper reports the effect of three infestation levels (25, 50 and 75%) caused by *T. granarium* and *R. dominica* and also storage periods (1, 2 and 4 months) on thiamine, riboflavin and niacin content of wheat, maize and sorghum grains.

Materials and methods

Preparation of grain samples. Mass culture of two insect species viz. *Trogoderma granarium* Everts and *Rhizopertha dominica* Fabricius was

Table 1. Effect of storage on vitamin contents of wheat, maize and sorghum (mg/100 g, on dry matter basis)

Cereals	Storage period (months)	Thiamine	Riboflavin	Niacin
Wheat	0	0.48 ± 0.00	0.16 ± 0.00	5.58 ± 0.00
	1	0.48 ± 0.00 (0)	0.16 ± 0.00 (0)	5.57 ± 0.01 (0.2)
	2	0.47 ± 0.00 (2)	0.15 ± 0.01 (6)	5.56 ± 0.00 (0.4)
	4	0.47 ± 0.01 (2)	0.15 ± 0.00 (6)	5.52 ± 0.00 (1)
	Mean	0.48	0.16	5.56
Maize	0	0.43 ± 0.01	0.17 ± 0.00	1.90 ± 0.00
	1	0.43 ± 0.00 (0)	0.17 ± 0.00 (0)	1.89 ± 0.01 (0.5)
	2	0.43 ± 0.00 (0)	0.17 ± 0.01 (0)	1.89 ± 0.00 (0.5)
	4	0.42 ± 0.01 (2)	0.16 ± 0.00 (6)	1.88 ± 0.01 (1)
	Mean	0.43	0.17	1.89
Sorghum	0	0.39 ± 0.01	0.15 ± 0.00	3.40 ± 0.00
	1	0.39 ± 0.00 (0)	0.15 ± 0.00 (0)	3.39 ± 0.00 (0.3)
	2	0.38 ± 0.01 (3)	0.14 ± 0.01 (7)	3.38 ± 0.01 (0.6)
	4	0.37 ± 0.01 (5)	0.14 ± 0.01 (7)	3.37 ± 0.01 (1)
	Mean	0.38	0.15	3.39
Cereals	SE (m)	0.02	0.02	0.33
	CD ($p < 0.05$)	0.06	NS	0.99
Storage period	SE (m)	0.02	0.02	0.35
	CD ($p < 0.05$)	NS	NS	NS
Cereals × Storage period	SE (m)	0.03	0.05	0.61
	CD ($p < 0.05$)	NS	NS	NS

Values are means ± SD of six independent determinations.
Figures in parentheses are percent decrease over control.

maintained in the ambient laboratory temperature (28.63–39.22 °C) and relative humidity (60.16–90.13%) conditions. The grains of commonly consumed varieties of wheat, maize and sorghum apparently free from insect infestation were further subjected to aluminium phosphide fumigation to eliminate any invisible insect populations. After fumigation such grains were put in glass jars (20 × 15 cm), each jar containing 1.5 kg grains. The jars were covered with muslin cloth with the help of elastic bands and placed in laboratory for 10 days for conditioning of grains. On the 10th day, moisture level of grains ranged from 10 to 11% which is congenial for multiplication of both insects. The jars of each food grain were subdivided into three sets.

In the first set of each food grain, 60 larvae of *T. granarium* per jar were released to obtain three levels of infestation (25, 50 and 75% in 3 replicates). In second set, 60 adults of *R. dominica* were released while in third set mixed population of both species (30 larvae of *T. granarium* + 30 adults of *R. dominica*) were released to achieve three infestation levels. In each set controls (jars without insects) were also kept simultaneously to study the effect of storage periods. It took 1, 2 and 4 months to obtain 25, 50 and 75% levels of

Table 2. Effect of insect infestation on vitamin contents of wheat grains (mg/100 g, on dry matter basis)

Insect species	Infestation level (%)	Thiamine	Riboflavin	Niacin
T. granarium	25	0.42 ± 0.02 (13)	0.14 ± 0.00 (13)	5.50 ± 0.01 (1)
	50	0.30 ± 0.01 (38)	0.12 ± 0.00 (25)	5.30 ± 0.02 (5)
	75	0.15 ± 0.00 (69)	0.08 ± 0.01 (50)	5.00 ± 0.01 (10)
	Mean	0.29	0.11	5.27
R. dominica	25	0.47 ± 0.03 (2)	0.15 ± 0.01 (6)	5.50 ± 0.02 (1)
	50	0.41 ± 0.02 (15)	0.14 ± 0.00 (13)	5.35 ± 0.02 (4)
	75	0.34 ± 0.01 (29)	0.13 ± 0.00 (19)	5.10 ± 0.01 (9)
	Mean	0.41	0.14	5.32
T. granarium	25	0.42 ± 0.02 (13)	0.15 ± 0.01 (6)	5.50 ± 0.03 (1)
+	50	0.33 ± 0.02 (31)	0.13 ± 0.00 (19)	5.36 ± 0.01 (4)
R. dominica	75	0.19 ± 0.01 (60)	0.10 ± 0.00 (38)	5.04 ± 0.00 (10)
	Mean	0.31	0.13	5.30
Control	0	0.48 ± 0.03	0.16 ± 0.01	5.58 ± 0.01
Insect species	S (m)	0.02	0.01	0.03
	CD ($p < 0.05$)	0.06	0.03	NS
Infestation level	SE (m)	0.04	0.02	0.06
	CD ($p < 0.05$)	0.12	0.06	0.18
Insect ×	SE (m)	0.07	0.03	0.12
Infestation level	CD ($p < 0.05$)	0.21	NS	NS

Values are means ± SD of six independent determinations.
Figures in parentheses are percent decrease over control.

infestation, respectively at 28.63 to 39.22 °C ambient laboratory temperature and 60.16 to 90.13% RH. When the desired levels of infestation approached, grains were immediately disinfested with aluminium phosphide fumigation to prevent further damage. Grains were cleaned and powdered in Cyclone Sample Mill to pass through 60 mesh sieve and stored in airtight polyethylene bottles for further analysis.

Vitamins estimation. Thiamine was determined by thiochrom method, riboflavin fluorometrically and niacin colourimetrically [10].

Statistical analysis. The data were statistically analysed for analysis of variance [11].

Results and discussion

Vitamin contents and effect of storage

The amount of thiamine in wheat was significantly higher than that of sorghum whereas riboflavin concentration of all the three cereals was almost same. On

Table 3. Effect of insect infestation on vitamin contents of maize grains (mg/100 g, on dry matter basis)

Insect species	Infestation level (%)	Thiamine	Riboflavin	Niacin
T. granarium	25	0.38 ± 0.01 (12)	0.15 ± 0.00 (12)	1.79 ± 0.00 (6)
	50	0.32 ± 0.00 (26)	0.11 ± 0.00 (35)	1.59 ± 0.01 (16)
	75	0.15 ± 0.00 (65)	0.07 ± 0.00 (59)	1.30 ± 0.00 (32)
	Mean	0.28	0.11	1.56
R. dominica	25	0.41 ± 0.02 (5)	0.16 ± 0.00 (6)	1.85 ± 0.02 (3)
	50	0.38 ± 0.01 (12)	0.15 ± 0.01 (12)	1.76 ± 0.01 (7)
	75	0.32 ± 0.00 (26)	0.14 ± 0.00 (18)	1.63 ± 0.00 (14)
	Mean	0.37	0.15	1.75
T. granarium	25	0.41 ± 0.01 (5)	0.16 ± 0.00 (6)	1.79 ± 0.01 (6)
+	50	0.35 ± 0.01 (19)	0.13 ± 0.01 (24)	1.63 ± 0.01 (14)
R. dominica	75	0.22 ± 0.00 (49)	0.11 ± 0.00 (35)	1.40 ± 0.01 (26)
	Mean	0.33	0.13	1.61
Control	0	0.43 ± 0.01	0.17 ± 0.01	1.90 ± 0.00
Insect species	SE (m)	0.02	0.01	0.04
	CD ($p < 0.05$)	0.06	0.03	0.12
Infestation level	SE (m)	0.03	0.02	0.05
	CD ($p < 0.05$)	0.09	0.06	0.15
Insect ×	SE (m)	0.05	0.04	0.07
Infestation level	CD ($p < 0.05$)	0.15	NS	NS

Values are means ± SD of six independent determinations.
Figures in parentheses are percent decrease over control.

the other hand, these cereals differed significantly in their niacin content wheat containing about twice the amount than that of maize (Table 1). During storage there was a marginal reduction in contents of vitamins. The maximum losses after 4 months of storage were 5, 7 and 1% for thiamine, riboflavin and niacin, respectively. Insignificant losses in thiamine content of wheat (6%) after 6 months of storage [5] and sorghum (2–3%) after 12 months of storage [12] have also been reported earlier.

Effect of insect infestation

Both species of insects (*T. granarium* and *R. dominica*) caused a significant ($p < 0.05$) reduction in thiamine, riboflavin and niacin contents of 3 cereal grains at different levels of infestation. In wheat *T. granarium* caused significantly higher losses of thiamine and riboflavin as compared to *R. dominica* and mixed population (Table 2). Losses of vitamins at 25, 50 and 75% grain infestation by *T. granarium* were 13, 38 and 69%; 13, 25 and 50% and 1, 5 and 10% for thiamine, riboflavin and niacin, respectively. However, *R. dominica* caused comparatively less damage and corresponding losses at 25, 50 and 75% grain infestation were 2, 15 and 29%, 6, 13 and 19% and 1, 4 and 9%. Mixture

Table 4. Effect of insect infestation on vitamin contents of sorghum grains (mg/100 g, on dry matter basis)

Insect species	Infestation level (%)	Thiamine	Riboflavin	Niacin
T. granarium	25	0.33 ± 0.01 (15)	0.13 ± 0.00 (13)	3.30 ± 0.01 (3)
	50	0.28 ± 0.00 (28)	0.10 ± 0.00 (33)	3.28 ± 0.02 (4)
	75	0.13 ± 0.00 (67)	0.05 ± 0.01 (67)	3.00 ± 0.00 (12)
	Mean	0.25	0.09	3.19
R. dominica	25	0.38 ± 0.01 (3)	0.15 ± 0.01 (0)	3.36 ± 0.01 (1)
	50	0.35 ± 0.01 (10)	0.14 ± 0.00 (7)	3.28 ± 0.00 (4)
	75	0.30 ± 0.00 (23)	0.13 ± 0.00 (13)	3.10 ± 0.00 (9)
	Mean	0.34	0.14	3.25
T. granarium	25	0.37 ± 0.02 (5)	0.14 ± 0.01 (7)	3.35 ± 0.01 (2)
+	50	0.32 ± 0.01 (18)	0.12 ± 0.00 (20)	3.28 ± 0.00 (4)
R. dominica	75	0.19 ± 0.00 (51)	0.07 ± 0.00 (53)	3.05 ± 0.02 (10)
	Mean	0.29	0.11	3.23
Control	0	0.39 ± 0.00	0.15 ± 0.00	3.40 ± 0.01
Insect species	SE (m)	0.02	0.01	0.03
	CD ($p < 0.05$)	0.06	0.03	NS
Infestation level	SE (m)	0.04	0.02	0.04
	CD ($p < 0.05$)	0.12	0.06	0.12
Insect ×	SE (m)	0.07	0.03	0.08
Infestation level	CD ($p < 0.05$)	NS	NS	NS

Values are means ± SD of six independent determinations.
Figures in parentheses are percent decrease over control.

of both insect species produced intermediate losses. Insect infestation has been reported to decrease thiamine to the extent of 56% in wheat grains but level of insect infestation was not recorded [3, 5].

In maize also losses at 75% level of infestation due to *T. granarium* were to the extent of 65, 59 and 32% in thiamine, riboflavin and niacin, respectively (Table 3). Corresponding losses due to *R. dominica* were 26, 18 and 14% only. *T. granarium* caused significantly higher losses of all the three vitamins than *R. dominica.*

Similarly different levels of *T. granarium* infestation in sorghum grains caused a marked reduction in the contents of thiamine (15–67%), riboflavin (13–67%) and niacin (3–12%) (Table 4). Losses due to *R. dominica* for thiamine (3–23%), riboflavin (0–13%) and niacin (1–9%) were comparatively less. Mixture of both species produced intermediate losses of vitamins. Losses in thiamine content of maize (32%) and sorghum (30–70%) have also been attributed to insect infestation [3, 9, 13]. Extensive losses in riboflavin [9, 13] and niacin [9] contents of sorghum grains were also caused by insect damage. But none of the investigators have assessed quantitatively the relationship between levels of insect damage and losses in nutrients, and also the effect of individual insect species.

While comparing the results of 3 cereals, losses in thiamine and riboflavin contents were found to be significantly ($p < 0.05$) higher than in niacin content. Interestingly in all three food grains, *T. granarium* caused more losses of vitamins as compared to *R. dominica*. The observed differences may be attributed to the nature of damage of the insect species as well as distribution of vitamins in seed components. Vitamins have been reported to be mainly concentrated in aleurone layer, bran or germ portion of the seed [2, 14, 15] and these components are more affected by *T. granarium* because of its primarily germ feeding habit [5]. Since *R. dominica* is mainly endosperm feeder, it could cause comparatively less damage to vitamins of the seed.

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