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OBSERVATION ON THE EXTENT OF GRAIN DAMAGE BY RICE WEEVIL WITH RESPECT TO THE PRESENCE OF FEW PHYTO-CHEMICALS IN THE RICE GRAIN

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ABSTRACT: Whole rice grains have been received increasingly attention by consumers due to their potential health benefits because of their phyto-nutrient capacity. Proper storage of grain is thus crucial to avoid insect induced loss. Extent of grain damage is related to grain physico-chemical properties. Present experiment delineated carbohydrate, flavonoid and phenolic content of three selected rice sample namely *Swarna masuri*, *basmati* and *gobinda bhog* in relation to *Sitophilus oryzae* infestation. Comparatively larger grains had higher phenolic content, flavonoid content and antioxidant capacity than the usual smaller grains. The phenolic content had positive correlation with the flavonoid content (P<0.001) and the antioxidant capacity (P<0.01). Carbohydrate and protein content are not correlated with grain size. The phenol and flavonoid content had positive correlation with grain length, grain length to width ratio and 100-grain weight (P<0.01), but had no relationship with grain width and grain thickness. Grain carbohydrate, had shown significant positive relation with *S.oryzae* infestation while in case of lipid, flavonoid and phenol content, the relation is significantly negative. In consideration of physico-chemistry of the rice grains proper storage procedure should be adopted.

KEYWORDS: *S.oryzae,* extent of infestation, grains, phyto-chemicals, pest.

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1. INTRODUCTION

Agriculture is one of the foremost sectors in Indian economy and within which food production plays a pivotal role in guaranteeing our food safety. India now is one of the leading countries in the world on food grain production. Food grain loss due to the insect pest infestation during storage is a global problem. In average grossly 50% food grain loss has registered due to improper storage [1]. Out of that 42% is only for insect pest attack [2]. In tropical countries the dimension of damage may extend up to 56% [3]. In India the damage of stored grains by insect pests was estimated as 6.5 percent of the total storage amount [4]. Among all the stored grains rice occupy the foremost position throughout the world. About 90% of world's rice is grown and consumed in Asia [5]. As an agrarian state, West Bengal produces a variety of agricultural commodities. But the problem of stored grain losses is a challenge that needs to be undertaken meritoriously. A number of insect pests are reported from stored rice, out of that rice weevil, *i,e*; *Sitophilus oryzae* Linn. (Coleoptera:Curculionidae) is the major one. Besides rice it also infests other cereal grains and their products also. The adults feed mainly on the grain endosperm thus reducing the carbohydrate content, while the larvae feed preferentially on the germplasm of the grain thus removing a large percentage of the proteins and vitamins [6]. Climatic factors, especially the micro-climate such as temperature, relative humidity and nature of air movements within the store-house affect the distribution, development, survival, behavior, migration, reproduction, population dynamics and outbreaks of insect pests [7]. Damage to stored grain is easier to categorize visually by measuring the amount of grain weight loss. As the physical and chemical properties of different rice grains are variable, hence the chance of insect pest infestation and degree of loss is different. The estimation of the extent of stored grain loss is primarily physical leading to financial is rather difficult exercise but needs to be done to address them effectively by apposite storage conditions. In this contemplation, to observe the relative degree of damage by *S.oryzae* to rice grains in relation to the physico-chemical characteristics, a study for three consecutive months (May-July) of 2017 was carried out at the Entomology Laboratory, Department of Zoology, University of Gour Banga, Malda and Department of Zoology, Tarakeswar Degree College, Tarakeswar, Hooghly conjointly.

2. MATERIALS AND METHODS

Insect Sample: Stock culture of the rice weevil was generated by collecting the adult weevils from the infested rice grains from the local rice retailer. The insects were surface sterilized and the culture was further maintained in glass bottle of two

liter capacity containing same non-infested disease free rice grains that was collected earlier. Clean and fresh grains were provided intermittently and adequately to the bottles to ensure proper growth and development of the weevil. The culture was periodically inspected and accordingly precautions were taken. The bottle is covered with cotton cloth, held with a rubber band for the passage of air and keeps them at 28±20C and 75-85% relative humidity (RH) for an insect propagation.

Rice sample: (Fig:1, Table:1)

Fresh rice of three different varieties, viz: *Swarna masuri* (SM), *Gobinda bhog* (GB) and Basmati (BS) were considered for the experiment. The grains were dried under softly sun light to prevent 'moldiness' and subsequently stored in air tight plastic jars. Only complete and intact un-infested grains were selected for the experiments.

Table 1: Characteristics Of Rice Grain Used For The Experiment

Common English name	Abbreviated name	Shape	Colour
Swarnamasuri	SM	Slender	Cremish white
Gobindabhog	GB	Bold	Milk white
Basmati	BM	Elongated	White

(a) (b) (c)

Fig1: Selected rice cultivars for experimentation (a) *Swarna masuri* (b) *Gobinda bhog* (c) *Basmati*

Assessment of grain physical characteristics: Grain dimension: Dimension is expressed by vernier constant (VC). VC is the least count (LC) of the vernier calliper and record it stepwise as in the equation, LC = 1 MSD - 1 VSD

Determination of Vernier constant (Least Count) of the vernier callipers:

MSD= 1 mm., 10 VSD= 9 MSD, 1 VSD= 9/10 MSD= 0.9 mm.

Then, VC= (1 MSD- 1 VSD) = (1-0.9) mm.= 0.1 mm.= 0.01 cm.

To measure the length of the rice grain, open the jaws of the Vernier Calliper and place the grain horizontally in between the two jaws and adjust the movable jaw, such that it gently grips the body without any undue pressure on it. Record the main scale reading just before the zero mark of the vernier scale (N). This reading (N) is called main scale reading (MSR). Note the number (n) of the Vernier scale division which coincides with the division of the main scale. It has been repeated for 3 times. Repeat steps 4 to 7 for three different positions and record the observations. Now find total reading (TR) using the following equation,

$$TR = MSR+VSR = N + (n \times V.C)$$

Where, TR- Total reading, MSR- Main scale reading, VSR- Vernier scale reading, N- Zero mark of the vernier scale , n- No of the vernier scale division ,V.C- Vernier constant.

Grain weight: To assess the loss of rice grain weight following infestation, fresh grain of 50 gm. is packed in plastic vial with 25 mature individuals of *S.oryzae* with proper aeration. At 12 consecutive days of intervals the weight of the grain is taken and tabulated.

Grain moisture content: Moisture content of rice grain was assessed following the method of Silva [1]. 25 gm. of grains were taken and placed in previously weighed crucibles and continuously dried at 105^0C in a hot air oven until the constant weight was attained. Moisture content was determined by calculating the difference between initial weight and dry weight of the sample.

Assessment of grain chemical characteristics:

Qualitative test:

The collected grain samples were shade dried for about 6-7 days and turned it into powdery form by using a mixer grinder at 20000 r.p.m. Those powders were then sieved by 0.5 mm metallic mesh and stored properly [8,9].

Aqueous extract: 10gm. of crude powder was mixed with 100 ml. of double distilled water containing a 250 ml. conical flask and mixed properly by using a magnetic stirrer for about 10 hrs. The mixture was then filtered by Whatman filter paper (no.1, 150 mm.) and the filtrate was used for the following phyto-chemical tests.

Tannin: Few drops of 1% FeCl3 solution was added to 10 ml. of aqueous extract. Appearance of blue black colored precipitate indicates the presence of tannin.

Phlobatannin: 2 ml. of conc. HCl was added to 10 ml. of aqueous extract and boiled for 1 min. Red precipitation indicates the presence of phlobatannin.

Carbohydrate: After taking 2 ml. of aqueous extract, 2 ml. of Molish's reagent (5% α napthol in absolute ethanol) was added to it and shaken vigorously until it mix properly 2 ml. of conc. H_2SO_4 was added to the mixture very carefully using a pipette. Presence of carbohydrate was indicated by the formation of redish-violet ring at the junction of two liquids.

Starch: 10 ml. of aqueous extract was taken in a test tube and boiled for about ten minutes, kept it for a few minutes for cooling and then about 3-4 drops of iodine solution was added to it by using a dropper. Appearance of violet colour indicated the presence of starch.

Protein: 1 ml. of 40% NaOH solution was added to 2 ml. of sample aqueous solution in a test tube. After mixing properly, 1-2 drops of CuSO4 solution was added. The colour of the solution turned into violet indicated the presence of the presence of protein.

Methanolic extract: 10gm. of crude powder was added to 100 ml. of 70% methanol containing 250 ml. conical flask and was mixed properly by using a magnetic stirrer for about 10 hrs. in room temperature and filtered through Whatman filter paper (no.1, 150 mm.) and the filtrate was used for the following phyto-chemical tests.

Terpenoid: 5ml. filtrate was taken and mixed with 2ml. of chloroform. 3ml. of conc. H_2SO_4 was added to the mixture very carefully. Presence of terpenoids was indicated by the appearance of redish-brown coloration at the interphase of two liquids.

Glycosides: 5 ml. of methanolic extract was taken in a test tube and 2 ml. of glacial acetic acid containing 2% $FeCl_3$ solution was added to it. Then 1 ml. of conc. H_2SO_4 was added very carefully along the wall of the test tube. Formation of a brown ring at the junction of two liquid indicates the presence of glycosides.

Steroid: 5 ml. of methanol extract was mixed with 0.5 ml. of anhydrous CH_3COOH and then cooled on an ice bath for 15 min. After adding 0.5 ml. chloroform to it, 1 ml. of conc. H_2SO_4 was poured along the wall of the test tube carefully by using a pipette. At the junction of two liquids, a redish brown ring was formed, that indicates the presence of the steroids.

Alkaloid: After taking 2 ml. of filtrate in a test tube, 2 ml. of 2N HCl was added to it. Then it as shaken vigorously and kept for 5 min. After separating the aqueous phase from two liquid, few drops of Mayer's reagent ($HgCl_2$+KI in water) was mixed to it and shaken until creamy colored precipitate appeared.

Cholesterol: 2 ml. of chloroform was mixed with 2 ml. of ethanolic extract and 10-

12 drops of acetic acid anhydride was added to the mixture and shaken properly. In addition to 2 drops of conc. H_2SO_4 to it, the reddish brown coloration of the mixture turned into bluish green coloration, that indicates the presence of cholesterol.

Phenol: 10 ml. of ethanol extract was treated with few drops of 2% $FeCl_3$ solution. Bluish black coloration indicates that the presence of phenol.

Flavonoid: 2gm. of crude grain powder was mixed with 10ml. of ethyl acetate over a water bath for about 5 min. The solution was then filtered through Whatman filter paper no.1. Dilute ammonia solution (10%) was mixed with 4 ml. of the filtrate and shaken vigorously. Appearance of yellow coloration of the solution indicates the presence of flavonoids.

Anthraquinone: Within a 100 ml. conical flask 0.5 gm. of crude powder was taken and 20 ml. of benzene was mixed with it. The mixture was stirred in a magnetic stirrer for about 4 hrs. and filtered through Whatman filter paper no.1. 0.5 ml. ammonia solution was added to 10 ml. of that filtrate and mixed properly. Presence of violet coloration at the interphase indicated the presence of anthraquinone.

Saponin: 0.5 gm. of crude powder was taken in a test tube and mixed with 15 ml. of doubled distilled water and boiled for a few minutes within a boiling water bath. Presence of saponin was indicated by the formation of intensive froth.

Quantitative tests:

The quantitative estimations of different phyto-chemicals were performed according to the following standard method.

Estimation of total protein: Total protein content was estimated according to Lowry *et al*. [10] with slight modification. Known concentration of bovine serum albumin was taken as standard and the OD value was taken at 750 nm. using a suitable blank.

Estimation of total lipid content: Estimation of total lipid content was done by following the method of Jayaraman *et al*. [11] with few modifications. 1 gm. of sample powder was added to 10 ml. of distilled water. 30 ml. of chloroform: methanol (2:1) was mixed thoroughly to it and kept overnight at room temperature. 20 ml. of chloroform and equal volume of distilled water was added to it and centrifuged at 1000 r.p.m. for 10 min. As a result three layers were appeared, out of which the lower one was collected and it was left in an oven for one hr. at 50^0C, remaining part was weighed.

Estimation of total carbohydrate: The total carbohydrate content was determined according to slight modifications of the method followed by Dubois *et al.* [12]. According to this method 50 gm. of the test sample was macerated in a pestle

and mortar with 20 ml. of ethanol and kept for incubation at 30^0C for about 10 hrs. The mixture was centrifuged at 1500 r.p.m for 20 min. and the supernatant was collected. 1 ml. of 5% phenol was mixed with 1ml of alcoholic mixture. 5ml. of conc. H_2SO_4 was added rapidly with constant stirring. It was kept for 30 min. at room temperature. Colour of the solution become changed into yellowish orange, the OD was measured at 490 nm. against a blank.

Estimation of flavonoid: For estimating the quantity of total flavonoid content, modified method of Boham *et al*. [13] was followed. A conical flask 10 gm. of grain powder was mixed with 100 ml. of 70% methanol. The mixture was then stirred using a magnetic stirrer for about 3 hrs. and filtered through Whatman filter paper no.1. After filtration the remaining powdered material was re-extracted again with 70% methanol and filtered in similar method. Both the filtrate was mixed and placed into a crucible and kept over a water bath of 60^0C for evaporation and remaining powder was weighed.

Estimation of total phenolics content: For estimating the total phenol content according to Obadoni *et al.*[14] the used sample must be fat free, for this purpose 5 gm. of crude plant powder was mixed with 100 ml. of n-hexane and remove fat using a soxlet apparatus for about 2 hrs. The resultant was used for further tests. Taken sample was boiled with 50 ml. of ether for about 15 min. Then it was filtered by using Whatman filter paper no.1. 5 ml. of the filtrate was taken in a 50 ml. conical flask and 10 ml. of double distilled water was added to it. 2 ml. of NH_4OH solution and 5 ml. of concentrated amyl alcohol were also added to the solution and stir continuously. Then it was kept at room temperature for about 30 min. The absorbance was measured at 550 nm. against suitable blank. The phenol content was estimated by gallic acid standard curve.

Observation on grain damage: For studying the grain damage, experiment was carried out in plastic containers (7cm. diameter × 5cm. height), each with about 25 gm. Of grain variety. There were 6 separate containers for each of the 6 cultivars with 3 replications for each, were maintained. The room condition was maintained at 29±2°C temperature and 84±2% RH respectively. Rice of each container was infested with two-week-old 30 adult rice weevils. After 12 days interval, each container was weighted and the extent of weight loss was calculated. This experiment was continued up to 60 days from the release of *S.oryzae* to each container. Daily temperature and humidity were maintained by B.O.D incubator (Yoma, model no.: 2789). Percent of grain damage and percent of grain weight loss was accordingly calculated. Average weight loss was

calculated for each variety separately. After completion of the experiment, percent of grain weight loss was from the difference of un-infested grain weight and the weight of the grain following the infestation of *S.oryzae.* Percentage of grain damage was assessed using the following formula:

Weight loss (%) = (weight loss of grains / total weight of grains) × 100

Damaged and undamaged grains were independently weighed by electronic balance machine. Weighing was recorded at 12, 24, 36, 48, and 60 days interval from the very date of treatment, *i.e;* the release of *S.oryzae*, in each container.

3. RESULTS

Assessment of grain physical characteristics:

Grain Dimension: It is essential to the measure the of volume (Length and breadth) of grains prior to study the extent of grain damage by stored grain pests. As *S.oryzae* is completing its life cycle within the holes of the grains, then surface area is very much important in this regard. Grains with high breadth is more suitable. Maximum length is measured in case of BS (0.79 cm.) and minimum in GB (0.43 cm.). Whereas breadth of the three rice varieties are more or less same that are 0.16 cm., 0.14 cm. and 0.16 cm. in SM, GB and BS respectively.

Table 2 : Dimension Of Selected Rice Varieties

Rice Cultivars	Length (cm.)	Breadth (cm.)	L/B ratio
Swarna masuri	0.67	0.16	4.18
Gobinda bhog	0.43	0.14	3.07
Basmati	0.79	0.16	4.93

Grain weight: Effective boring by *S.oryzae* is directly correlated with the amount of the seed kernel that is proportional to the weight of the of the grains. Again weight is dependent on grain shape and dimension of the seed, so it can be varied in different grains. As the larvae and adults of the *S.oryzae* specially engulf the seed kernel, then grains with high kernel part are very much susceptible for pest attack. In

rice grain maximum weight has been obtained in BS (15.13±0.03 mg./grain) and minimum in GB (7.76±0.01 mg./grain) and medium in SM (13.15±0.02 mg./grain).

Table 3: Individual Grain Weight Of Selected Rice Varieties

Grain variety	Total amount taken for weighing (gm.)	Number of grains counted	weight of each grain (mg.)
Swarna masuri	5	380 ± 0.47	13.15 ± 0.02
Gobinda bhog	5	644 ± 0.94	7.76 ± 0.01
Basmati	5	330 ± 0.73	15.13 ± 0.03

Grain moisture: Moisture content of the grains is the prime factor for storage, it is variable in different grains and also fluctuate in respect to time and other environmental factors. In this study, maximum (14%) moisture content has obtained from SM and minimum (13.20%) in BS, whereas, GB contain moderate (13.60%) amount of moisture.

Table 4 :Percentage Of Moisture Content In Selected Rice Varieties

Grain variety	Weight of petriplate (W)	Weight of (petriplate+grain) before incubation (W_1)	Weight of (petriplate+grain) after incubation (W_2)	Percentage of moisture content (%)
SM	11.6	11.6+5=16.6	11.6+4.30=15.90	14
GB	11.6	11.6+5=16.6	11.6+4.32=15.92	13.60
BS	11.6	11.6+5=16.6	11.6+4.34=15.94	13.20

Assessment of grain chemical characteristics:

Qualitative assessment:

The type and amount of the nutritional components and secondary metabolites present in the different rice varieties varied largely and this is correlated with the extent of insect pest infestation. From the study it has revealed that carbohydrate, protein, phenolics and flavonoids are present in all the grains and their amount differ from each other **(Fig.2, Table:5)**. But tannin, phlobatannin, cholesterol, terpenoid, glycosides, phenol, steroids, anthraquinones, saponin and alkaloid are totally absent in the selected grains.

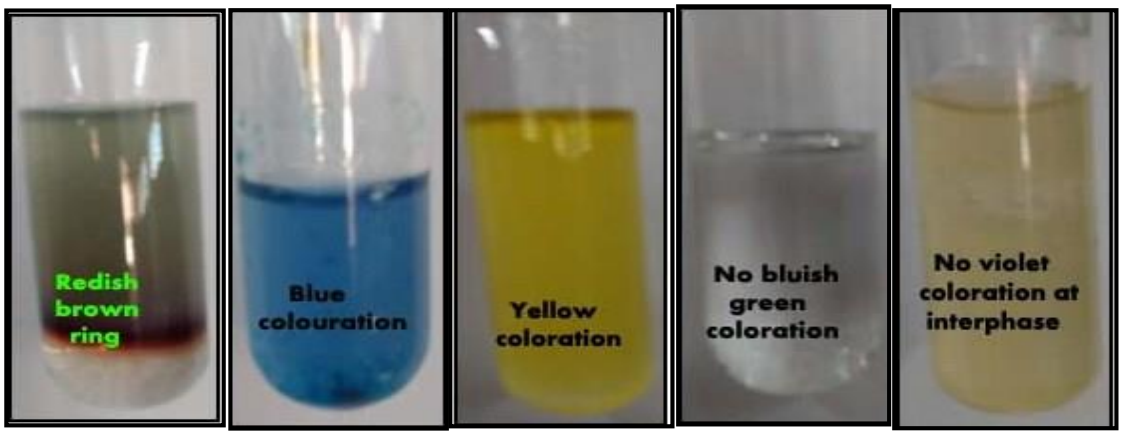
Table 5: Observation On Some Selected Phyto-Chemical Properties In Rice Varieties Under Experimentation:

Name of the different	Phyto-chemical properties of Rice grain

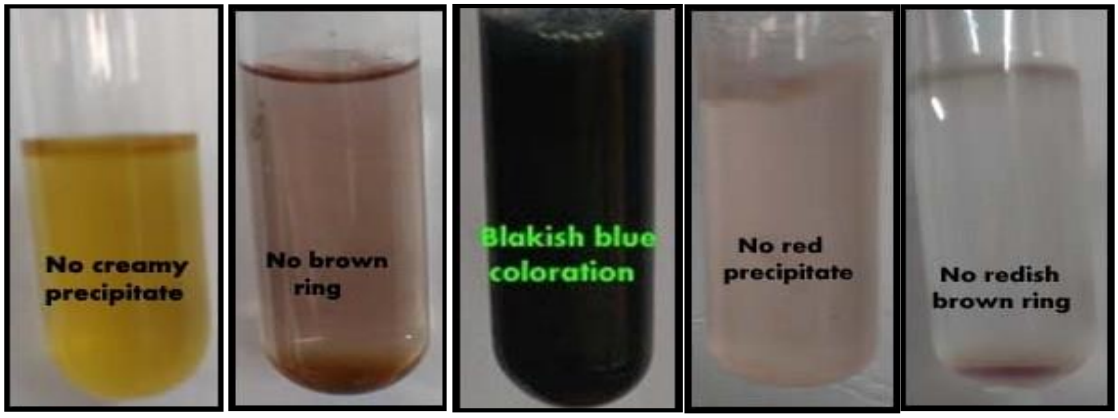
Phyto-chemicals	Rice varieties		
	SM	GB	BS
Tannin	--	--	--
Phlobatannin	--	--	--
Cholesterol	--	--	--
Terpenoid	--	--	--
Glycosides	--	--	--
Phenolics	++	++	++
Flavonoid	++	++	++
Steroid	--	--	--
Anthraquinone	--	--	--
Saponin	--	--	--
Carbohydrate	++	++	++
Protein	++	++	++
Alkaloid	--	--	--

(++ : Presence of phyto-chemicals and --: Absence of phyto-chemicals)

(SM- *Swarna masuri*, GB- *Gobinda bhog*, BS- *Basmati*)



(a) **(b)** **(c)** **(d)** **(e)**



(f) **(g)** **(h)** **(i)** **(j)**

(k) **(l)** **(m)** **(n)**

Fig.2: Quantitative assessment of some selected phyto-chemicals in rice (a-Carbohydrate, b-Protein, c-Flavonoids, d-Cholesterol, e-Anthraquinone, f-Alkaloid, g- Glycosides, h-Phenolics, i-Phlobatanin, j-Steroid, k-Tanin, l- Terpenoid and m- Saponin and n- Starch)

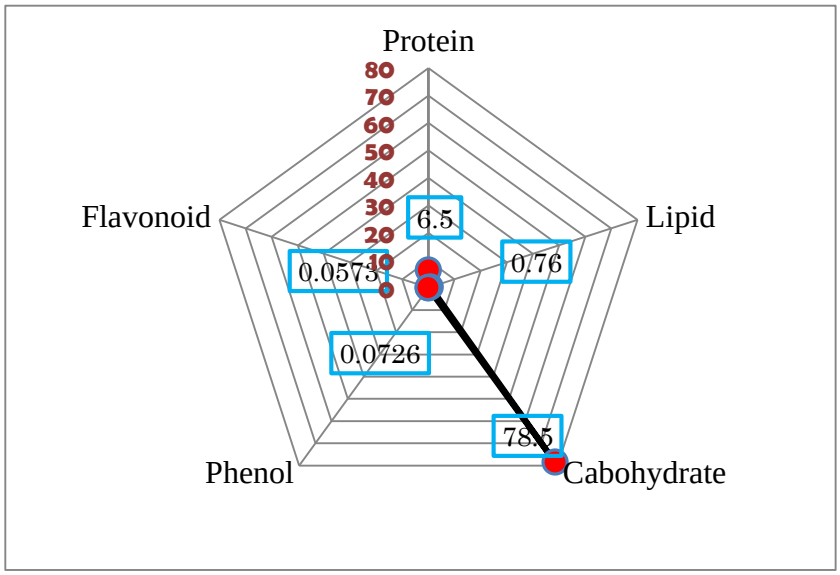
(Absence of colour formation negate the absence of that particular components)

Quantitative assessment:

The quantitative estimation of different phyto-chemicals revealed that they are present in different quantity in different grain samples. In SM maximum carbohydrate content (78.5 gm./100gm.) is present that was greater than the other two rice varieties, *i,e*, 77.4 gm./100gm. in GB and 76.8 gm./100 gm. in BS. Again protein content was maximum in GB (8.2 gm./100gm.), whereas less in SM *i,e.* 6.5gm./100gm. Likewise, lipid content in BS (1.2 mg./gm.), was much more greater than the other grain varieties. Other phyto-chemical content also varies greatly in different grains, *viz*- phenol content was maximum in BS (63.1mg.GAE/100gm.) and was minimum in SM (57.3 mg.GAE/100gm.). Maximum flavonoid content has obtained from BS (87.2 mg./100gm.) and minimum from SM (72.6 mg./100gm.), other grains contained moderate amounts of the phyto-chemical **(Table:6).**

Table 6: Quantitative Estimation Of Some Selected Phyto- Chemicals In Grain

Rice Varieties	Total Carbohydrate (gm./ 100 gm.)	Total protein (gm./100 gm.)	Total lipid (gm./100 gm.)	Total flavonoid (mg./100gm.)	Total phenolics (mg.GAE/100gm.)
SM	78.5	6.5	0.76	72.6	57.3
GB	77.4	8.2	0.92	86.8	61.3
BS	76.8	6.9	1.2	87.2	63.1



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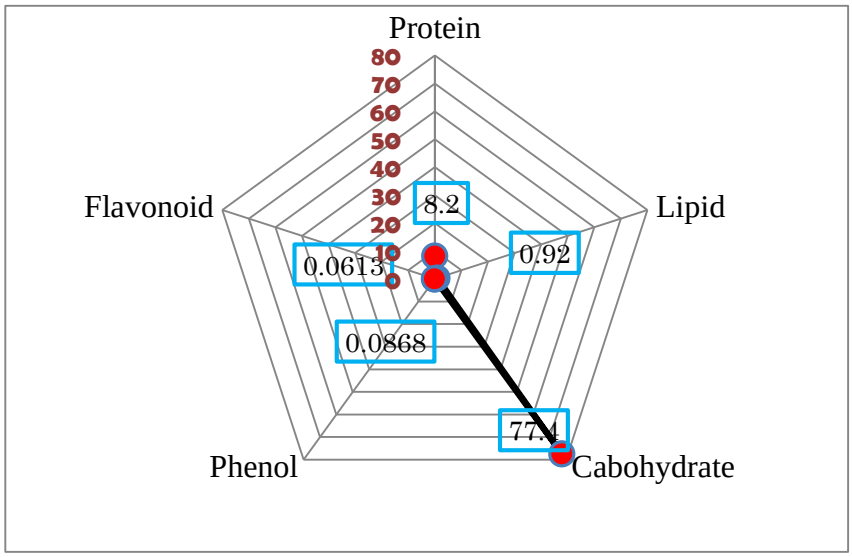

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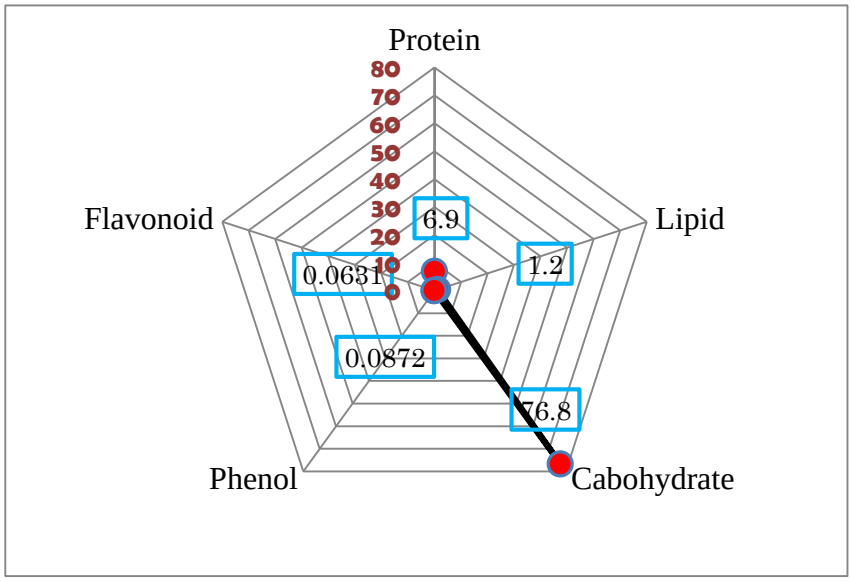

(c)

Fig.3: Relative importance of six phytocompound in selected food grains:

(a) *Swarnamasuri* (b) *Gobindabhog* (c) *Basmati*

Table 7: Correlation Matrix Of The Phyto-Compounds That Were Extracted From The Food Grains

	Carbohydrate	Protein	Lipid	Flavonoid	Phenol
Carbohydrate	1.0000				
Protein	-0.8886*	1.0000			
Lipid	-0.5456*	0.6174*	1.0000		
Flavonoid	-0.9479*	0.9341*	0.4767	1.0000	
Phenol	0.2947	0.5687*	-21891	-0.3379	1.0000

(*): Significant at 5% level

Significant negative correlation was noted between grain carbohydrate and protein content. Higher the amount of grain carbohydrate, lower would be the amount of protein. Both lipid and flavonoid had also exhibit negative relation with grain carbohydrate content. Phenol had however insignificant positive relation with carbohydrate. Grain protein had significant positive relation with lipid flavonoid and phenol content. Relation between flavonoid and protein were insignificantly positive. A negative and insignificant relation was noted between flavonoid and phenol. Grossly grain lipid content had no impact on grain flavonoid and phenol content. Insignificant and negative relation was noted between grain flavonoid and grain phenol content.

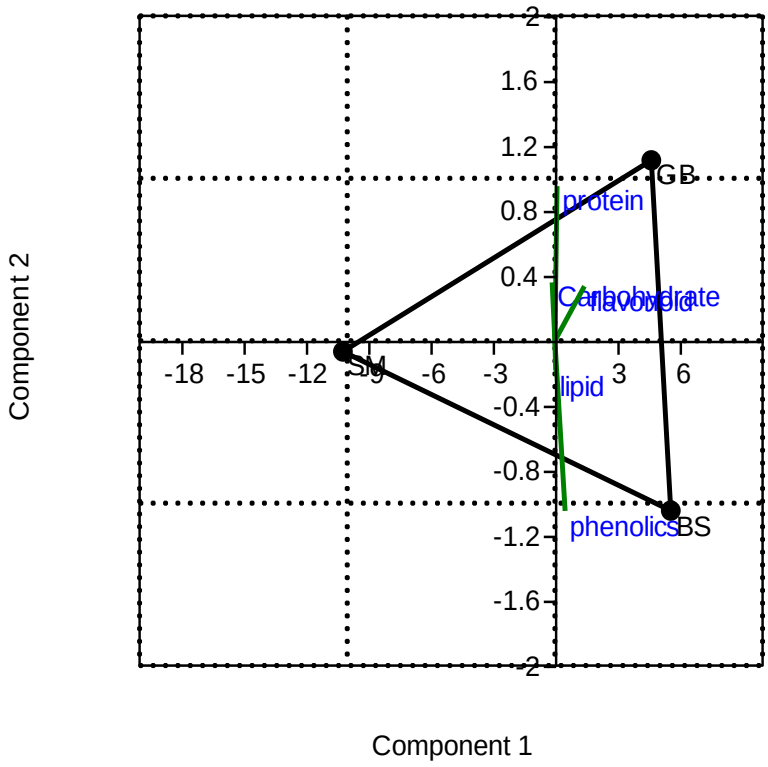

Fig.4: Principal component analysis of the important phyto-chemicals of the rice grains

Principal component analysis had shown that the phenolics imparted significant negative impact on *S.oryzae* infestation. Grain protein content had very little effect on *S.oryzae* incidence. Effect of grain lipid and carbohydrate had respectively moderate effect on grain infestation. Grossly, in consideration of all phyto-cheimcal properties, GB and BS belong to same category. While SM is somewhat dissimilar from the rest of the two.

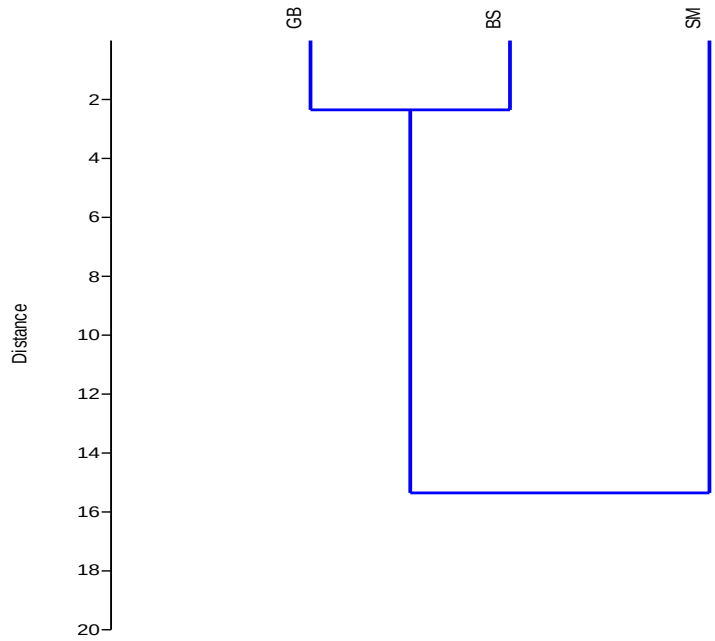

Fig.5 : Dendogram showing the categorization of the grain depending on the phyto-nutrient properties

In cladistics or phylogenetics, an outgroup is a group of organisms that serve as a reference group when determining the relationship among six monophyletic groups of grain sample. The out-group is used as a point of comparison for the in group, the set of phyto-compound study that specifically allows the phylogeny to be rooted. Among the rice cultivars, GB and BS had somewhat similar in phyto-compounds. However the phyto-compound of SM differed considerably from other two rice cultivars.

Extent of damage:(Fig.6 and 7, Table. 8)

In the present experiment grain weight loss indicated the quantitative loss in stored grains due to the infestation of *S.oryzae.* In SM the extent of loss at 12, 24, 36, 48 and 60 days interval was 12.60%, 18.30%, 25.42%, 31.90% and 35.80% respectively. In GB, the degree of loss was 11.10%, 14.90%, 19.92%, 23.18% and 27.30% respectively at the same time intervals. In BS rice the value of loss was 5.10 %, 10.30%, 13.40%, 17.88% and 21.16% respectively

Fig.6: Rice grains following infestation with *S.oryzae*, a-*Swarna masuri* , b-*Gobinda bhog,* c-*Basmati*

Table 8: Amount And Percentage Of Weight Loss By *S.Oryzae* In Selected Rice Cultivars

Days	Amount of grain provided (gm.)	SM			GB			BS		
		Wt. of grains after infestation	Wt. Loss(gm.)	Percentage of wt loss (%)	Wt. of grains after infestation	Wt. Loss (gm.)	Percentage of wt. Loss (%)	Wt. of grains after infestation	Wt. Loss (gm.)	wt. Loss (%)
12	25	21.65	3.35	13.40	22.10	2.90	11.60	23.65	1.35	5.40
12	25	21.08	3.20	12.80	22.35	2.65	10.60	23.08	1.20	4.80
Average	25	21.72	3.15	12.60	22.37	2.62	11.10	23.72	1.27	5.10
24	25	20.45	4.55	18.20	21.26	3.74	14.96	22.45	2.55	10.20
24	25	20.04	4.60	18.40	21.29	3.71	14.84	22.40	2.60	10.40
Average	25	20.24	4.57	18.30	21.27	3.72	14.90	22.24	2.57	10.30
36	25	18.68	6.32	25.30	20.01	4.99	19.96	18.68	3.32	13.28
36	25	18.62	6.38	25.55	20.03	4.97	19.88	18.62	3.38	13.52
Average	25	18.65	6.35	25.42	20.02	4.98	19.92	18.65	3.35	13.40
48	25	17.08	7.92	31.70	19.29	5.71	22.84	20.08	4.92	19.68
48	25	16.98	8.02	32.10	19.12	5.88	13.52	20.98	4.02	16.08
Average	25	17.03	7.97	31.90	19.20	5.79	23.18	17.03	4.47	17.88
60	25	16.20	8.80	35.20	18.10	6.90	27.60	19.82	5.18	20.72
60	25	15.73	9.10	36.40	18.25	6.75	27.00	19.60	5.40	21.60
Average	25	15.68	9.31	35.80	18.17	6.82	27.30	15.68	5.29	21.16

Grossly, among rice samples, maximum grain damage (%) after 60 days was registered for SM (35.80%) while the least was noted in BS (21.16%).

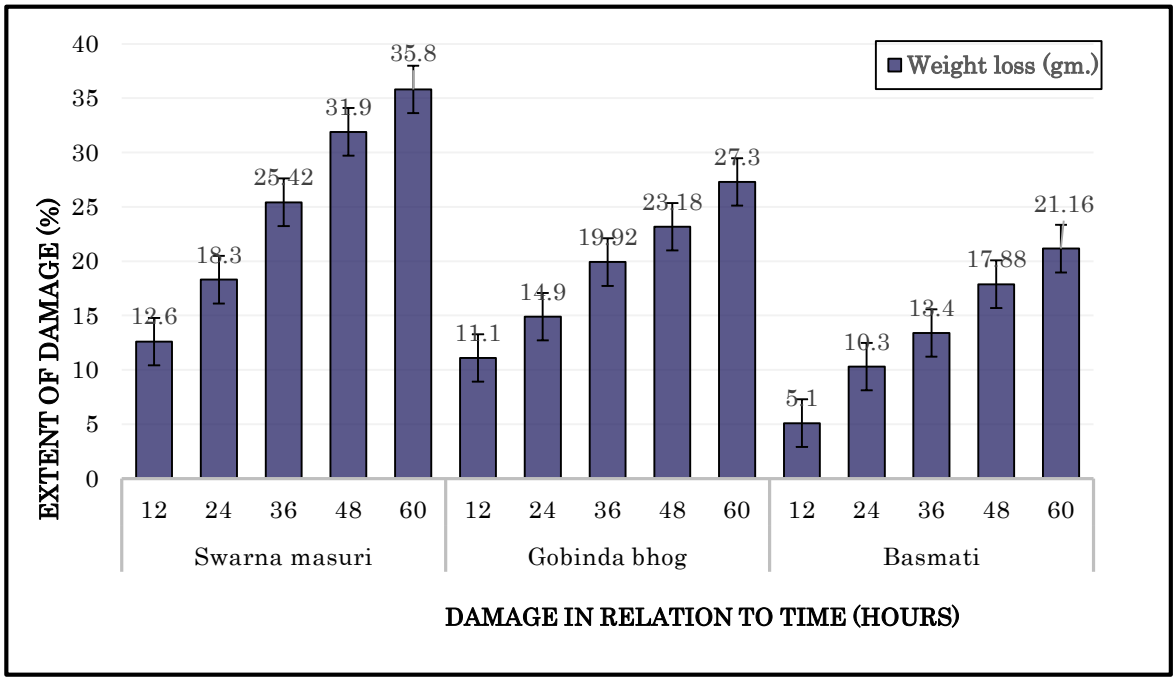

Fig. 7: Extent of weight loss in selected rice cultivars by *S.oryzae*

4. DISCUSSION

Flavonoids enable food to be tasty which is in line with the work of Dakora *et al.* [15]. He had noted that flavonoids promote peculiar taste in prepared foods. The flavonoids naringenin and quercetin deterred aphid 'probing' and feeding as documented by Weaver *et al.* [16]. According to Bors *et al*. [17] flavonoids imparted negative effects on insect herbivory. The mode of insect deterrent activity of flavonoids is connected with their efficiency to restrict the feeding behavior of insects as documented by Beninger *et al*. [18]. It has been shown that glycosides in *alfalfa* plant augmented feeding behavior of pea aphid as documented by Ding *et al*.[19]. In consideration to insect-pests activity, 'phenolics' act as digestion inhibitors, and also reacts with 'oxygen species' by producing free radicals [20]. Carbohydrate content provides the main energy sources of the food grains; especially in the rice. It constitutes the main endosperm part of the grains. The carbohydrate content mainly stored in the form of starch and a few non starch polysaccharides [21]. So higher the amount of carbohydrate higher would be the possibility of the insect incidence. Actually damage to grain is directly related to the quality and variety of grain attention in relation to the type of the grain should be given priority, the so thus, can be minimized /controlled by the selection of appropriate variety with a modulation of the micro-climatic conditions of storage. Boham *et al*. [13] had reported that the increase of 'phenolics' is related to higher resistance in *Brassica* plant. It had documented that the amount of free p-coumaric acid in grains was related to the degree of resistance

level of infestation by *Sesamia* larval forms to growing maize plant [22]. It has been further documented that the development of *S. oryzae* on legumes, peas, lentils, green and black gram was related to the grain properties [23]. About 79-81%, 56-74% and 36-40% weight loss in barley, rice and wheat due to *S.oryzae* and *S.granarius* infestation at 25°C and 70% RH respectively was noted [24]. Loss of grain weight due to *S.oryzae* infestation varied from 4 to 52% in different sorghum varieties during storage up to 9 weeks at 30°C and at 72% R.H. [25]. It has been reported that *S.zeamais* caused 85-93% grain damage after 60 days following rearing with *S.oryzae* [26]. In the present observation, in consideration of rice cultivars, maximum grain damage (35.80%) occurred in SM and minimum in BS (21.16%) after 60 days following release of *S.oryzae.* So it can be concluded that extent of grain damage was proportionately related to chemical nature of the grains.

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