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A New Approach in Analysis of the Factors Affecting the Chemical Components in Brown Rice

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현미중 화학성분함량 결정요인 해석에 관한 새시도

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요 약

동일비중을 갖는벼의 현미중 수개 화학성분함량은 품종의 유전적 상수로서 그값은 환경요인에의하여 영향받지 아니하고 환경요인은 비중별 분포비율만 변화시킨다는 가설을 질소함량에 대하여 검정증명하고 인산, 가리, 칼슘 및 마그네시움에 대하여 동가설의 입증가능성과 가설이 갖는 영양생리적 의의를 검토하였다.

The concentration of a chemical constituent in brown rice is determined by the genetic response to the environmental condition. Thus the same variety has different values of a chemical compo nent, for example protein, [1,2] according to its growing condition.

Then is it possible to separate the genetic effect and the environmental effect in a chemical content of brown rice? It seems possible if the following hypothesis is proved.

Hypothesis: The concentration of some chemical constituents of brown rice with the same specific gravity is the same as a genetic constant of the variety without being affected by the environmental factors which change only the percent distribution of specific gravity of grains. First of all, this hypothesis was tested on the nitrogen content.

MATERIALS AND METHODS.

Each two samples of three varieties, Jinhung Nonglim 6 and IR 667-Suwon 215 were obtained from different growing conditions. i.e. pot experiment, farmer's field, experimental field and so on.

The air dried grains were immersed in tab water for 20 minutes and separated into 6 classes differing suceessiuely 0.4 in specific gravity from 1,00 to 1.24 by using sodium chloride or calcium chloride solution. No grain has higher specific gravity than 1.24 in all three varieties. After rinsed with the tab water, dried in the recurrent dryer for 24 hours at 70°C the weight was measured and the percentage to total weight was calculated as the percent distribution of specific gravity. The embryo was separated from brown rice by a razor blade in three classes (1.04-1.08, 1.12-1.16 and 1.20-1.24). The deembryoed brown rice was ground to 40 mesh and 0.5g of it was digested in a microkjeldahl flask with H_2SO_4-H_2O_2.

One hundred milligrams of embryo were used for digestion. Nitrogen was determined by the distillation method, phosphorus by the vanado-molybdate method, and potassium, calcium and magnecium by the atomic absorption spectrophotometry.

All chemical analyses are of one replicate.

Statistical analyses on nitrogen content and grain weights distributed in each specific gravity were carried to test association between specific gravity and the environmental condition accordng to Chi-square test and the effect of environmental factors and the interaction between variety and specific gravity were tested (4).

RESULTS AND DISCUSSION

NITROGEN CONTENT, DISTRIBUTION PERCENT AND 1000-GRAIN WEIGHT:

The nitrogen contents in the deembryoed brown rice were shown in table 1. It shows greater difference between specific gravitie than that between two different environments. Nitrogen contents seem to be same at the same specific gravity within variety. It appears to be well correlated to specific gravity negatively in all three varieties. Tani (3) also reported the highly significant negative correlation between protein content and specific gravity. The percent distribution of unhulled grain weight and its 1000-grain weight in each specific gravity are shown in table 2. The maximum percent distribution is not in the same specific gravity between two environm ents in all three varieties. It indicates the possib le environmental effect on the percent distribution.

STATISTICAL ANALYSIS: The independency of specific gravity from environment on the nitrogen content was proved by Chi-square test on 3x2 contingency table. However, there was highly significant association between specific gravity and environment on weight distribution in all varieties as shown in table 3. Whether the environmental factors affect the nitrogen content uniformly in all specific gravity classes is still obscure. For testing it analysis of variance was done considering the environment as replication, variety as main plot and specific gravity as sub-plot.

Table 1 Nitrogen content of deembryoed brown rice in various specific gravity (mg N/g dw at 70°C)

Variety	Jinhung		Nonglim 6		IR 667-Suwon 215	
Specific gravity	I	II	I	II	I	II
1.04-1.08	13.0	13.3	13.0	14.2	17.9	16.2
1.12-1.16	12.4	12.3	12.1	12.2	15.2	15.4
1.20-1.24	11.2	11.5	11.5	11.2	13.6	11.1
Pooled Sample	11.3	11.7	11.9	11.5	15.5	14.2

Table 2 Percent distribution of weight of unhulled rice and 1000-grain weight in various specific gravity

Variety	Jinhung				Nonglim 6				IR 667-Suwon 215			
Environment	I		II		I		II		I		II	
Specific gravity	%	g	%	g	%	g	%	g	%	g	%	g
1.00—1.04	0.8	17.9	0	0	2.2	16.5	0	0	4.0	20.8	3.4	20.6
1.04—1.08	0.9	20.4	0.2	20.9	3.7	18.0	0.4	15.8	5.7	22.7	5.1	21.8
1.08—1.12	1.5	22.1	3.1	22.1	7.7	19.2	2.1	16.5	19.9	25.0	11.9	24.1
1.12—1.16	4.9	24.6	9.9	24.0	24.8	21.5	6.0	18.2	46.2	26.6	30.7	25.4
1.16—1.20	7.5	26.9	51.5	29.8	47.7	23.3	29.0	21.0	19.3	26.1	47.2	27.1
1.20—1.24	84.4	28.7	35.3	29.1	13.9	22.7	62.4	23.7	4.9	25.9	1.7	27.8

There was no significant difference between replication. Thus it is clear now that the environmental factors do not affect the nitrogen content. The nitrogen content between specific gravity classes only is significantly different (P=0.0)

The nitrogen contents of the pooled samples (table I) are not much different in two varieties except IR667-Suwon 215. Thus these may not be so good samples and also the sample size may not be enough for testing the hypothesis. The difference of nitrogen content among the pooled samples, however, are mostly greater than those of the same gravity in Jinhung and Nonglim 6. Even IR667-Suwon 215 showed little difference in the specific gravity having considerably high percent distribution. Therefore, the above hypothesis is acceptable.

According to the hypothesis the difference of nitrogen content in the same specific gravity could be fully explained. It could be so due to the different distribution percent within 0.4 of specific gravity interval. Such reasoning deduced from the hypothesis may be strongly supported by the fact that the greater differences are shown in the lower specific gravity class. Thus the nitrogen content with the same specific gravity is a varietal genetic constant and the nitrogen content of pooled sample is changed only by percent distribution which is affected only by the environmental condition.

Table 3 Association between specific gravity and environmental condition

	Variety	df	X^2	P	association
Nitrogen content	Jinhung	2	0.004	1.0-0.99	NO
	Nonglim 6	2	0.044	0.98-0.95	NO
	IR667-Suwon 215	2	0.162	0.95-0.90	NO
Weight of Brown rice	Jinhung	4	172.53	<0.01	Yes
	Nonglim 6	4	103.29	<0.01	Yes
	IR667-Suwon 215	4	61.86	<0.01	Yes

Table 4 P_2O_5 K_2O in deembryoed brown rice in specific gravity

Variety		Jinhung		Nonglim 6		IR667-Suwon 215	
Environment		I	II	I	II	I	II
	S.G						
P_2O_5	1.04-1.08	5.04	4.92	5.04	5.27	5.27	5.27
	1.12-1.16	4.35	4.12	4.47	4.92	5.04	5.04
	1.20-1.24	4.02	3.69	4.35	4.12	4.12	4.47
K_2O	1.04-1.08	3.84	3.60	3.24	3.98	3.12	3.12
	1.12-1.16	3.36	3.17	3.00	3.12	2.88	3.00
	1.20-1.24	2.76	2.76	2.88	2.76	2.76	2.88

Unit; mg/g dw

APPLICABILITY OF HYPOTTESIS ON P,K, Ca and Mg:

Phosphorus and potassium contents in relation to specific gravity and environmental condition showed a quite similar trend to nitrogen (table 4). In many cases calcium showed greater deviation between two environments than that among specific gravity classes even though the calcium content is clearly decreased with the inerease of specific gravity. Magnecium showed no consistency

Thus it appears that the hypothesis is well

agreed also on phosphorus, potassium and probably on calcium. The hypothesis may not be true in all chemical components considering the physiological role of each chemical constituent in the ripening process. The only chemical constituents which are effective quantitatively in the ripening process may agree with the hypothesis.

TTable 5 Nitrogen content in rice embryo in various specific gravity

Variety	Jinhung		Nonglim 6		IR667-Suwon 215	
Environment	I	II	I	II	I	II
Specific gravity						
1.04-1.08	43.3	44.0	46.0	45.5	43.4	44.5
1.12-1.16	39.3	40.8	43.4	43.5	40.8	41.8
1.20-1.24	35.2	36.4	41.8	41.0	38.8	35.8

Unit; mg N/g dw

PHYSIOLOGICAL SIGNIFICANCE OF HYPOTHESIS: The specific gravity seems to be closely related to maturity of the grain in terms of 1,000-grain weight (Table 2) and the quality of brown rice.

The lower the specific gravity the more the unmatured green rice appeared. As the specific gravity increases the 1,000-grain weight increases also. In most cases, however, the highest percent distribution of grain weight coinsided with the highest 1,000-grain weight. It may indicate that the specific gravity is better parameter than 1,000-grain weight in relation to the ripening physiology.

The factors determining the specific gravity are firstly the difference in the chemical composition, i,e, carbohydrates, protein, lipid and ash etc., and secondly the difference in the grain anatomy. The chemical difference may be due to the duration of starch formation in the endosperm. When the duration of ripening is short or the rate of starch synthesis is very low the bran layer may be fully formed but the stored starch is limited. But it does not appear to be sole reason, because the nitrogen content in the embryo showed the similar trend to the deembryoed brown rice (Table 5).

The anatomical differences such as the water imbition rate of hull and the size of air cavity between the hull and bran layer may contribute to the difference in specific gravity. There is a decreasing trend of the hull percentage with increasing of specific gravity. The contribution of hull percentge on specific gravity cannot be neglected but there must be some anatomical factors also. The significance of hull percentage relating anatomical difference siould be further investigated.

Considering that the ripening is a nutriophysiological process the hypothesis indicates that the grain in the same specific gravity has the same nutriophysiological condition during the ripening in the same variety. It may be true at the level of individual grain even though the rice plants were grown in quite different environments. Thus the nutriophysiological factors controlling the specific gravity could be elucidated only by the precise investigation of ripening process at the level of individual grain in relation to their position in the ear together with the anatomical change. Since the amino acid content and pattern in the embryo or in the deembryoed brown rice appear to show a different trend from nitrogen content among the varieties(unpublished data) the physiological significance of nitrogen content may be greatly different among varieties.

Accroding to the hypothesis nitrogen or other chemical constituents for the variatal difference must be investigated in a certain specific gravity. It is especially true when the grain samples have

different growing condition for eliminating the environmental effect. The percent distribution may have significance for the interpretation of physiological response of variety to the environmental factors.

CONCLUSION

The hypothesis that the grain having the same specific gravity has the same nitrogen content in the same variety without being affected by the environmental conditions, which change only the percent distribution of grains in the specific gravity is proposed. The hypothesis appeares to be agreeable to nitrogen and some other chemical constituents but not all.

There is also physiological significance for the acceptance of hypothesis. The physiological factors related to specific gravity must be further investigated at the level of individual grain to support fully this hypothesis.

SUMMARY

The hypothesis that the grain having the same specific gravity has the same content in some chemical constitituents as a genetic constant of a variety without being affected by the environmental conditions which affect only the percent distribution of grain in specific gravity was tested on nitrogen. Also the applicability of hypothesis on phosphorus, potassium, calcium and physio logical significance of hypothesis were discussed.

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