

Water Deficit Stress Induced Changes In Metabolic Organic Compounds in Chickpea Grains



Chemistry

KEYWORDS : chemical composition, chickpea, water deficit.

Chandana Jain

Deptt. of Life Science; Boston College for Professional Studies, Gwalior

Pratima Jain

Deptt. of Chemistry, Govt. K.R.G. P.G. College, Gwalior

ABSTRACT

The aim of the present study was to quantify the extent of changes in the concentration of different metabolic organic compounds in chickpea grains under extreme moisture stress and non stress so that nutritional quality can be defined. Chemical composition of grain protein, carbohydrate, starch, soluble sugars contents in chickpea samples were estimated under water stress to non-stress environments. Results indicated that a higher amount of grain protein, carbohydrate and soluble sugars were found however starch content decreased under moisture stress environment. Average protein increased by 5.04%, carbohydrate 3.68% and soluble sugars 21.44% over non stress content value. Moisture stress induced reduction in starch. It was found that starch reduced by 4.73% in water deficit stress.

Introduction

Chemical composition and nutrient value of chickpea makes it an important food supplement for mankind. In India it is grown under varied environmental conditions of extreme moisture stress to non-stress conditions as a post-rainy season rainfed crop. Water stressed environmental condition is one of the most limiting factor in the determination of composition of organic compounds and mineral elements of chickpea. Climate change and food security is a big challenge to the humankind. Climate change is real, and its first impacts are already being felt. Until recently, most assessments of the impact of climate change on the food and agriculture sector have focused on the implications for production and global supply of food, with less consideration of other components of the food chain. But World Food Summit (WFS) in November 1996 adopted the definition of food security "when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." Climate change refers the long-term changes in average weather conditions like temperature rising due to global warming, water deficit due to frequent droughts. Thus in future more and more studies will be needed to quantify the extent of changes in the concentration of different metabolic organic compounds and mineral elements in food crop grains under extreme moisture stress and non stress so that nutritional quality can be defined.

Material and Methods

Twenty four varieties of desi and kabuli chickpea were selected which are commonly in use for this study. The experimental material grown under two environmental conditions viz. moisture stress and non stress with two replications. Two sets of each variety were grown, one in stress and other non stress. At maturity 10 plants were selected and then the grain obtained from the selected plants was bulked for chemical analyses.

Content values of Protein, carbohydrate, soluble sugars, starch was estimated in both the grain samples one from non stress or normal condition and another from moisture stress condition. Protein content was determined by Lowry method (1951) using the Folin- Ciocalteu phenol reagent. The Lowry protein assay is for determining the total level of protein in a solution. The total protein concentration is exhibited by a color change of the sample solution in proportion to protein concentration, which can then be measured using colorimetric techniques. The Lowry method is sensitive to pH changes and therefore the pH of assay solution was maintained at 10 - 10.5. The carbohydrate component estimated by anthrone method. Sugars react with the anthrone reagent under acidic conditions to yield a blue-green color. There is a linear relationship between the absorbance and the amount of sugar that was present in the original sam-

ple. This method determines both reducing and non-reducing sugars because of the presence of the strongly oxidizing sulfuric acid. Starch is hydrolysed into simple sugars by dilute acids and the quantity of sample sugars is measured colorimetrically. The sample is treated with 80% alcohol to remove soluble sugars and then starch is extracted with perchloric acid. In acidic medium starch is hydrolysed to glucose and dehydrated to hydroxymethyl furfural. This compound forms a green coloured product with anthrone (Hansen and Moller, 1975).

Results and Discussion

Concentrations of grain protein, carbohydrate, starch and soluble sugars of 24 chickpea samples were analyzed (table 1) to work out the chemical composition under moisture stress to non-stress conditions. Results of chemical analysis indicated that a higher amount of grain protein, carbohydrate and soluble sugars were recorded under moisture stress however starch content was decreased. Mean value of protein concentration increased from 20.40 g/100g to 21.42 g/100g. High increase of 8.64% and 8.58% over non stress was noted in samples of chickpea varieties JG226 and JG130 respectively as compared to average increase of 5.04%. Alghamdi (2009), Keyvan (2010), Rezaci et. al. (2010), Khamassi (2011) and Mansourifar (2011) also had similar findings. Carbohydrate found to be increased by average 3.68 % over non stress. Mean value of carbohydrate was increased from 52.28 g/100g to 53.78 g/100g due to water stress. Chemical analysis for soluble sugars showed that mean value increased from 3.99 g/100g to 4.86 g/100g under water deficit. Increase in sugar content in response to drought stress also reported by Kameli and Loselo (1993) Hossein et. al (2001). High increase of 34.35% and 34.16% in soluble sugars was recorded in chickpea varieties JG226 and JG130 respectively as compared to average content increase of 21.44% over non stress. Nayar et.al (2006) reported 23 to 47% higher accumulation of soluble sugar in stress. Moisture stress induced reduction in starch. Average 4.73% decrease was recorded in starch under stress. High decrease of 8.15% and 7.59% was noted in JG130 and JG74 respectively. Similarly Nayer and Heidari (2008) reported starch content decreased upto 16% in drought.

Results suggests that chickpea varieties JG226, JG130, JG370, JG74, JG315 and JGK3 which recorded higher accumulation of soluble sugars under moisture stress also exhibited higher depletion of starch. Similarly it was observed that those varieties which showed minimum increase in soluble sugars content under moisture stress environment also recorded minimum depletion of starch such as JG11 and JG16 This trend was evident in other varieties also. Nayer and Heidari (2008) reported similar results. This phenomenon of breaking down of starch into soluble sugars showed that under moisture stress or drought situa-

tions plants tend to convert starch into soluble sugars. There appears to be enough hypothetical evidence to suggest that there is inter-relationship between starch and soluble sugar concentration. It suggests that quantitative increase in the content value of soluble sugar concentration has a direct effect on the quantitative decrease of content value of starch concentration in chickpea. It shows that as a result of moisture stress or drought stress in chickpea starch present in chickpea grains tend to convert into soluble sugars. These soluble sugars may be glucose, sucrose, fructose etc. This may be a mechanism in chickpea to tolerate or escape the drought stress condition. Few studies are available to confirm these findings. Wang et.al.1996 studied with a variety of plants to demonstrate that drought induced conversion of hexoses and other carbohydrates, such as sucrose and starch, into sugar alcohols (polyols) and proline.

Table.1 Chemical composition of chickpea grain protein, carbohydrate, soluble sugars and starch in water stress and non stress

Sample variety	Protein (g/100g)			Carbohydrate (g/100g)		
	Non-stress	Moisture stress	CVV %	Non-stress	Moisture stress	CVV %
JG74	20.25	21.65	6.92	51.19	53.07	3.68
JG370	19.43	19.78	1.83	48.28	50.00	3.55
JG315	19.41	20.27	4.43	47.27	48.15	1.86
JG218	21.18	21.55	1.77	49.60	50.12	1.05
JG226	16.84	18.29	8.64	46.95	49.51	5.45
JG322	18.57	19.41	4.50	47.66	48.77	2.33
Vishal	20.57	21.88	6.37	50.42	52.15	3.45
JG11	21.12	22.26	5.40	49.59	49.97	0.77
JG6	19.25	20.53	6.68	50.79	51.28	0.96
JG16	19.36	19.43	0.36	49.44	50.12	1.38
JG130	19.58	20.98	8.58	50.53	52.81	4.52
JGK3	21.26	22.68	6.70	55.84	58.28	4.37
BG2085	20.77	21.54	3.68	54.65	55.57	1.70
JGK-1	21.27	21.71	2.07	54.49	55.35	1.57
BG3000	21.71	22.75	4.79	55.35	57.17	3.29
C-711	20.47	22.18	8.33	55.52	57.53	3.62
C-714	21.21	22.71	7.10	54.65	55.58	1.70
C-716	21.99	23.38	6.35	54.69	55.17	0.89
C-723	20.68	22.31	7.88	54.08	56.14	3.81
C-725	21.55	22.19	2.95	53.67	57.33	6.82
C-729	20.25	21.53	6.35	55.33	57.24	3.45

C-720	21.28	22.38	5.15	55.35	56.11	1.37
C-727	21.39	21.41	0.09	54.03	55.84	3.35
C-731	20.31	21.31	4.90	55.39	57.60	3.99
Mean	20.40	21.42	5.04	52.28	53.78	3.68

Sample variety	Soluble sugars (g/100g)			Starch (g/100g)		
	Non-stress	Moisture stress	CVV %	Non-stress	Moisture stress	CVV %
JG74	3.92	4.97	26.79	41.46	38.32	-7.59
JG370	3.70	4.89	32.16	37.49	35.42	-5.52
JG315	3.53	4.46	26.52	37.17	35.64	-4.12
JG218	3.68	4.33	17.82	38.65	37.68	-2.51
JG226	3.29	4.42	34.35	37.33	34.52	-7.52
JG322	3.62	4.21	16.30	37.87	36.77	-2.90
Vishal	3.99	4.91	23.21	39.53	37.80	-4.38
JG11	3.76	4.26	13.16	39.65	37.79	-4.70
JG6	3.91	4.77	21.99	39.69	37.19	-6.31
JG16	3.72	4.27	14.78	38.38	37.05	-3.47
JG130	4.01	5.38	34.16	39.44	36.22	-8.15
JGK3	4.30	5.40	25.61	45.33	42.68	-5.85
BG2085	4.15	4.86	16.99	43.56	42.21	-3.09
JGK-1	3.79	4.64	22.30	43.96	41.73	-5.07
BG3000	4.29	5.17	20.51	44.72	42.82	-4.25
C-711	4.34	5.15	18.66	45.23	43.60	-3.60
C-714	4.19	4.82	15.05	43.72	42.50	-2.79
C-716	4.17	4.87	16.93	44.14	42.46	-3.81
C-723	4.19	4.98	18.88	43.29	41.40	-4.38
C-725	4.33	5.32	22.86	45.87	42.40	-7.55
C-729	4.22	5.17	22.66	44.69	42.77	-4.31
C-720	4.16	4.82	15.87	44.32	43.11	-2.74
C-727	4.31	5.21	20.77	42.91	41.01	-4.43
C-731	4.42	5.28	19.46	45.12	43.01	-4.67
Mean	3.99	4.86	21.44	41.81	39.84	-4.73

REFERENCE

- Alghamdi, S. S. (2009). Chemical composition of faba bean (*Vicia faba* L.) genotypes under various water regimes. *Pakistan Journal of Nutrition* 8: (4) 477-482. | Hansen, J. and Moller, I. (1975) Percolation of starch and soluble carbohydrates from plant tissue for quantitative determination with anthrone. *Anal Biochem.* 68(1):87-94. | Houssen, M., Bohabuddin, Quifa Ma., Niel C.Turner and Jairo A.Palta (2001) Reaction of chickpea to water stress; yield and seed composition. *J. of Science of Food & Agriculture.*81 (13):1288-1291 | . Hodge, J.E. and Hofreiter, B.T. (1962). In: *Methods in Carbohydrate Chemistry*, (Eds. Whistler, R.L. and Be Miller, J.N.), Academic Press, New York | Keyvan, S. (2010). The effects of drought stress on yield, relative water content, proline, soluble carbohydrates and chlorophyll of bread wheat cultivars. *Journal of Animal and Plant Sciences (JAPS)* 8 (3) 1051-1060. | Kameli, A. and Losel, D. M.(1993). Carbohydrates and water status in wheat plants under water stress. *New Phytologist* 125: 609-614 | Khamssi Nahid Niari, (2011). Grain Yield and Protein of Chickpea (*Cicer arietinum* L.) Cultivars under Gradual Water Deficit Conditions. *Research Journal of Environmental Sciences*, 5: 611-616 | Lowry, O.H., Rosebrough, N.J., Farr A.L.,Randall,R.J.(1951). "Protein measurement with the Folin phenol reagent". *J.Biol.Chem.* 193 (1): 265-75. | Mafakheri, A., A. Siosemardeh, B. Bahramnejad, P.C. Struik, Y. Sohrabi (2011) Effect of drought stress and subsequent recovery on protein, carbohydrate contents, catalase and peroxidase activities in three chickpea (*Cicer arietinum*) cultivars.*AJCS* 5(10):1255-1260 | Nayyar, Harsh., Satwinder Kaur, Smita Singh and Hari D Upadhyaya (2006) Differential sensitivity of Desi (small-seeded) and Kabuli (large-seeded) chickpea genotypes to water stress during seed filling; effects on accumulation of seed reserves and yield. *Journal of the Science of Food and Agriculture*; 86(13), pages 2076-2082. | Nayer, Mohammadkhani and Reza Heidari (2008) Drought-induced Accumulation of Soluble Sugars and Proline in Two Maize Varieties *World Applied Sciences Journal* 3 (3): 448-453 |