Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

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Asian Journal of Plant Sciences
Volume 1 Number 3: 224-225, 2002

Effect of Various Chemicals on Carbohydrate Content in Potato Microtubers after Dormancy Breaking

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Abstract: The effect of carbon disulfide (CS_2), gibberellic acid (GA_3), rindite, and thiourea on sugar and starch content in microtubers of different potato cultivars, was studied. Tubers were planted in greenhouse after dormancy breaking and were analyzed for starch and sugars immediately after harvesting. The tubers treated with thiourea, resulted the highest starch content in all the cultivars as compared with other treatments. The treatments GA_3, rindite and CS_2 resulted in highest sucrose content in cultivars Atlantic, Désirée and Diamont respectively. The treatment CS_2 in cultivar Atlantic and GA_3 in cultivars Désirée and Diamont, resulted the highest glucose content than other treatments. Tubers treated with CS_2 resulted the highest fructose content in all cultivars, while the treatment thiourea, resulted least fructose content in cultivars Atlantic and Désirée.

Key words: Potato (*Solanum tuberosum*), Dormancy, CS_2, rindite, GA_3, thiourea, starch, sugars

Introduction

Potato is one of the world's three most important sources of starch, the others being maize and wheat. Starch is used in the food industry as thickener and in the non-food industry for more than 500 different products (Kempf, 1986). Starch is the major reserve carbohydrate in most of the higher plants. It is stored in the form of water insoluble, osmotically inactive granules in amyloplasts and chloroplast. During the growth phase, tubers of the same size can show considerable variation in their metabolic state, even when they are growing on the same stolon, as has been observed for the level of sucrose synthase (susy) activity (Sung *et al*., 1989). Sucrose, glucose, and fructose are the major sugars, which accumulate in potato (*Solanum tuberosum* L.) tubers. High levels of reducing sugars (glucose and fructose), lower the suitability of tubers for processing. Reducing sugars react with free amino groups during frying leading to the formation of a brown pigment, which can make chips and french fries unacceptable for consumers. Individual determination of glucose, fructose and sucrose, the major sugars in potatoes, is becoming essential as more studies are being conducted on genetic and biochemical mechanisms of carbohydrates formation and degradation in potato tubers. There is also an interest in predicting the storage potential of tubers based on their sucrose content at harvest (Sowokinos, 1978) and in analyzing sugar content of potatoes stored at various conditions. Sowokinos (1990) reported that starch in potato tubers frequently converts to undesirably high concentrations of reducing sugars (glucose and fructose) when abiotic stresses are experienced during the pre and postharvest phases.

Recently various chemicals are being used to break the dormancy of potato tubers, therefore the present study was conducted to check the effects of such dormancy breaking chemicals on sugars and starch content growing under greenhouse conditions after dormancy breaking.

Materials and Methods

Plant material: Microtubers of cultivars Atlantic, Désiréewhen and where your study was conduced and Diamont were treated with CS_2, GA_3, rindite, and thiourea. After dormancy breaking the tubers were planted in greenhouse and samples of each treatment were analyzed for carbohydrate content immediately after harvest.

Determination of Sucrose, D-glucose, and D-fructose: Potato samples were analyzed for reducing and non reducing sugars (sucrose, D-glucose, and D-fructose) using a kit (Boehringer Mannheim, Lewes, England, Cat. No. 716260) and spectrophotometer at an absorbance of 340 nm. Samples of freshly harvested minitubers were selected and stored below 4°C for extraction. Two grams of peeled potatoes for each treatment was homogenized by mixing with 2 ml distilled water, transferred quantatively in a 25 ml beaker and filled up to approximately 6 ml of water. Carrez-I and carrez-II-solution of 0.2 ml each was added one after other shaking vigorously after each addition. The pH was adjusted between 7-7.5 with NaOH. The solution was then transferred quantitatively to a 25 ml volumetric flask, rinsing with water, and added 0.012 ml n-octanal by shaking till the foam disappeared. The final volume was made 10 ml by adding distilled water. It was then mixed and filtered through Whatman filter paper No. 41. The undiluted solution of 0.2 ml (light yellow, occasionally light green) was immediately used for the assay. Results were expressed as gram reducing sugars (i.e., glucose and fructose) per 100 g of fresh potato weight.

Determination of starch: Potato samples were analyzed for starch using a kit (Boehringer Mannheim Lewes, England, Cat No. 207748) and spectrophotometer at an absorbance of 340 nm. Samples of each treatment were sliced and dried in an oven for at least 48 hrs. One gram of dried sample was crushed into a fine powder using a pestle and mortar. The powder was homogenized accurately into a 100 ml Erlenmeyer flask by adding 20 ml dimethyl sulfoxide and 5 ml HCl (8 mol l^{-1}). The flask was closed with parafilm and incubated for 30 min at 60°C in a hot water bath, cooled quickly to room temperature, adding 20 ml water and the pH was adjusted between 4-5 with NaOH (5 mol l^{-1}) during vigorous shaking. The solution was transferred to a 100 ml volumetric flask by rinsing with distilled water, filled up to the mark with distilled water, and filtered the solution through Whatman filter paper No. 41. The undiluted solution of 0.2 ml was used for the assay immediately after filtration and the starch content was calculated and results were expressed in g 100^{-1} g of dry powder basis. Treatment effects were compared after analysis of variance. The treatment means were compared using Duncan's multiple range test for significance at a probability of 0.05%.

Results and Discussion

Effect of different chemicals on starch content: Significant differences were observed among cultivars and treatments for starch and sugar content. Tubers treated with thiourea had resulted the highest starch content of 318.2, 309.9 and 322.1 mg gm^{-1} for cultivars Atlantic, Désirée, and Diamont respectively (Table 1).The difference for the starch content among the tubers treated with thiourea and untreated was 20.0, 35.3, and 5.0 mg gm^{-1} for cultivars Atlantic, Désirée and Diamont respectively. Treatment CS_2 in Cultivars Atlantic and Diamont, and treatment rindite in cultivar Désirée had resulted the lowest starch content as compared to other treatments. The slight increase of starch content in all the cultivars treated with thiourea, do indicates the characteristic changes in the activities of starch synthesis during the tuber development. These results are in accordance with the results of (Sowokinos, 1976), who stated that the chemicals resulted in thiourea, may increase the synthesis activities in amyloplast. Currently, there is a lack of information regarding the effect of thiourea on carbohydrates and further studies are needed to investigate the matter deeply.

Effect of different chemicals on sugar content (Sucrose, D-glucose and D-fructose): In developing potato tubers the bulk of incoming sucrose is degraded by sucrose synthase rather than invertase (Morrell *et al*., 1986) which implies that only two enzymes catalyze irreversible reactions during the conversion of sucrose into starch in this tissue. In this study variations were observed for sucrose content among the cultivars and treatments (Table 1). The tubers treated with GA_3 resulted the highest sucrose content (9.8mg gm^{-1}) in cultivar Atlantic as compared with other treatments. The treatments rindite and CS_2 resulted the highest sucrose content of 6.5 and 7.8 mg g^{-1} in cultivars Désirée and Diamont respectively. In this study all the treatments resulted the required content of sucrose for chipping potatoes. These results are in accordance with the results of

Table 1: Effect of various chemicals on starch and sugars content in various cultivars of potato microtubers after dormancy breaking

Cultivar/ treatment	Carbohydrate content (mg g^{-1})			
	Sucrose	D-Glucose	D-Fructose	Starch
Atlantic				
Control	9.8ab[a]	4.5a	4.9a	298.1NS[b]
CS_2	11.5b	4.7a	5.4a	290.4 NS
GA_3	12.4a	2.5b	4.7a	299.5NS
Rindite	9.3b	4.2a	3.8ab	301.1NS
Thiourea	5.5c	4.5a	3.5b	318.2NS
Désirée				
Control	4.5a	5.2b	1.6b	274.6NS
CS_2	4.5a	7.1a	2.9a	302.4NS
GA_3	3.3b	7.4a	1.5b	304.6NS
Rindite	5.7a	6.6a	2.8a	273.9NS
Thiourea	2.5b	5.8b	1.3b	309.9NS
Diamont				
Control	3.5b	8.2a	0.5a	303.5NS
CS_2	5.5a	4.6b	2.7b	297.7NS
GA_3	1.7b	8.9a	0.7a	305.4NS
Rindite	2.0b	8.5a	1.7a	307.2NS
Thiourea	2.8b	8.1a	1.1a	322.1NS

[a] Means with same letter are not significantly different at P = 0.05% according to the (DMRT). b Not significant.

(Sowokinos *et al.*, 1988), who suggested the minimum sucrose and glucose content of 1.0 and 0.35 mg gm^{-1} of fresh weight respectively for chipping potatoes. Significant differences were observed among treatments for D- glucose content. The treatment rindite resulted the highest glucose content in cultivar Atlantic as compared to other treatments (Table 1). The treatment CS_2 and GA_3 resulted the highest glucose content in cultivars Désirée and Diamont respectively. It is pertinent to describe here that the tubers treated with rindite, CS_2 and GA_3 resulted contradictory for glucose content in all cultivars. Developing tubers also characteristically contain low amounts of fructose (Davies *et al.*, 1985) and this has been attributed to the presence of high fructokinase activity as stated by (Gardner *et al.*, 1992). In this experiment the tubers of all the cultivars treated with CS_2 resulted highest fructose content as compared with untreated tubers. The tubers treated with thiourea, resulted minimum fructose content in cultivars Atlantic and Désirée compared with other treatments which indicates a negative correlation with starch content. The increase activities of starch synthesis enzymes (amylase or phosphorylase) in the tubers during development may be a possible reason for low concentration of fructose. In this study all the cultivars treated with various chemicals resulted highest fructose content as compared with untreated tubers. Differences among cultivars were clear, hence the results of this study are in accordance with that of (Brown *et al.*, 1990) who stated that the reducing sugar content of tubers varies with genotypes and cultivars.

Acknowledgment

This research was supported by Microtuber laboratory, Korea Research Institute of Bioscience and Biotechnology (KRIBB).

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