IJTA © Serials Publications

National Academy of Agricultural Science (NAAS) Rating : 3. 03

Effect of Pulsing Treatment on Refrigerated Storage of Gladiolus (*Gladiolus* Spp.) Spikes

Avneet Kaur* and Kushal Singh

ABSTRACT: The spikes of gladiolus cvs. White Prosperity and Nova Lux were harvested at tight bud stage. The pulsing treatment was given for 20 h with the solutions containing sucrose, glucose and fructose (20 %) in combination with aluminium sulphate (400 $\mu g\ ml^{-1}$) and GA_3 (50 $\mu g\ ml^{-1}$). After the treatment, spikes were stored under refrigerated condition for 6, 12 and 18 days. For physiological and biochemical studies, samples from tepals of the florets were takenandkeeping quality of the spikes was determined after storage. The fresh and dry weight of the florets showed increase with increase in storage duration. Pulsing treatment with sucrose in combination with aluminium sulphate and GA_3 led to the maximum weight gain in fresh weight in both the cultivars. GA_3used in combination with sugars did not show significant increase in dry weight. Treatment with sucrose solutions increased the sucrose content of florets but GA_3 did not affectmuch. Glucose contents of florets also increased during storage. Maximum florets opening at one time were observed withincreased storage duration and with pulsing treatments containing sugars. Sucrose in combination with aluminium sulphate and GA_3 was most effective.

Keywords: *Gladiolus, Pulsing solutions, Sugars, Gibberellic acid, Aluminiumsulphate, Refrigerated storage*

INTRODUCTION

Flowers due to their diversity in beauty, form, texture, color and fragrance adds aesthetic pleasure to the world. Gladiolus (*Gladiolus* sp.) is a queen of bulbous ornamental plants [1]. This corm propagated plant is native to Africa. This cut flower has named “Gladiolus” derived from the Latin word “*gladius*” which means sword because of appearance of its sword-like leaves.

Gladiolus due to their majestic flower spikes, relative ease of production and long keeping quality attracts both the florists and growers. It is very popular as a cut flower because of its diverse spike forms and colour combinations. Inflorescence shows florets of different colors, forms and sizes. The spikes are harvested at bud stage and opening of the florets exhibit acropetal succession. The production and handling of cut flowers are equally important. Under normal conditions, gladiolus spikes can be kept in the vases for 8-10 days and this long keeping quality makes it an attractive cut flower [2].

Carbohydrates especially sucrose are important reserve compounds because it is the main transporting form of sugar to flower bud [3,4]. Sugars are main food source that maintain turgor pressure, act as energy source to increase flower longevity and facilitate flower opening. They also act as precursors for respiration of cut flowers. Treating with pulsing solutions containing sucrose has moderately increased the keeping quality of gladiolus flowers [5]. In cut gladiolus spikes, sucrose slightly increased spike longevity and delayed petal senescence. Khan *et al* [6] reported that exogenous application of sugars and hormones in vase solution prolonged quality of roses and carnation cut flowers.

Gibberellic acid, a plant growth regulator plays important role in maintaining cut flowers. It increases the shelf life and improves the water status and carbohydrate contents of cut flowers [7]. Vase solution containing benzyladenin and GA (50 mg l), followed by BA (50 mg l) with sucrose (50 g l) significantly increased fresh anddry weight of cut spikes as reported by Singh and Jitendra [8].

To increase the longevity of cut flowers, application of some germicides such as aluminium sulphate, silver thiosulphate etc have been suggested that prevent rapid proliferation of microorganisms and maintainthe vase life of cut flowers. These

* Department of Botany, Punjab Agricultural University, Ludhiana, *E-mail: avneetkhalsa08@gmail.com*

antimicrobial compoundsare used in the preservative solutions to decrease bacterial proliferation, reduce pH of vase solution and improve water uptake [9]. Pal and Kumar [10] has shown that aluminum sulphate application (300 ppm or in combination with sucrose 2%, 4%) in cut gladiolus "Pink friendship" flowers increases the flower diameter.

For the maintenance of the harvested cut flowers in 'fresh' condition for longer duration the flowers are stored in refrigerated conditions. Singh *et al* [11] reported that the refrigerated storage assures the supply of flowers in the market, hence, an important strategy to prolong the sale season of flowers. In refrigerated (cold) storage, flowers can be stored either wet or dry. Usually, the wet storage method is for short term storage and the dry storage is for longer periods. Low temperature arrests the metabolic and physical activities of the pests and diseases resulting in the improvement of quality, reduction in post-harvest losses and increase in vase life [12].

MATERIAL AND METHODS

The spikes of gladiolus belonging to cvs. White Prosperity and Nova Lux were harvested at tight bud stage (when 1-2 basal florets showed color) and were subjected to pulsing treatments. The treatments were given by dipping the basal 5-7 cm portion of the spikes in the respective solution for 20 h at 23±2°C temperature under continuous illumination of 1000 lux intensity. After the treatment, the spikes were grouped in bundles of 3 each, loosely tied at the base with the rubber band and stored in vertical position in the cool chamber (4±0.5°C; 90-95% R.H.) for 6,12 and 18 days. The freshly-harvested spikes served as control. Three to four tepals from the middle portion of the spikes were excised and used for physiological and biochemical analysis. After storage, maximum number of floretsopen at one time was evaluated by placing them in distilled water in an air-conditioned laboratory at 22±3^{0}C and 16 h light duration of 1000 Lux intensity provided by 40 Watt white fluorescent tubes.

Fresh weight of the floret

The fresh weight of three florets from middle portion of each spike was measured in g and mean value was calculated.

Dry weight of the floret

After measuring the fresh weight, the florets were dried at 62 °C and their dry weights were calculated.

Sucrose

Sucrose was estimated by method as given by[13].

To 0.5 ml of sugar extract taken in a test tube, 0.5 ml of 6% KOH was added. The tubes were heated in water bath at 80^{O}C for 20 min to destroy free fructose. After cooling the tubes to room temperature, 1 ml of 0.1% resorcinol reagent and 3 ml of 30% HCl were added. The tubes were incubated at 80^{O}C for 10 min and intensity of pink colour developed was read at 490 nm. Blank was prepared by adding 1 ml of 0.1% resorcinol to 1 ml 6% KOH and then 3 ml of 30% HCl. The concentration of sucrose was calculated against standard curve prepared by using sucrose standards (10-100 µg) and was expressed as mg g^{-1} DW.

Glucose

Glucose was estimated by glucose oxidase and peroxidase reaction[14].

For estimating glucose firstly the reagents were prepared. Reagent A was prepared by dissolving 30 mg glucose oxidase (4 units/mg) and 1.5 mg peroxidase (100 units/mg) in 5 ml of 0.1 M sodium phosphate buffer (pH 7). Reagent B was prepared by dissolving 30 mg O-diansidine in 5 ml of ethanol. The solution was filtered and filtrate stored in refrigerator in amber-coloured bottle. Reagent C was prepared by mixing 5 ml of reagent A with 2.5 ml of reagent B and 4.25 ml of 45% glycerol. According to the method, 1 ml of reagent C was added to 1 ml of sugar extract. In blank, 1 ml of water was taken instead of glucose. After incubation at 30 °C (45 min), 2 ml of 2N HCl was added and colour intensity read at 540 nm. The standard of glucose (50-100 µg) was always run along with the samples to counter the effect of denaturation of glucose oxidase andperoxidaseduring storage. The concentration of glucose was calculated against standard curve prepared by using glucose standards and was expressed as mg g^{-1} DW.

Maximum number of florets open at one time

The maximum number of florets that were open at one time on the spike was recorded by counting the open florets on each spike daily.

RESULTS AND DISCUSSION

Fresh and Dry Weight of the Florets

Results presented in the Table 1 show that fresh weight of the florets increased with increase in duration of storage. The florets gained maximum weight after 18 days of storage. This could be attributed to the continued absorption of water and growth of petals during storage. The spikes subjected to pulsing treatment with sucrose, aluminium sulphate and GA_3 in combination showed the maximum increase inweight.

Similar trends were observed with dry weight of the florets (Table 2). Dry weight showed increase with the increase in storage duration. Sugars caused increase in dry weight of the florets, sucrose being the most effective. GA_3 did not show any significant increase in dry weight when used in combination with sucrose, glucose as well as fructose.

Sucrose and Glucose Contents

Sucrose content of florets showed slight increase with the increase in storage duration (Table 3). The pulsing treatments with solutions containing sucrose increased the sucrose content of florets and isindicative of the supplementing the endogenous level. The content remained more or less same in rest of the pulsing treatments including glucose or fructose in combination with aluminium sulphate and GA_3.

Glucose content of florets exhibited increase with increase in duration of storage being maximum after 18 days of storage. Higher glucose content was observed in the spikes treated with sucrose and glucose pulsing solutions (Table 4). Increase in glucose contents in case of florets of spikes pulse-treated with sucrose is apparently due to hydrolysis of sucrose in the florets.

Maximum Florets Open at Open Time

Pulsing treatments were found effective in improving the number of florets that exhibited opening at one time (Table 5). The number showed slight increase in spikes treated with aluminium sulphate alone and in combination with GA_3 than the control spikes which showed the minimum number of florets opening at one time. Sucrose was more effective than glucose and fructose. GA_3 in the pulsing solutions increased the effect of sugars.

The number of florets that open at one time showed decrease with increase in the duration of storage and was minimum (3.84) in spikes after 18 days of storage as compared to control (6.24) and those stored for 6 days (5.53) and 12 days (4.81). This indicates loss of ability of florets to open with prolonged storage.

Table 1

Effect of sugars, aluminium sulphate and GA_3 on fresh weight of florets of gladiolus cultivars White Prosperity and Nova Lux after storage for varying durations

Treatment	*White Prosperity*					*Nova Lux*					*Overall Mean*
	0 day	*6 day*	*12 day*	*18 day*	*Mean*	*0 day*	*6 day*	*12 day*	*18 day*	*Mean*	
Sucrose 20% + Aluminium sulphate,400 $\mu g\ ml^{-1}$	0.737	0.757	0.824	1.139	0.864	0.838	0.804	0.914	0.967	0.881	0.873
Sucrose 20% + Aluminium sulphate,400 $\mu g\ ml^{-1}$+GA_3, 50 $\mu g\ ml^{-1}$	0.663	0.813	0.987	1.914	1.094	0.950	0.989	1.096	1.314	01.087	1.091
Glucose 20% + Aluminium sulphate,400 $\mu g\ ml^{-1}$	0.786	0.746	0.804	0.979	0.829	0.687	0.706	0.770	0.929	0.773	0.801
Glucose 20% + Aluminium sulphate,400 $\mu g\ ml^{-1}$+GA_3, 50 $\mu g\ ml^{-1}$	0.706	0.833	0.928	0.966	0.858	0.827	0.826	0.923	1.345	0.980	0.919
Fructose 20% + Aluminium sulphate,400 $\mu g\ ml^{-1}$	0.750	0.779	0.859	0.834	0.806	0.742	0.820	0.847	0.995	0.851	0.829
Fructose 20% + Aluminium sulphate,400 $\mu g\ ml^{-1}$+GA_3, 50 $\mu g\ ml^{-1}$	0.721	0.693	0.774	0.707	0.724	0.723	0.647	0.821	1.018	0.802	0.763
Aluminium sulphate, 400 $\mu g\ ml^{-1}$	0.697	0.693	0.774	0.639	0.701	0.661	0.651	0.698	0.750	0.690	0.696
GA_3, 50 $\mu g\ ml^{-1}$+Aluminium sulphate,400 $\mu g\ ml^{-1}$	0.686	0.647	0.789	0.520	0.661	0.609	0.636	0.663	0.811	0.680	0.671
Control	0.642	0.692	0.747	0.552	0.658	0.633	0.602	0.618	0.791	0.661	0.660
Mean	0.710	0.739	0.832	0.917	0.778	0.741	0.742	0.817	0.991	0.823	0.801

Mean values for storage duration: 0 day=0.726; 6 day=0.741; 12 day=0.825; 18 day=0.954

CD (p=0.05) Cultivars (A)=NS; Storage duration(B)=0.054; Treatments (C)=0.081; AxB=NS; AxC=NS; BxC=0.16; AxBxC=0.23

Table 2
Effect of sugars, aluminium sulphate and GA_3 on dry weight of florets of gladiolus cultivars White Prosperity and Nova Lux after storage for varying durations

Treatment	*White Prosperity*					*Nova Lux*					*Overall Mean*
	0 day	*6 day*	*12 day*	*18 day*	*Mean*	*0 day*	*6 day*	*12 day*	*18 day*	*Mean*	
Sucrose 20% + Aluminium sulphate, 400 μg ml^{-1}	0.072	0.090	0.098	0.102	0.091	0.085	0.088	0.100	0.106	0.095	0.093
Sucrose 20% + Aluminium sulphate, 400 μg ml^{-1}+GA_3, 50 μg ml^{-1}	0.075	0.094	0.101	0.111	0.095	0.840	0.085	0.104	0.129	0.091	0.093
Glucose 20% + Aluminium sulphate, 400 μg ml^{-1}	0.085	0.095	0.099	0.100	0.095	0.082	0.085	0.095	0.101	0.090	0.093
Glucose 20% + Aluminium sulphate, 400 μg ml^{-1}+GA_3, 50 μg ml^{-1}	0.080	0.097	0.099	0.105	0.095	0.078	0.095	0.112	0.124	0.102	0.099
Fructose 20% + Aluminium sulphate, 400 μg ml^{-1}	0.078	0.083	0.086	0.098	0.086	0.082	0.092	0.101	0.102	0.094	0.090
Fructose 20% + Aluminium sulphate, 400 μg ml^{-1}+GA_3, 50 μg ml^{-1}	0.076	0.084	0.083	0.098	0.085	0.089	0.090	0.095	0.103	0.094	0.090
Aluminium sulphate, 400 μg ml^{-1}	0.068	0.086	0.088	0.088	0.083	0.082	0.083	0.092	0.095	0.088	0.086
GA_3, 50 μg ml^{-1} +Aluminium sulphate, 400 μg ml^{-1}	0.065	0.084	0.090	0.096	0.084	0.087	0.092	0.092	0.096	0.091	0.088
Control	0.064	0.080	0.085	0.090	0.080	0.080	0.088	0.090	0.092	0.088	0.084
Mean	0.074	0.088	0.092	0.099	0.088	0.083	0.089	0.098	0.105	0.093	0.091

Mean values for storage duration:0 day=0.079; 6 day=0.089; 12 day=0.095; 18 day=0.102

CD (p=0.05) Cultivars (A)=0.004; Storage duration (B)=NS; Treatments (C)=0.008; AxB=0.008; AxC=0.012; BxC=0.017; AxBxC=0.023

Table 3
Effect of sugars, aluminium sulphate and GA_3 on sucrose content of florets of gladiolus cultivars White Prosperity and Nova Lux after storage for varying durations

Treatment	*White Prosperity*					*Nova Lux*					*Overall Mean*
	0 day	*6 day*	*12 day*	*18 day*	*Mean*	*0 day*	*6 day*	*12 day*	*18 day*	*Mean*	
Sucrose 20% + Aluminium sulphate, 400 μg ml^{-1}	22.49	26.71	27.68	31.29	27.04	30.68	22.80	35.24	36.75	31.37	29.21
Sucrose 20% + Aluminium sulphate, 400 μg ml^{-1}+GA_3, 50 μg ml^{-1}	25.42	30.31	33.77	36.86	31.59	33.86	32.62	33.86	30.04	32.60	32.10
Glucose 20% + Aluminium sulphate, 400 μg ml^{-1}	9.55	10.51	19.46	27.20	16.68	16.62	13.24	18.00	17.51	16.34	16.51
Glucose 20% + Aluminium sulphate, 400 μg ml^{-1}+GA_3, 50 μg ml^{-1}	14.13	11.65	17.22	16.71	14.93	17.24	14.71	13.55	15.11	15.15	15.04
Fructose 20% + Aluminium sulphate, 400 μg ml^{-1}	9.59	13.11	18.75	19.37	15.21	13.95	18.44	16.88	15.95	16.31	15.76
Fructose 20% + Aluminium sulphate, 400 μg ml^{-1}+GA_3, 50 μg ml^{-1}	10.84	15.86	19.69	18.17	16.14	17.37	12.93	16.26	16.53	15.77	15.96
Aluminium sulphate, 400 μg ml^{-1}	11.28	12.75	19.73	19.13	15.72	14.15	13.73	14.35	14.86	14.27	15.00
GA_3, 50 μg ml-1+Aluminium sulphate, 400 μg ml^{-1}	8.66	10.26	16.22	10.79	11.48	12.37	12.13	13.26	14.15	12.98	12.23
Control	10.51	14.44	16.06	13.66	13.67	13.02	14.13	15.64	15.47	14.57	14.12
Mean	13.61	16.18	20.95	21.46	18.05	18.81	17.19	19.67	19.60	18.82	18.44

Mean values for storage duration:0 day=16.21; 6 day=16.69; 12 day=20.31; 18 day=20.53

CD (p=0.05) Cultivars (A)=1.06; Storage duration (B)=1.50; Treatments (C)=2.25; AxB=2.12; AxC=NS; BxC=NS; AxBxC=NS

Table 4
Effect of sugars, aluminium sulphate and GA_3 on glucose content of florets of gladiolus cultivars White Prosperity and Nova Lux after storage for varying durations

Treatment	*White Prosperity*					*Nova Lux*					*Overall Mean*
	0 day	*6 day*	*12 day*	*18 day*	*Mean*	*0 day*	*6 day*	*12 day*	*18 day*	*Mean*	
Sucrose 20% + Aluminium sulphate, 400 µg ml^{-1}	27.56	44.89	32.67	34.45	34.90	28.45	33.45	40.78	43.11	36.45	35.68
Sucrose 20% + Aluminium sulphate, 400 µg ml^{-1}+GA_3, 50 µg ml^{-1}	23.78	48.22	35.22	46.89	38.53	28.45	35.33	49.33	55.33	42.11	40.32
Glucose 20% + Aluminium sulphate, 400 µg ml^{-1}	27.55	42.89	40.67	45.00	39.03	23.78	35.11	42.67	47.78	37.34	38.19
Glucose 20% + Aluminium sulphate, 400 µg ml^{-1}+GA_3, 50 µg ml^{-1}	31.78	46.33	40.89	54.22	43.31	26.89	38.22	44.78	55.55	41.36	42.34
Fructose 20% + Aluminium sulphate, 400 µg ml^{-1}	25.78	38.77	36.89	40.00	35.36	21.33	22.45	30.11	35.00	27.22	31.29
Fructose 20% + Aluminium sulphate, 400 µg ml^{-1}+GA_3, 50 µg ml^{-1}	26.00	46.89	33.33	47.33	38.39	28.22	26.67	30.44	37.11	30.61	34.50
Aluminium sulphate, 400 µg ml^{-1}	27.78	40.22	35.89	36.67	35.14	22.22	25.89	27.33	37.78	28.31	31.73
GA_3, 50 µg ml^{-1}+Aluminium sulphate, 400 µg ml^{-1}	29.56	39.11	36.89	40.22	36.45	25.55	31.55	30.22	40.11	31.86	34.16
Control	20.89	28.22	33.78	30.22	28.28	24.44	22.45	25.56	35.33	26.95	27.62
Mean	26.74	41.73	36.25	41.67	36.60	25.48	30.12	36.47	44.68	33.58	35.09

Mean values for storage duration:0 day=26.11; 6 day=35.93; 12 day=36.36; 18 day=43.18
CD (p=0.05) Cultivars (A)=1.35; Storage duration (B)=1.91; Treatments (C)=2.88; AxB=2.71; AxC=4.07; BxC=5.76; AxBxC=NS

Table 5
Effect of sugars, aluminium sulphate and GA_3 on maximum florets open at one time in spikes of gladiolus cultivars White Prosperity and Nova Lux after storage

Treatment	*White Prosperity*					*Nova Lux*					*Overall Mean*
	0 day	*6 day*	*12 day*	*18 day*	*Mean*	*0 day*	*6 day*	*12 day*	*18 day*	*Mean*	
Sucrose 20% + Aluminium sulphate, 400 µg ml^{-1}	7.11	6.33	5.00	3.89	5.58	6.78	6.55	5.00	4.11	5.61	5.59
Sucrose 20% + Aluminium sulphate, 400 µg ml^{-1}+GA_3, 50 µg ml^{-1}	8.89	7.22	6.44	4.89	6.86	8.11	7.11	6.33	4.67	6.55	6.70
Glucose 20% + Aluminium sulphate, 400 µg ml^{-1}	6.22	5.78	5.11	4.11	5.30	7.00	5.89	5.33	4.11	5.58	5.44
Glucose 20% + Aluminium sulphate, 400 µg ml^{-1}+GA_3, 50 µg ml^{-1}	6.56	6.11	5.67	4.89	5.81	8.00	6.89	6.11	5.00	6.50	6.15
Fructose 20% + Aluminium sulphate, 400 µg ml^{-1}	5.67	5.22	4.56	4.44	4.97	6.89	5.22	4.67	3.45	5.06	5.01
Fructose 20% + Aluminium sulphate, 400 µg ml^{-1}+GA_3, 50 µg ml^{-1}	6.34	5.89	5.00	4.78	5.50	7.33	5.89	6.22	4.33	5.94	5.72
Aluminium sulphate, 400 µg ml^{-1}	4.33	4.67	3.00	2.44	3.61	4.89	4.56	3.56	2.55	3.89	3.75
GA_3, 50 µg ml^{-1}+Aluminium sulphate, 400 µg ml^{-1}	4.78	4.33	3.78	3.11	4.00	5.00	4.33	4.44	3.22	4.25	4.12
Control	4.22	3.78	3.11	2.55	3.41	4.22	3.89	3.33	2.56	3.50	3.45
Mean	6.01	5.48	4.63	3.90	5.00	6.47	5.59	5.00	3.78	5.21	5.10

Mean values for storage duration:0 day=6.24; 6 day=5.53; 12 day=4.81; 18 day=3.84
CD (p=0.05) Cultivars (A)=0.13; Storage durations (B)=0.19; Treatments (C)=0.28; AxB=0.27; AxC=NS; BxC=0.56; AxBxC=NS

REFERENCES

Bhattacharjee S K and De L C (2005), Medicinal herbs and flower. Pointer publishers, Jaipur-1400.

Reddy T V and Murali T P (1994), Influence of silver thiosulphate on the post-harvest life of gladiolus (cv. Friendship) flowers. In: Prakash J and K RBhandary (Ed.), Floriculture Technology, Trades and Trends). Oxford & IB H Publishing Co Pvt Ltd Calcutta, pp. 509-12.

Faraji S, Naderi R, Ibadli O V, Basaki T, Gasimov S N and Hosseinova S (2011), Effects of post harvesting on biochemical changes in *Gladiolus* cut flowers cultivars (White prosperity). *Middle-East J Sci Res* **9(5):** 572-77.

Seyf M, Khalighi A, Mostofi Y and Naderi R (2012), Study on the effect of aluminum sulphate treatment on postharvest life of the cut rose 'Boeing' (*Rosa hybrid* cv. Boeing). *J Hortic For Biotech* **16(3)**: 128-32.

Otsubo M andIwaya-Inoue M (2000), Trehalose delays senescence in cut gladiolus spikes. *Hort Science* **35**: 1107-10.

Khan F N, Yasmin L, Nasrin T A A, Hossain M J and Golder P C (2009), Effect of sucrose and pH on the vase life of gladiolus flower. *SAARC J Agri***7(1)**: 11-18.

Saeed T, Hassan I, Abbasi N A and Jilani G (2014), Effect of gibberellic acid on the vase life and oxidative activities in senescing cut gladiolus flowers. *Plant Growth Regul* **72(1)**: 89-95.

Singh A and Jitendra K (2008), Effects of plant growth regulators and sucrose on post harves tphysiology, membrane stability and vase life of cut spikes of gladiolus. *Plant Growth Regul* **55**: 221-29.

Ichimura K, Taguchi M and Norikoshi R (2006), Extension of the vase life in cut roses by treatment with glucose, isothiazolinonic germicide, citric acid and aluminum sulphate solution. *Japan Agric Res Quarterly* **40**: 263-69.

Pal A and Kumar S (2004), Response of floral preservatives on postharvest quality of gladiolus spike cultivar 'Pink Friendship'. *Advances in Plant Sci* **17(2)**: 529-32.

Singh K, Arora J S and Bhattacharjee S K (2001), *Postharvest handling of Cut Flowers*: Tech Bull No. 10. All India Research Project on Floriculture, IARI, N. Delhi pp. 39.

Nowak J and Mynett K (1985), The effect of sucrose, silver thiosulfate and 8-hydroxyquinoline citrate on the quality of *Lilium* inflorescence cut at the bud stage and stored at low temperature. *Scientia Hortic* **25**: 299-302.

Roe J H (1934), A calorimetric method for determination of fructose in blood and urine. *J Biochem* **107:** 15-22.

Gascon S and Lampon I (1968), Purification of internal invertase of yeast. *J BiolChem* **243**: 1567-72.