QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 713

POTATO CRISP QUALITY. FURTHER STUDIES ON THE EFFECT OF NITROGEN FERTILIZER APPLICATION: WINTER HARVEST

by D. WINTERTON, Dip. Ind. Chem.

SUMMARY

A comparison of five levels of nitrogen fertilizer showed that nitrogen above that required for normal plant growth during winter months had no effect on the specific gravity or the colour of potato crisps. Poorly-coloured crisps were produced only from potatoes in the lower specific gravity range. These had the highest reducing sugar, free amino acid, and vitamin C concentrations.

I. INTRODUCTION

A previous trial using five levels of nitrogen fertilizer on a potato crop harvested in the summer (November, December) indicated that nitrogen above that required for adequate plant growth had no effect on the specific gravity of potatoes or on the colour of crisps (Eastwood *et al.* 1956; Talburt and Smith; Winterton 1969).

Since potatoes are normally harvested in the Lockyer Valley from June to December, it was decided to investigate the effect of the five levels of nitrogen fertilizer on processing quality of a winter-harvested crop.

II. MATERIALS AND METHODS

The trial was planted as a rotational crop. It was restricted to the Sebago variety which accounts for approximately 70% of the total Queensland potato crop (Verhoeven 1967). Harvesting was carried out in June.

Five levels of nitrogen fertilizer were applied: nil, 67·2, 134·5, 201·6 and 268·9 kg ha^{-1} as sulphate of ammonia. The basal fertilizer consisted of 112 kg P_2O_5 per hectare as superphosphate and 56 kg K_2O as sulphate of potash. Each treatment was replicated five times, using a 5 x 5 latin square design.

SPECIFIC GRAVITY MEASUREMENT. A sample of 88 kg was taken from each plot. This was washed and graded, and the specific gravity distribution and mean specific gravity were determined using the methods of Lugt (1960). Potatoes in each specific gravity range were subsampled for chemical analysis and frying tests.

CHEMICAL DETERMINATION. Total solids were determined by oven drying. Reducing sugars and sucrose were determined by the methods of Ting (1956) and Furuholem *et al.* (1964). Free amino nitrogen was determined using the method of Rosen (1957), after extraction of amino acids (Talley *et al.* 1958).

PROCESSING. Potatoes were peeled in an abrasive peeler and sliced in a rotary hand-operated slicer. The slices were thoroughly agitated in cold water to remove free starch, and drained to remove excess water. They were then fried in hydrogenated beef fat at 185°C, until the fat stopped bubbling.

COLOUR MEASUREMENT. Potato crisps were examined visually and rated for colour according to the scale suggested by Wright and Whiteman (1954)—

90 very light cream
80 golden brown
70 dark brown

Crisps having a colour rating of 70 are barely salable.

III. RESULTS

FREE AMINO NITROGEN. Free amino nitrogen concentrations (calculated on a dry weight basis) for each sp. gr. range and for each fertilizer treatment are contained in table 1.

TABLE 1

FREE AMINO NITROGEN CONTENT OF POTATOES
(MICRO MOLES LEUCINE EQUIVALENT (DRY WEIGHT))

Specific Gravity	Nil	Fertilizer Application (kg ha^{-1})				
		67·2	134·5	201·6	268·9	Means +
Up to 1·055	301·96	266·66	271·84	308·12	339·81	297·68 f
1·055—1·065	256·95	232·57	257·39	278·05	280·39	261·07 g
1·065—1·075	230·27	187·26	224·12	222·98	235·07	219·94 h
1·075—1·085	211·00	183·94	203·39	204·12	223·67	205·22 i
Means	250·04	217·61	239·19	253·32	269·74	
	a*	b	c	d	e	

* a, b, c, d, e, N.S.
+LSD 5% 26·76, 1% 35·73 f > g, h, i ($p < 0·01$); g > h, i ($p < 0·01$)

Increasing amounts of nitrogen fertilizer had no significant effects on the amounts of free amino nitrogen present. However, specific gravity had significant effects: increases in specific gravity resulted in decrease in free amino nitrogen.

CRISP COLOUR. Mean colour ratings are given in table 2. There was no improvement in crisp colour with increasing fertilizer application. Browning of crisps occurred mainly in potatoes wth a sp. gr. below 1·055 and there was a significant improvement in colour in crisps with increasing sp. gr. in all levels of fertilizer application.

TABLE 2

COLOUR RATING OF POTATO CRISPS

Specific Gravity	Nil	Fertilizer Application (kg ha^{-1})				
		67·2	134·5	201·6	268·9	Means+
Up to 1·055	80	78	77	77	76	76 f
1·055—1·065	82	81	79	80	79	80 g
1·065—1·075	87	84	83	85	84	85 h
1·075—1·085	89	89	88	89	88	88 i
Means+	85	83	82	83	81	
	a*	b	c	d	e	

* a, b, c, d, e, N.S.
+LSD 5% 1·2, 1% 1·6 i > h > g > f ($p < 0.01$)

SUGARS. The reducing sugar concentrations of potatoes in each sp. gr. range and treatment are given in table 3. There was no significant difference due to fertilizer application, but potatoes in the lower sp. gr. ranges were significantly higher in reducing sugars than those in the higher sp. gr. ranges.

TABLE 3

REDUCING SUGAR CONTENT OF POTATOES (%)

Specific Gravity	Nil	Fertilizer Application (kg ha^{-1})				
		67·2	134·5	201·6	268·9	Means+
Up to 1·055	0·295	0·325	0·308	0·318	0·280	0·305 f
1·055—1·065	0·233	0·268	0·268	0·260	0·265	0·259 g
1·065—1·075	0·200	0·245	0·235	0·235	0·235	0·230 h
1·075—1·085	0·220	0·243	0·240	0·243	0·240	0·237 i
Means	0·237	0·270	0·263	0·264	0·255	
	a*	b	c	d	e	

* a, b, c, d, e, N.S.
+LSD 5% 0·022, 1% 0·030 f > g, h, i ($p < 0.01$), g > h, i ($p < 0.05$)

No definite trend was observed on the effects of nitrogen fertilizer applications on total sugars (table 4). However, an application of 201·6 kg ha^{-1} produced significantly lower total sugar levels than applications of 134·5 and 268·9 kg ha^{-1}. There was very little effect of sp. gr. on total sugars, but the highest sp. gr. range was significantly higher in total sugars than other ranges. Since there was a significant reduction in reducing sugar levels with increasing sp. gr. (table 3) there was evidently a significant rise in sucrose content with increasing sp. gr.

VITAMIN C. Levels of nitrogen fertilizer application had no effect on vitamin C concentration (table 5). However, there was a decrease with increasing specific gravity.

SPECIFIC GRAVITY. Rates of nitrogen application had no effect on mean specific gravity (table 6).

TABLE 4

TOTAL SUGAR CONTENT OF POTATOES (%)

Specific Gravity	Nil	Fertilizer Application (kg ha^{-1})				
		67·2	134·5	201·6	268·9	Means+
Up to 1·055	0·473	0·500	0·515	0·405	0·420	0·463 f
1·055—1·065	0·438	0·405	0·503	0·378	0·508	0·446 g
1·065—1·075	0·415	0·450	0·503	0·368	0·508	0·449 h
1·075—1·085	0·433	0·440	0·563	0·413	0·598	0·489 i
Means*	0·439	0·449	0·521	0·391	0·508	
	a	b	c	d	e	

* LSD 5% 0·091, 1% 0·127 c > d ($p < 0·01$), e > d ($p < 0·05$)
+LSD 5% 0·034, 1% 0·045, i > g, h ($p < 0·05$)

TABLE 5

VITAMIN C CONCENTRATION OF POTATOES
(MILLIGRAMS PER 100 GRAMS (DRY WEIGHT))

Specific Gravity	Nil	Fertilizer Application (kg ha^{-1})				
		67·2	134·5	201·6	268·9	Means+
Up to 1·055	95·03	57·78	63·49	99·67	80·23	79·24 f
1·055—1·065	85·35	48·59	66·50	70·05	68·22	67·74 g
1·065—1·075	68·67	57·51	64·29	66·30	63·91	64·14 h
1·075—1·085	61·52	46·96	59·75	55·83	49·04	54·62 i
Means	77·64	52·71	63·51	72·96	65·35	
	a*	b	c	d	e	

* a, b, c, d, e, N.S.
+LSD 5% 9·22, 1% 12·32 f > h, i ($p < 0·01$); g > i ($p < 0·01$); f > g ($p < 0·05$); h > i ($p < 0·05$)

TABLE 6

MEAN SPECIFIC GRAVITY

Nil	Fertilizer Application (kg ha^{-1})			
	67·2	134·5	201·6	268·9
1·065 7	1·065 0	1·066 5	1·065 5	1·065 4
	a*	b	c	d

* a, b, c, d, N.S.

IV. DISCUSSION

Results obtained from chemical analyses of a winter crop of potatoes varied only slightly from those obtained from the summer-harvested crop (Winterton 1969). Again, crisp browning occurred most markedly in the lowest specific gravity range, which had the highest free amino nitrogen and reducing sugars. There was a gradual improvement in crisp colour with increasing sp. gr.

Potatoes from this crop were also examined for vitamin C content, as it had been suggested by Joslyn (1957) and Glegg (1964, 1966) that this was also a component in the browning reaction.

Potatoes in the lowest sp. gr. range had a significantly higher vitamin C content than potatoes in other sp. gr. ranges which suggests that vitamin C, in combination with free amino nitrogen and reducing sugars rather than reducing sugars alone, may have an effect on browning of crisps.

The mean specific gravity of potatoes from this trial (approximately 1·065) while being higher than that obtained from the previous trial (near 1·060) was still too low for processing (Talburt and Smith 1967). This aspect lends itself to further study in an endeavour to improve the crisping quality of potatoes from the Lockyer Valley.

V. ACKNOWLEDGEMENTS

The author thanks Mr. W. Mills, Agriculture Branch, for supplying potatoes for this trial; Miss. E. Goward, Biometry Branch for statistical analysis of results; Mr. E. Gall and Miss T. Chuisano for laboratory assistance and Mr. C. Clark for preparation of samples.

REFERENCES

EASTWOOD, T. and WATTS, J. (1956).—The effect of nitrogen fertilization upon chipping quality. Chip Colour I. *Am. Potato J.* 33:187.

GLEGG, K. M. (1964).—Non enzymatic browning of lemon juice. *J Sci. Fd. Agric.* 15:876.

GLEGG, K. M. (1966).—Citric acid and the browning of solutions containing ascorbic acid. *J. Sci. Fd. and Agric.* 17:546.

JOSLYN, M. D. (1957).—Role of amino acids in the browning of orange juice. *Fd. Res.* 22:1.

KEFFORD, J. K. (1957).—The laboratory examination of canned foods XIII Ascorbic acid content. *Fd. Pres. Q.* 17:42.

TALBURT, W. F. and SMITH, O. (1967).—*Potato Processing.* (Avi Publishing Co. Inc. Westport:Conn.)

VERHOEVEN, G. (1967).—Potato growing in Queensland. *Qd. Agric. J.* 93:714.

WINTERTON, D. (1969).—Potato Crisp Quality—The Effect of Nitrogen Fertilizer Application. *Fd. Technol. Aust.* 21:58.

(Received for publication 2 June 1975)

The author is a technologist at the Department of Primary Industries Otto Madsen Dairy Research Laboratory, Hamilton, Queensland. He was formerly on the staff of the Sandy Trout Food Preservation Research Laboratory, Queensland Department of Primary Industries.