Effect of tissue type, variety and storage on cell wall chemistry of onion (*Allium Cepa L.*)

Ng Annie[1], Smith Andrew C.[1] and Waldron Keith W.[1]

Abstract

Onion is one of the major vegetable crops grown in Europe and a large proportion of them is processed. In the European Union, 450 000 tons of onion waste are produced annually mainly from the UK, Holland and Spain. Industrial onion waste comprises a mixture of damaged whole onions and outer, dry leaves and fleshy tissues. There is a concern over the production of large quantities of industrial onion waste, and its disposal. The aim of this investigation is to understand the cell wall chemistry of onion waste, with the intention of converting the environmentally-unfriendly onion waste into food ingredients. Alcohol-insoluble residues (AIRs) were prepared as the source of cell wall materials and were analyzed for their carbohydrate compositions. On a whole organ basis, the cell wall carbohydrate composition was similar to each variety studied, and no significant change resulted from commercial storage, with or without sprout suppressant. However, there were significant differences in the carbohydrate composition of cell wall from different component tissues. Cell walls of inner leaf bases contained galactose-rich pectic polysaccharides. The outer layer had less pectic galactose, and the outer brown skin contained virtually none. This was accompanied by changes in cell wall polymers and may be related to the dry and protective nature of the non-lignified outer skin. Storage did not induce any significant change in the yield, total carbohydrate and carbohydrate components of AIRs. The differences in cell walls from different tissues provide the basis for developing processing methods for exploiting onion waste.

Introduction

Onion (*Allium Cepa L. cv Sturon, Durco, Hysam, Grano de Oro and Caribo*), a ripened bulb, is one of the major vegetable crops grown in Europe and a large proportion of them are processed. Because of the growing interest in current environmental issues, there is a need to identify means for converting the vast quantity of industrial onion waste (450 000 tons produced annually mainly from the UK, Holland and Spain) into useful products. Industrial onion waste mainly consists of brown dry skin, two outer fleshy leaves, and top and bottom parts of the onion.

Onions have been identified as an important source of dietary fibre and pectin (Fenwick, 1985). There have been several studies on the cell-wall polymers of onion bulb tissues (Redgwell and Selvendran, 1986). In addition, investigations concerning the cell wall chemistry of onion tissues different in cultivar (Allium Cepa L cv Sturon, Durco, Hysam, Grano de Oro and Caribo, 5 commonly processed varieties in Europe) or of their component tissues have shown that cell walls of inner leaf bases contained galactose-rich pectic polysaccharides, and the outer layer had less pectic galactose, and the outer brown skin contained virtually none; however, the cell wall carbohydrate composition was similar to each variety studied (Ng et al. 1998a). As part of a large study for exploiting onion waste into profitable food-grade products, one of the objectives is to investigate the use of processing methods (such as pressure-cooking and extrusion-cooking) to modify the physiochemistry of onion cell wall materials. Lecain et al. (1998) have demonstrated that cell walls of outer tissues from Hysam onions were much more strongly degraded than those from the Delta variety during pressure-cooking. Hence, the differences of cell wall composition between varieties and their component tissues will have significant influence on the degree of heat degradation of onion tissues.

Onion Varieties

Since onions are largely cross-fertilized, they show some variation in the colour and shape of the bulb in different varieties. Sturon, Durco, Hysam, Grano de Oro and Caribo varieties studied by Ng et al. (1998a) were the most popular inter-mediate globe shape and the skin colour of these onion varieties were yellow, except brown for Sturon and reddish-yellow for Grano The carbohydrate compositions of cell-wall materials from whole onion was rich in pectic polysaccharides, as indicated by the levels of rhamnose, arabinose, galactose and uronic acid; they also contained glucose and relatively small amounts of xylose and mannose

[1] Institute of Food Research, Norwich Research Park, Colney, Norwich NR4 7UA, United Kingdom

(Table 1). The yield and total carbo-hydrate of the cell wall materials of whole onions and their component tissues were not significantly affected by variety

Tissues Types

Inner tissues contributed the major average weight of onions (Ng et al., 1998a). The cell-wall materials of outer skin tissues gave a very high yield (on a dry weight basis) than their component tissues. The carbohydrate compositions of cell-wall materials from brown dry skin, outer two fleshy leaves, inner tissue, or top and bottom parts of onion were also rich in pectic polysaccharides (Table 1). Interestingly, there were significant differences in the carbohydrate composition of cell wall from different tissues (Ng et al., 1998a). Cell walls of inner leaf bases contained galactose-rich pectic polysaccharides. The outer layer had less pectic galactose, and the outer brown skin contained virtually none. The relative sizes of the arabinose and/or galactose side-chains may relate to the degree of solubility of pectic polymers, reflecting the maturity of onion tissues. In addition, Durco, Hysam and Caribo varieties of onion skin had significantly lower carbohydrate yields compared to Sturon and Grano varieties. This probably reflects the post-harvest handling, which may have differentially removed outer brown layers.

Table 1. Carbohydrate composition of CAIRs of fresh and stored onions.

	Carbohydrate (mol %)								Total	Ratio
	Rha	Fuc	Ara	Xyl	Man	Gla	Glc	UA	μg/mg	UA NS
Fresh										
Whole	2	1	3	4	3	10	30	47	807	4
Skin	2	1	1	4	2	1	32	547	828	30
Cuter	2	1	3	4	3	12	28	48	793	3
Inner	2	1	4	4	3	17	29	39	816	2
Top and Bottom	2	1	3	6	2	4	28	53	791	8
Stored										
Skin	1	1	1	4	2	1	37	52	762	26
Cuter	1	1	2	4	2	13	33	45	739	3

Values were represented as the mean of the 5 onion varieties, value in parentheses are expressed as the standard deviation of onion varieties (Soyrce: Ng et al 1998)

Abbreviations:

Rha - rhamnose, Fuc - fructose, Ara - arabinose, Xyl - xylose, Man - mannose, Gal - galactose, Glc - glucose, UA - uronic acid, and UA NS - uronic acid neutral sugars (arabinose + galactose).

Storage and Sprout Suppressant

On a whole organ basis, the weight of six months stored onions (0℃) was similar to the fresh onions indicating that little or no water loss by evaporation occurred during commercial storage, with or without sprout suppressant (Ng et al., 1998a). Storage did not induce any significant change in the yield, total carbohydrate and carbohydrate components of cell wall materials.

Extractability of Cell-Wall Components

A detailed fractionation of cell walls of whole onions and their component tissues has already been carried out by Ng et al. (1998a). Most of the extractable pectic polymers of onion tissues were solubilized by the CDTA-1 and Na_2CO_3-1 extraction, whilst relatively little was released by the water, imidazole, CDTA-2, Na_2CO_3-2 and KOH extraction In addition, skin of onions solubilized relatively less uronic acid of water-soluble polymers compared to the outer and inner tissues (Ng et al., 1998a). This difference in solubility may reflect the maturity of onion tissues. However, skin of onions contained relatively higher levels of extractable uronic acid of CDTA-soluble polymers compared to the outer and inner tissues. Sturon, Durco, Hysam, Grano de Oro and Caribo varieties showed a similar trend (Ng et al., 1998a). Furthermore, there were no major effects of sprout suppressant or storage.

Effects of Heating

Industrial processing often involves heat treatment. Heating of onions not only induced tissue softening but also had a considerable effect on the extractability of the cell wall polymers (Lecain et al., 1998) Heat-induced modification of the plant cell walls probably involves dissolution of pectic polymers through β-elimination degradation (Sajjaanantakul et al., 1993; Greve et al., 1994a and b; Ng and Waldron, 1997a and b; Ng et al., 1998b) and also results in cell separation (Van-Buren, 1979; Jarvis and Duncan, 1992; Parker and Waldron, 1995; Brett and Waldron, 1996). Recently, Lecain et al. (1998) have demonstrated that the

cell walls of outer tissues from Hysam onions were much more strongly degraded than those from the Delta variety during pressure-cooking. This may be due to differences in the degree of methylesterification of the wall uronide However, there is little information on the effects of heat treatment on the chemistry of cell-wall polysaccharides of onion waste, particularly the brown dry skin and the two fleshy outer tissues.

In order to investigate the effect of heat treatment on the solubility of cell-wall polysaccharides of skin and outer tissues of onions, alcohol-insoluble residues of skin and outer tissues were prepared, as the source of cell-wall materials, and were extracted with hot water (100℃, 30 min; method and materials see Ng et al., 1998b). The cell wall materials from skin reported here contained much lower levels of hot-water-soluble uronic acid than from outer tissues (Fig. 1 and Fig. 2). However, Grano skin or outer tissues were much less degraded than those from Sturon and Hysam varieties. In addition, there were no major effects of sprout suppressant or storage. Hence, the substantial variation which existed in cell wall composition among onion tissues as reported previously by Ng et al. (1998a) will have significant influence on the degree of solubilisation of onion tissues during subsequent heating. Clearly, the effect of thermal degradation on pectic polymers of different varieties and their component tissues requires further work, particularly if the exploitation of cell-wall polymers from a mixture of onion varieties and their component tissues into food-grade products are to be optimised.

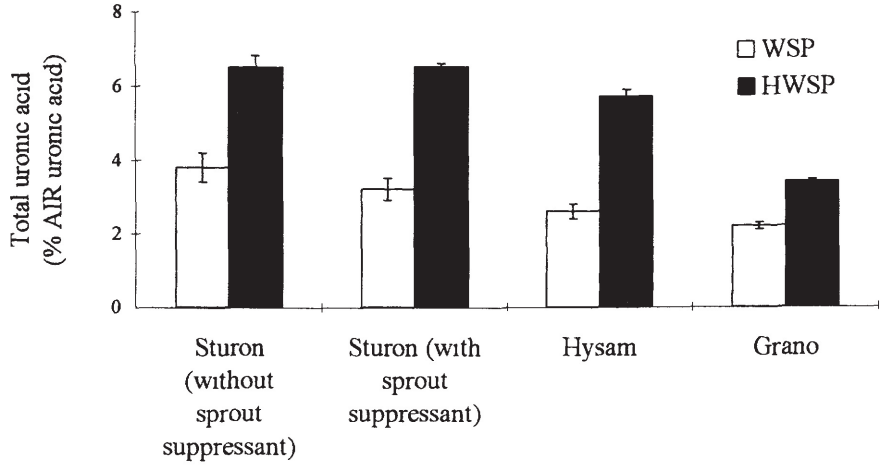

Fig. 1. Effect of heating on the solubility of cell wall materials of onion skin.

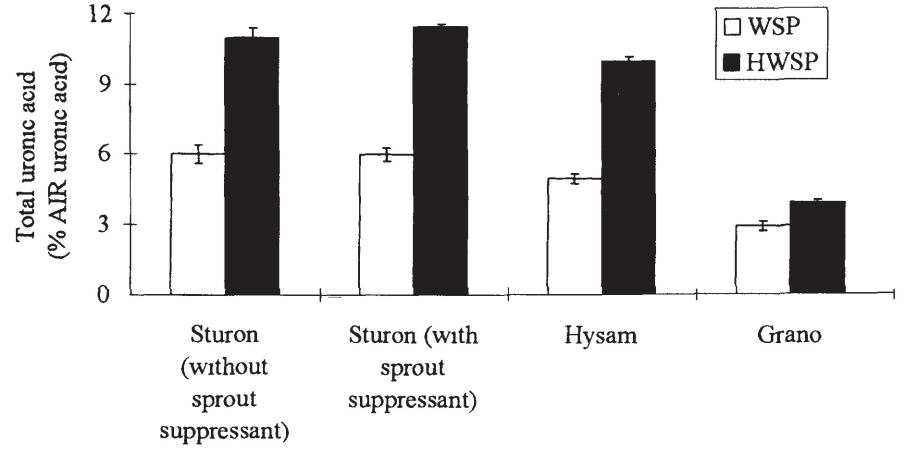

Fig. 2. Effect of heating on the solubility of cell wall materials of onion outer tissues.

Conclusion

The cell wall carbohydrate composition was similar among varieties, and not affected by sprout suppressant or storage. The cell-wall pectic polysaccharides of onions consisted of a range of structurally related polymers which differed widely in their ease of extraction from the cell-wall complex, in particular most of the pectic polymers were extracted by CDTA-1 and Na_2CO_3-1. A substantial variation exists in cell wall composition between onion tissues. The differences in cell wall polymers from different tissues provides the basis for developing processing methods (such as pressure-cooking and extrusion-cooking) for exploiting onion waste.

Apart from understanding the cell wall chemistry aiming at improving the value of the onion waste, the initial objective is to produce a flavour-free fibre, using a combination of technologies, from the outer-brown skin and outer fleshy leaves. This multi-disciplinary research programme brings together scientific expertise of the different participants, including Agro-technological Research Institute (The Netherlands), Univeristy Autonoma de Madrid (Spain), British Onion Producers Association (UK), Herbstreith and Fox (Germany) and Triumphus Onion Products (The Netherlands). This project involves the extraction of oil, fructo-oligosaccharides and sugars, and the subsequent modification of the remaining residues, by using physical, chemical and biochemical techniques to improve the solubility of fibre components. The modified fibre will eventually be added to texturally-sensitive food such as dairy products, drinks, sauces and desserts.

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