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# Changes of Chemical Composition in Tuberous Root of Yacon by Different Curing Conditions

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**ABSTRACT : Tuberous root of yacon (*Polymnia sonchifolia* Poeppig & Endlicher) has not starch, and its brix degree changes during the curing. Therefore its chemical composition changes were investigated according to different curing conditions. Tuberous root contained 87.1% moisture at harvesting, that was decreased to 84.1~86.0% at 30 days after curing in different curing conditions. Brix degree was increased from 5.7 to 14.2~15.8% at 30 days after curing in comparison to at harvesting. Free sugars were detected from tuberous root in yacon by HPLC; that were fructose, glucose and sucrose. Fructose contents were increased from 0.09 to 1.04~1.79% during 30 days in five curing conditions. Glucose contents were shown to increase from 0.03 to 1.04~1.37%. Sucrose contents were shown to increase from 0.04 to 0.13~0.43%. Tuberous root contained fructose, glucose and sucrose in order of amount that were highest in single-polyethylene film covered green house. Sucrose was little as comparison with fructose and glucose. Fructose and glucose were increased to 16.7 and 40.7 times, respectively, but sucrose was increased little about 6.8 times.**

***Keywords :*** yacon, curing, moisture, brix degree, fructose, glucose, sucrose, *Polymnia sonchifolia*.

Yacon (*Polymnia sonchifolia* Poeppig & Endlicher) is Compositae, originate from the Andean highlands, has large tuberous root (100~500 g F.W.). Tuberous root of yacon is similar to that of the dahlia or sweet potato tubers, but the fresh tuberous roots of yacon are juicy and sweet like fruits such as pears (Ohyama *et al.*, 1990). The fresh, boiled or fried tuberous roots are edible.

The tuberous root contained a high concentration of fructose, glucose, and sucrose, and a low content of nitrogen and potassium. The major constituents of free nitrogen were amides and amino acids such as asparagine, glutamine, proline and arginine (Asami *et al.*, 1989). Kandler & Hoph (1980) reported that the tubers of plants from the Compositae family such as *Helianthus tuberosus*, Dahlia often contain inulin, a high degree of polymerization oligofructan with about 35, as a major reserve carbohydrate. It is considered that the fructose is reserve carbohydrates in yacon tubers, but the occurrence, structure and content of fructose have not been documented.

Ohyama *et al.* (1990) determined the composition of the storage carbohydrate, isolated the trisaccharide, and analyzed the structure of the oligofructan. They reported that fructose was major free sugars and contained about 35% of dry matter. The physiological role of fructoside in plants has not been fully documented, but it has been suggested that the fructoside operate as an extension of the sucrose pool (Nelson & Spollen, 1987). The trisaccharide content was almost the same as that of sucrose, and much higher than that in the bulb scales of tulips, hyacinths or daffodils (Ohyama *et al.*, 1985, 1988a, b).

Storage conditions, especially temperature and moisture, influence on various physiological activities in tuber and tuberous root crops. Of these, particularly important is the starch to sugar balance in starch crops. Tuberous root of yacon has not starch, but brix degree changes during the period of curing and storage. In this report, changes of chemical composition were investigated and discussed in different curing conditions of yacon tuberous root.

## MATERIALS AND METHODS

### Plant material and cultivation

Crown bud of yacon (*Polymnia sonchifolia* Poeppig & Endlicher) was obtained from the National Crop Experiment Station, Rural Development Administration in 1994. Seedlings of yacon were cultivated in the field of an experimental farm, Chonbuk National University from May 10 to No- vember 10 (about 170 days) in 1998. Fertilizers application was 70-60-200 kg/ha of N-$P_2O_5$-$K_2O$ and 10 tons/ha of compost. It was tilled twice by the depth about 17 cm at 3 days and 30 days before planting and ridged at every 70 cm interval. The surface of ridges was mulched by polyethylene film, which was combined with transparency on center and black on both outside. At 30 days after planting, the plants were earthen up above film around roots.

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### Curing conditions and sampling

The harvested tuberous roots were cured on November 10 under different conditions, that were open field (OF), single-polyethylene film covered green house (GH), room temperature about 21±1°C (RT), low temperature at 101 (LTI) and low temperature at 4±1°C (LTII). Tuberous roots were sampled every 5 days during 30 days.

### Measurement of moisture content

Before loading the tuberous root samples, petri dishes were measured it's weight after being dried at 105±1°C for 2 hours and cooled on desiccator. Petri dishes with about 2~3 g tuberous root were measured as soon as tuberous roots were sliced off from 4 to 6 pieces with 2~3 mm, respectively, and then it's weights were measured after being dried at 105±1°C for 3 days and cooled on desiccator. Used digital chemical balance was could to record 0.01 g. The ratio of moisture content was calculated as the following equation.

$$\text{Moisture content } (\%) \frac{W_2 - W_3)}{W_2 - W_1)} \times 100$$

$W_1$ : Weight of petri dish
$W_2$ : Weight of sample and petri dish
$W_3$ : Weight of dried sample and petri dish

### Measurement of brix degree

Washed tuberous root was chipped off the skin, extracted using a juicer and then heated for 30 minutes at 60±1°C. Brix degree was measured directly by digital refractometer (Dull *et al.*, 1992).

### Free sugars analysis

To analysis free sugars, 200 g of tuberous roots were sliced and placed in a warring blender. The samples were covered with 100% ethanol to make the final concentration of 80% ethanol. Tuberous root and ethanol were blended at 4,000 rpm for 20 min. The mixture was then filtered with suction, and the residue was re-washed with 200 m*l* ethanol and filtered once more. The volume of the filtrate from the extract and the washing was reduced to less than 25 m*l* by a rotary vacuum evaporator. The concentrated samples were made up to 25 m*l* with distilled water. For elimination of colorful pigment and small particles, the concentrate was passed through the Sep-Pak $C_{18}$ plus cartridge. The 15 μ*l* of the decolored concentrate was injected into High Performance Liquid Chromatography (HPLC) of which conditions are presented in Table 1.

**Table 1.** Conditions of HPLC for analysis of free sugars in the tuberous root of yacon.

| | Conditions |
|---|---|
| Instrument | Beckman HPLC (U.S.A.) |
| Column | Carbohydrate analysis column (4.6 × 250 mm) |
| Detector | Waters model 410 refractive index |
| Sensitivity | × 8 |
| Temperature | 35°C |
| Mobile phase | Acetonitrile/water (75/25) |
| Flow rate | 1.5 ml/min. |
| Attenuation | × 4 |
| Sample size | 15 μ*l* |

## RESULTS

### Changes of moisture content

The moisture content of tuberous root in yacon was 87.1% when it was harvested. After curing in the 5 conditions for 30 days, that was ranged from 84.1 to 86.0%, which was some decrease. Moisture content was most decreased about 3% in the open field. It was decreased a little about 1.1% in the low temperature at 10±1°C and at 4±1°C (Fig. 1).

### Changes of brix degree

Brix degree was increased from 8.5 to 10.1% after curing compared with at harvesting. At 30 days after curing treatments, it was highest increased to 15.8% in the single-polyethylene film covered green house. It was increased rapidly from harvesting to 5 days, and then increased slowly in the all treatments (Fig. 2). Increase ratio was 73.6% during early 5 days, and 26.4% during the rest of 25 days.

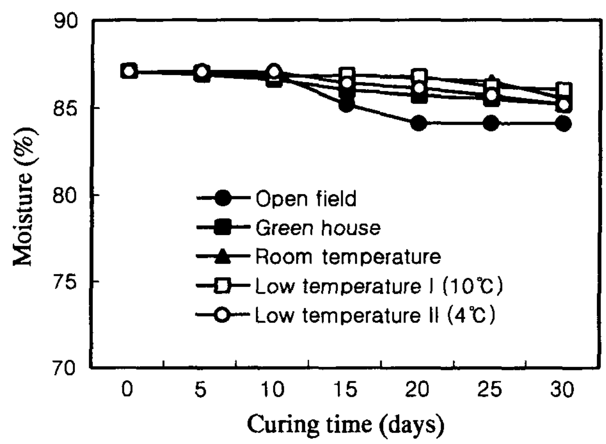



**Fig. 1.** Changes of moisture content by different curing conditions in yacon.

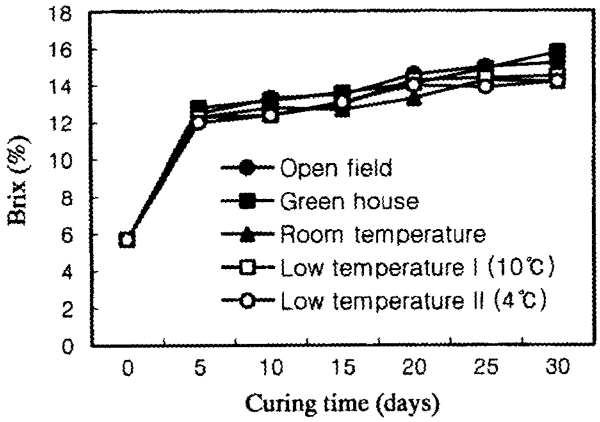
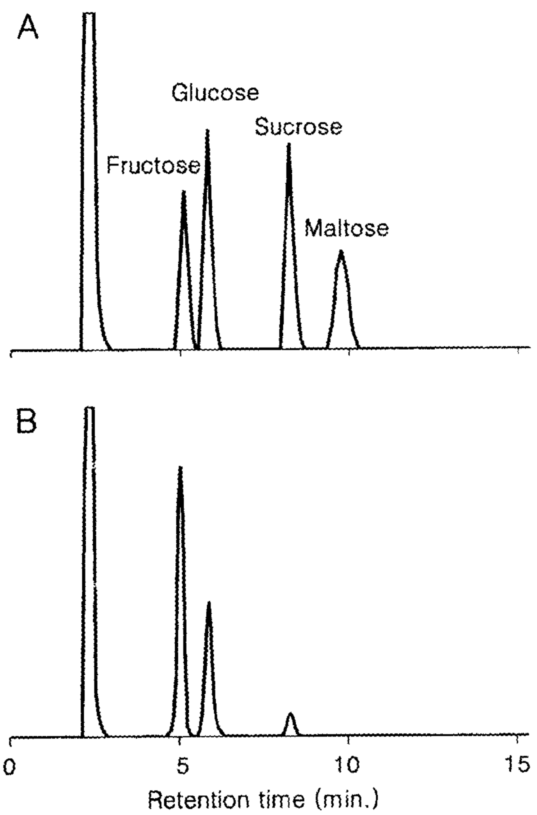



**Fig. 2.** Changes of brix degree by diffderent curing conditions in yacon.

## Changes of free sugar content

Free sugars of tuberous root were detected by HPLC, which were fructose, glucose and sucrose (Fig. 3). The changes of sugar contents during the 30 days curing in tuberous root were shown in Fig. 4.

Fructose contents were shown different levels according to curing conditions and periods; it was 0.09% at harvesting




;. 3. High performance liquid chromatogram of free sugars. A: standard solution, B: tuberous root of yacon.

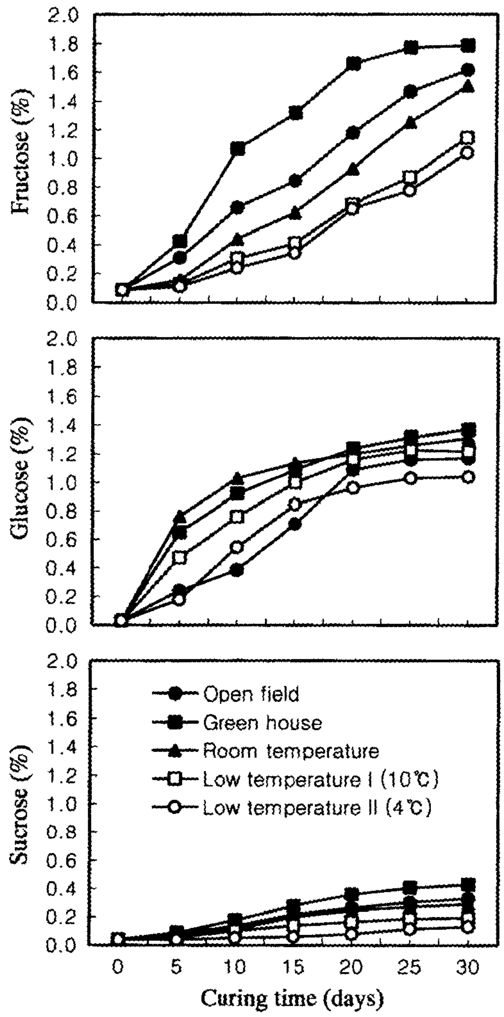



**Fig. 4.** Changes of free sugar content by different curing conditions in yacon.

and increased up to 1.79% at 30 days after curing in the single-polyethylene film covered green house. In case of curing in the open field and room temperature, fructose contents increased to 1.62 and 1.50% respectively, that was similar to content in the single-polyethylene film covered green house. Curing in the low temperature at 10±1°C and at 4±1°C, however, fructose contents increased to 1.15 and 1.04%, that was a little about 0.64 and 0.58 times respectively, as compared with in the single-polyethylene film covered green house.

Glucose contents increased from 0.03% at harvesting to 1.04~1.37% after 30 days curing in all treatments. It was most increased the content in case of curing in the single-polyethylene film covered green house. Most of contents increased rapidly at early 10 days, but the content in the open field increased rapidly at middle 10 days.

Sucrose contents increased from 0.04% at harvesting to 1.03~4.03% at 30 days after curing in all treatments. Most of

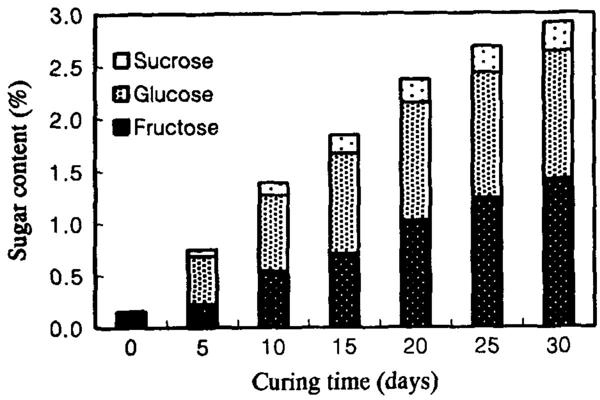



**Fig. 5.** Increase of sugar contents of tuberous root during the 30 days curing in yacon.

content was shown to increase in all treatments gradually. It was most increased the content in case of curing in the single-polyethylene film covered green house, that was also shown in fructose and glucose. Increased contents of sucrose were little as comparison with contents of fructose and glucose.

## DISCUSSION

If it were to increase sugar content in fruits and vegetables that water content decrease, so sugar content relative with water content (Cho & Bae, 1995). Water content of tuberous root in yacon decreased gradually during 30 days curing after harvesting in all treatments, at the same time, brix degree increased. Fruits and vegetables contain about 90% water; most of sugars are glucose, fructose and sucrose (Hulme, 1970). Plants produce the glucose by photosynthesis. It is used to make the cellulose to form tissue and organ, or to storage starch in fruit. Storage starch was hydrolyzed to sugar (especially sucrose, fructose and glucose) by enzyme after harvesting, when this time, water used (Cho & Bae, 1995). Tuberous root of yacon, however, has not starch. Therefore it is question what materials to be fructose, glucose and sucrose. Ohyama *et al.* (1990) suggested that it is low degree of polymerization (DP) oligosaccharides (DP 3 to 10 fructans). The trisaccharide content was almost the same as that of sucrose. It appears that tuberous root of yacon belong to the group which accumulates low-DP fructans like onion and tulip bulbs, and are different from inulin accumulating plants like *Helianthus tuberosus* or *Dahlia.* Starch was hardly detected in yacon tubers, as in the case of vegetative tissues of *Allium* (Pollock, 1986). The high content of free fructose and low DP fructans in the yacon tuberous root suggests that the tuberous roots are a good material for the production of fructose or low DP fructosylsucroses (Ohyama *et al.*, 1990). In this study, monosaccharide such as fructose and glucose increased from 0.09 and 0.03 to 1.42 and 1.21 mg/g D.W. respectively, but disaccharide such as sucrose increased from 0.04 to 0.27% (Fig. 5). These saccharides were originated from DP oligosaccharides (DP 3 to 10 fructans) and the part of saccharides was changed during the curing.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## REFERENCES


Asami, T., M. Kubota, K. Minamisawa, and T. Tsukihashi. 1989. Chemical composition of yacon, a new root crop from Andean highland. *Japan J. Soil Sci. Plant Nutr.* 60:122-126.

Cho, S. I., and Y. M. Bae. 1995. Study and application of the relationship between water content and sugar content in fruit and vegetables. *J. Kor. Soci. Agricultural Machinery.* 20(3):299-306.

Dull, G. G., R. G. Leffler, G. S. Birth, and D. A. Smittle. 1992. Instrument for nondestructive measurement of soluble solids in honeydew melons. Transactions of the ASAE. 35(2):735-737.

Hulme. 1970. The biochemistry of fruits and their products. Academic Press Inc.

Kandler, O., and H. Hoph. 1980. Occurrence, metabolism, and fruction of oligosaccharides. Stump, P. K. and E. E. Conn (Edt). The Biochemistry of the Plants. Vol. 3. Academic Press London. New York p221-270.

Nelson, C. J., and W. G. Spollen. 1987. Fructans. *Physiol. Plant.* 71:512-516.

Ohyama, T., T. Ikarashi, and A. Baba. 1985. Determination of the structure of oligofructan in the tulip bulb. *Soil Sci. Plant Nutr.* 31:293-298.

Ohyama, T., T. Ikarashi, and A. Baba. 1986. Analysis of the reserve carbohydrates in bulb scales of autumn planting bulb plant. *Jap. J. Soil Sci. Plant Nutr.* 57:119-125.

Ohyama, T., T. Ikarashi, and A. Baba. 1988a. Effect of cold storage treatment for forcing bulbs on the C and N metabolism of tulip plants. *Soil Sci. Plant Nutr.* 34:519-533.

Ohyama, T., T. Ikarashi, T. Matsubara, and A. Baba. 1988b. Behavior of carbohydrates in mother and daughter bulbs of tulips (*Tulipa gesneriana*). *Soil Sci. Plant Nutr.* 34:293-298.

Ohyama, T., O. Ito, S. Yasuyoshi, T. Ikarashi, K. Minamisawa, M. Kubota, T. Tsukihashi, and T. Asami. 1990. Composition of storage carbohydrate in tubers of yacon (*Polymnia sonchifolia*). *Jap. J. Soil Sci. Plant Nutr.* 36(1):167-171.

Pollock, C. J. 1986. Fructans and the metabolism of sucrose in vascular plants. *New Phytol.* 104:1-24.