B. Tech. (Food)

EFFECT OF OSMOTIC AGENTS ON DEHYDRATION OF YACON (*Smallanthussonchifolia*) SLICES

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Abstract

The experiment was conducted to study the effect of osmotic agent on quality of yacon slices at 50□C for 24 h. Yacon containing 80% moisture content was cut into slices of approximately 2 cm diameter and 1.5 cm thickness and 4.52 g average weight were used for osmotic dehydration. The osmotic agents used were honey and sucrose solutions of 60□Bx. The water loss was found to be 44.47 and 35.66% in case of honey and sucrose treated sample, respectively. The moisture content reduced 45 and 40.32% in sucrose and honey treated samples respectively after 24 h of osmotic dehydration. Likewise, solid gain was found to be 35.9 and 32.11% in honey and sucrose treated sample, respectively after 24 h of osmotic dehydration. The total solids resulted higher in honey treated sample i.e 36.6 % than sucrose treated sample i.e. 31.4%. The weight reduction was found to be 6.32 and 5.62% in honey and sucrose treated sample after 24 h of osmosis. The total titrable acidity of honey treated and sucrose treated sample was found to be similar i.e., 0.4%. The increment in reducing sugar is found to be more in case of honey treated sample i.e. 32.48% than sucrose treated sample i.e. 25.38%. Hence, the results revealed that the dehydration of Yacon slices is affected by the different osmotic agent used and honey is found to be more suitable osmotic agent than sucrose solution.

Introduction

Yacon (yacón, llacón, llakuma, aricoma, jiquima) (*Smallanthus sonchifolius*) belongs with other 21 Smallanthus species to the family of the Asteraceae. In Peru, seven *Smallanthus* species are found, from which yacon the only domesticated species is and still cultivated in small plot only for retail sale (Brako and Zarucchi, 1993; Grau *et al*., 2001). This plant has a branching system that gives rise to aerial stems about 2 to 2.5 m high. Yacon yields starchy, fruit-like roots of different shapes and sizes that are usually consumed raw and taste sweet. Their crunchy texture very much resembles that of an apple(Grau, 1997).Several carbohydrates are stored in the roots of yacon: fructose, glucose, sucrose, low degree of polymerization (DP) oligosaccharides (DP 3 to 10 fructans), and traces of starch and inulin (Asami *et al*., 1989; Ohyama *et al*., 1990). Yacon may provide the low calories and fiber necessary to survive the stress of sedentary lifestyles combined with overconsumption of carbohydrates and fats (Hermann and Heller, 1997).

Different preservation methods have been employed to extend the shelf life of fruits andvegetable, among which canning, freezing and drying are most notable methods in industry scale (Burrows 1996, Mcminn and Magee, 1998). These preservation techniques have been known to require high amount of energy, difficulty in high volume of water removal during exhausting, browning, aroma and flavor retentions value (Rahman and Lamb, 1991). The drying of fruit by creating osmotic pressure is called osmotic dehydration, which has been in attention due to the better retention of color, flavor and nutritional constituent (Tiwari, 2005; Rahman, 1992) so may overcome these difficulties. The production of Yacon is seasonal and it generates interest in the preserved products having qualities close to those of fresh ones. Dehydration of Yacon is a new product, development in context of Nepal. Osmotic dehydration of similar Yacon like fruits are quite popular in many countries which extends the shelf-life and consumer perception and in marketing too. However, such kind of scientific study is very limited. The research may help to find out the mass transfer kinetics of Yacon in different osmotic agent. As osmotic agent plays an important role in osmotic dehydration, we can find out the appropriate osmotic agent for Yacon. We can relate this to one step ahead of the product diversification.

Thus, the present work concerns on the study of the effect of different osmotic agent on the rate of dehydration kinetics.

Materials and Methods

Materials

Fresh, ripe, and matured Yacon were purchased from the local market of Kathmandu, Nepal. Sucrose and honey were bought from the local market of Kathmandu, Nepal.

Methods

Osmotic dehydration of Yacon slices

Damaged, immature and bruised Yacon were sorted out from undamaged and sound fruits. The selected fruits were washed with tap water to remove dust, mud and were manually peeled. The peeled Yacon were cut into slice of 1.5 cm × 2 cm (thickness× diameter) and were immediately dipped into 0.1% KMS solution to inhibit enzymatic browning. Each slice was weighed separately in electrical balance after removing the surface moisture by the use of tissue paper. Sucrose and honey were used as an osmotic agent to prepare osmotic solution. The osmotic solutions were made up to 60°Bx.The osmotic dehydration process was followed by the process given by Mini and Archana (2016). The samples were taken at an interval of 60 minutes in first 4 hours and last 4 hours over a period of 24 hours. After removal from the osmotic medium, samples were placed in a beaker containing distilled water and shaken manually for 30 seconds to remove superficially adsorbed osmotic liquid. Before evaluation, rinsed samples were placed on the blotting paper to remove excess water.

Analytical methods

The moisture content of fresh fruit was determined by hot air oven method as Ranganna (2009), until the constant weight was obtained. The weight loss was determined by subtracting the final weight from initial weight. The surface moisture of the product was removed by the help of tissue paper and then weighed in an electric balance. The slices were transferred to a pre-weighed aluminum dish, weighed and dried in the hot air oven. After cooling in a desiccator, the dish and the dried samples were reweighed. The percentage total solids (% TS) was calculated as follows:

$$\%TS=\frac{W_3-W_1}{W_2-W_1}\times100$$

Where, W_1 = Weight of aluminium dish
W_2= Weight of dish and sample
W_3 = Weight of dish and the vacuum dried samples.

Observations on dehydration kinetics such as % Solid Gain (SG), % Water Loss (WL) were recorded using the following formulae (Kaur and Singh 2013).

$$\%\ SG = \frac{m-m_0}{M}$$

$$\%\ WL = \frac{(M_0-m_o)-(M-m)}{M_0}\times 100$$

Where, M_0 = Initial mass of fresh fruit prior to osmotic dehydration (g)
M= mass of sample after time ‘t’ of osmotic dehydration (g)
m= dry mass of fruit after time ‘t’ of osmotic dehydration (g)
m_0= dry mass of fresh fruit prior to osmotic dehydration (g)

Titratable acidity was determined by standard titration as per Ranganna (2009). The reducing sugar of slices of Yacon during osmotic dehydration was determined as perLane and Enyon method as described by Ranganna, (2009).

Data analysis

All the data obtained in this work were analyzed by the statistical program known as Microsoft excel.

Results and discussion

Effect of osmotic agents on water loss (WL) and moisture content

Change in water loss is shown in figure 1. The percentage water loss using 60°Bx sucrose and honey solution was found for first 4 hours and last 4 hours during the interval of 24 hours at 50°C temperature which showed that WL linearly increased with time. The percentage WL in honey solution increased from 30.77 to 44.47% during 24 hours of time. Similarly, in case of sucrose solution the WL increased from 21.7 to 35.66%.

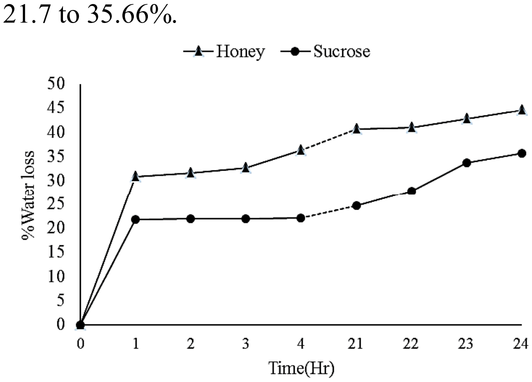

Fig 1. *Influence of honey and sucrose solution of 60□Bx at 50□C on % water loss of Yacon slices*

The greater rate of water loss was found where the honey was used as an osmotic agent as compared to sucrose solution. Sucrose has found to be one of the best osmotic agents because of its effectiveness, convenience and desirable flavor. Its diffusivity is much lower than that of water, which results in little solid uptake in the tissue. Rate of removal of moisture is a characteristic of prime importance to every dehydration process as it is indicative of process effectiveness. It is also suggestive of the productive duration of the process.

Change in % moisture content is shown in figure 2. The moisture content of Yacon slices exposed to sucrose syrup concentrations of 60°Bx, after 24 hours of treatment, were from 80 to 45 % while from 80 to 40.32% in case of honey treated samples, respectively. Comparing honey and sucrose treated sample, it is observed that during all the period of osmosis in syrup concentrations of 60°Bx, the reduction of moisture content was much higher in honey treated sample in comparison to that of sucrose.

The effect of syrup concentration on the reduction of moisture content in fruits already demonstrated that the increase in osmotic syrup concentration increases diffusional changes and the osmotic pressure exerted on the fruit cell structure which consequently results in greater moisture reduction in more concentrated solutions (Jalali *et al*., 2006). However, syrup concentration is not a critical parameter in the range of 65 to 75° Bx (SAS, 1993). Various solutes such as sucrose, lactose, maltodextrin and sodium chloride are known to be efficient for osmosis over 60% concentration (Jalali *et al*., 2006).

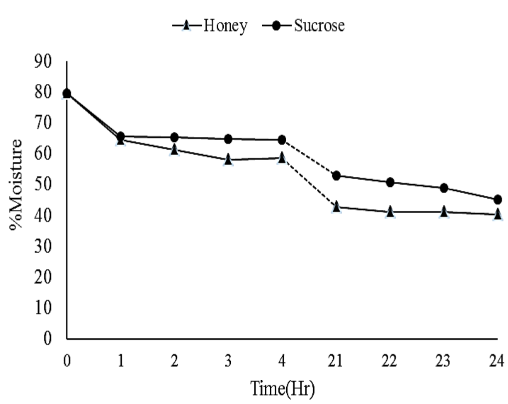

Fig 2. *Influence of honey and sucrose solution of 60□Bx at 50□C on % moisture of Yacon slices*

Effect of different osmotic agents on solid gain (SG) and total solid

The percentage solid gain using 60°Bx sucrose and honey solution was found for first 4 hours and last 4 hours during the interval of 24 hours at 50°C temperature which showed that % SG linearly increased with time which is shown in figure 3. The dotted lines shown in the above graph indicates the time interval between 4th and 21st hour of experiment to study the effects on solid gain of Yacon slices. The percentage SG in honey solution increased from 13.1 to 35.9%. Similarly, for sucrose solution it was observed to increase from 10.3 to 32.11%.

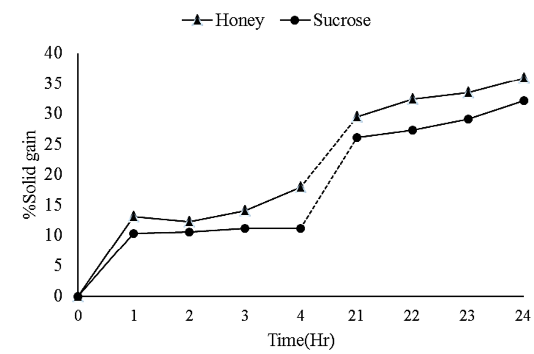

Fig3. *Influence of honey and sucrose solution of 60□Bx at 50□C on % solid gain of Yacon slices*

From the result, the use of low molecular weight osmotic agents enhanced mass transfer during osmotic dehydration. Due to a higher rate of penetration of low molar mass molecules, the solid enrichment occur instead of dehydration during the process, resulting in the promotion of water loss. Fructose have a lower molecular weight than sucrose, resulting in the promotion of mass transfer during osmotic dehydration (Ispir and Togrul, 2009). Higher solid gain and water loss were observed in honey treated sample compared to sucrose-treated sample. Low molecular weight solutions have higher corresponding osmotic pressures, which could favor plant cell plasmolysis (Tortoe, 2010). Consequently, the osmotic process facilitate uptake of low molecular weight solutes resulting in the spread of plasmolysis throughout the tissues and gradually dehydrating the different tissue layers. Low molecular weight solutes markedly penetrated the fruits, whereas those of higher molecular weight only showed a slight and slow inward motion (Khanom *et al*., 2014).

Fig 4. shows that amount of total solids in the osmo-dried fruit significantly increased with honey treated sample than in sugar solution concentration. The dotted lines shown in the above graph indicates the time interval between 4th and 21st hour of experiment to study the effects on total solids of Yacon slices. Thus, the use of honey solution resulted in higher amount of water loss. The total solids using 60°Bx sucrose and honey solution was found for first 4 hours and last 4 hours during the interval of 24 hours at 50°C temperature linearly increased with time. The total solids in sample treated with honey increased from 20.38 to 36.6 % during the interval of 24 hours. Similarly, with the sucrose solution the value increased from 20.38 to 31.4%.

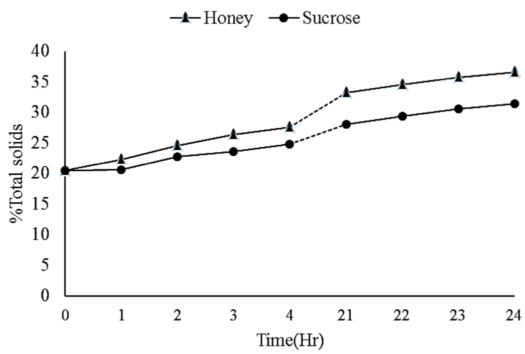

Fig 4. *Influence of honey and sucrose solution of 60□Bx at 50□C on % total solids of Yacon slices*

The higher amount of sugar uptake probably resulted in rapid development of a concentrated sugar layer under the surface of the fruit pieces, upsetting the osmotic pressure gradient across the fruit-sugar solution interface and therefore decreasing the driving force for water flow (Hawkes and Flink, 1978). Hughes *et al.* (1958) working on the penetration of malto-saccharides in processed Clingstone peaches, reported that the rate of solute penetration was directly related to the solution concentration and inversely related to the size of the sugar molecule.

Effect of different osmotic agents on Weight reduction

Figure 5 shows that the osmotic solution of sugar and honey increased the weight reduction values during the first four hours of osmosis and then it was found to be decreasing at the last few hours over the period time of 24 hours of experiment. The dotted lines shown in the above graph indicates the time interval between 4th and 21st hour of experiment to study the effects on weight reduction of Yacon slices. The weight reduction was found to be decreasing from 12.76 to 6.32% in case of honey treated sample and then the value was found to be decreasing from 9.78 to 5.62% in sucrose treated sample.

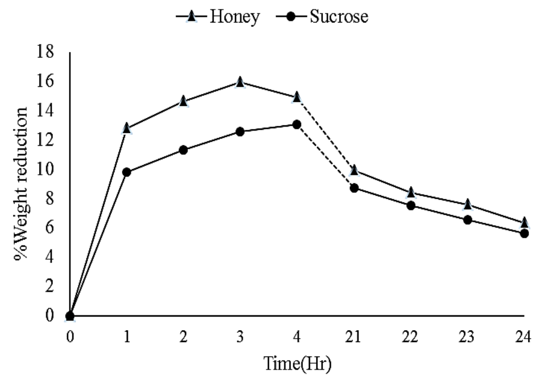

Fig 5. *Influence of honey and sucrose solution of 60□Bx at 50□C on %weight reduction of Yacon slices*

Ponting *et al.* (1966) using apples, noticed that at high sugar concentrations (above 65%) additional increase in concentration did not promote further weight loss. Similar responses to concentration increases were observed by Contreras and Smyrl (1981) although there was a difference regarding the concentration cut point; that is, the point above which an increase in concentration was not followed by a significant increase in weight loss. This difference can be explained on the basis of differences in experimental setup among the above workers (Lazarides *et al.*, 1995).

Effect of different osmotic agents on acidity

Change in acidity is shown in Fig. 6. The dotted lines shown in the above graph indicates the time interval between 4th and 21st hour of experiment to study the effects on acidity of Yacon slices. The total acidity (malic acid) of fresh Yacon was found to be 1.62% while the total titratable acidity was found to decrease to 0.44% in honey solution. Likewise, reduction in total acidity in case of sucrose solution decreased to 0.4%. This might be due to leaching of acids into the medium during osmotic dehydration process. The lowest total acidity was found to be somewhat similar in both the solutions. Since acidity kept on decreasing, the Yacon slices after osmosis tend to lose their sourness and become too sweet. So, the acid can be added while preparing the osmotic solutions in order to balance the acidity of the Yacon slices. The highest water loss in honey treatment may enhance the diffusion of acids into the osmotic solution due to organic acids presented in fruit easily dissolve in water (Bawa and Gujral, 2000).

Vilhena *et al*., (2000) found total titratable acidity (TTA) of 1.8% for the fresh Yacon pulp, the first parameter was similar to that of the present study. According to Palomino and Rios (2004), the pH and the total soluble solids (TSS) increase and the TTA decreases with the maturation of Yacon. Therefore, the difference between the values presented can be due to the degree of maturation of the roots.

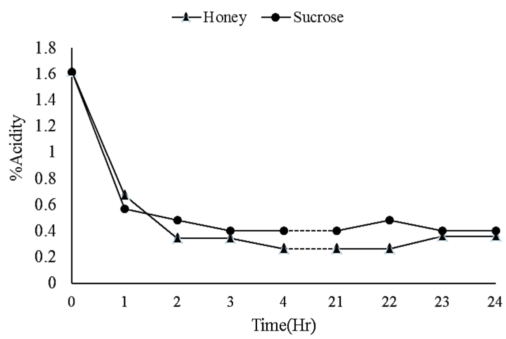

Fig 6. *Influence of honey and sucrose solution of 60□Bx at 50□C on % acidity of Yacon slices*

Effect of different osmotic agents on reducing sugars

It was observed that the rate of solid gain was found to be higher in case of honey treated sample than sugar treated sample. Figure 7 shows that the increase in reducing sugars in case of honey and sucrose treated sample, respectively during the interval of 24 hours at 50°C. The dotted lines shown in the above graph indicates the time interval between 4th and 21st hour of experiment to study the effects on reducing sugar of Yacon slices. The amount of reducing sugar was found to be 19.3%. As the experiment was carried out, reducing sugar kept on increasing from 19.3.3 to 32.48% in case of honey treated sample. Meanwhile in case of sugar treated sample, the increment in the amount of reducing sugar was 19.3.3 to 25.38%.

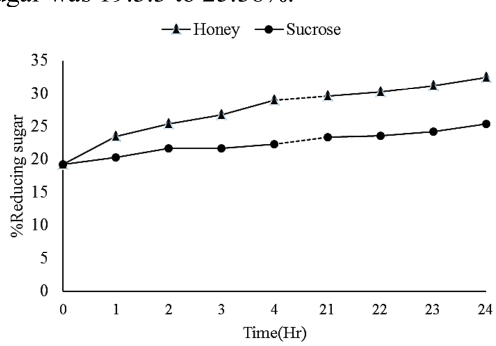

Fig 7. *Influence of honey and sucrose solution of 60□Bx at 50□C on % reducing sugar of Yacon slices*

The increment in reducing sugar was found to be more in case of honey than sugar treated slices. This may be due to the higher viscosity of osmotic solutions, immersion time as well as saturation of Yacon slices by osmotic solutions. The reducing sugar content of carrot candy prepared in honey (75°Bx) was found to be increasing. The reducing sugar content of sample containing honey was 5.5 times greater than sample containing jaggery (Dahal,2014).

Conclusions

The solid gain and water loss was found to be greater in case of honey treated Yacon slices. The reducing sugar content of honey treated sample was higher than the sucrose treated Yacon slices. Though honey was found to be better osmotic dehydrating agent compared to sugar but ultimately weight loss was almost similar for both osmotic agent after 24 hours.

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