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Technical Factors Influencing to Production of Yam Bean Beverage

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Abstract: Yam bean (*Pachyrhizus erosus*) is a starchy root and one of most the popular edible roots grown in many parts of Vietnam. Yam bean has high crude fibre content as well as other valuable compositions. Research on yam bean is limited. Therefore, we decided to perform one beverage production from yam bean root. We focused on investigation the effectiveness of enzymatic extraction treated by pectinase, hemicellulase and cellulase to get the best juice recovery. The extracted yam bean juice was then supplemented by sucrose and citric acid to get a specific beverage. We noticed that pH 5.0, 45 min and 40°C were enough for pectinase 0.2%:hemicellulase 0.2%:cellulase 0.2% on the extraction of yam bean fluid. On the consumer palate, yam bean beverage had the best sensory score while being supplemented with 8% sucrose and 0.08% citric acid.

Key words: Yam bean, beverage, extraction, pectinase, hemicellulase, cellulase

INTRODUCTION

Yam bean is a tropical tuber legume easily grown and holds a great potential as a new source of starch. Yam bean starch shows functional properties which are peculiar to those of most starch root crops. Yam bean starch paste presents a high viscosity profile, high retrogradation tendency and low stability on cooking. The functional properties of yam bean starch, similar to those of cassava starch, allows yam bean to be used as a potential new source of starch (Melo *et al*., 2003). The chemical properties of flour produced from the yam bean include 5.8% moisture content, 5.7% crude fat, 6.2% crude fiber and 85% available carbohydrate, indicating appropriate shelf-stable flour, low fat and abundant energy (Buckman *et al*., 2017). Its protein content is reported to range between 20.2 and 21.2%. Yam bean could improve the nutritional content of maize flour by incorporating yam bean (Atinuke, 2015). Yam bean can also be processed to maize based cereal blends (Aminat *et al*., 2012).

Diabetes is one of the most serious health concerns all over the world. Yam bean is rich in fructooligosaccharides including inulin, a soluble fiber. Inulin is sometimes called natural insulin. So, yam bean which contains inulin might be helpful for alleviating blood glucose levels. Yam bean extract may help decrease postprandial blood glucose level by inhibiting α-glucosidase.

One publication has reported the chemical constituents of yam bean root (Fernandez *et al*., 1997). Mussary *et al*. (2013) studied the postharvest conservation of yam bean root and there are immunomodulatory activities in yam bean fiber (Kumalasari *et al*., 2014). Cantwell *et al*. (2002) investigated the effect of chilling injury to yam (Fig. 1).

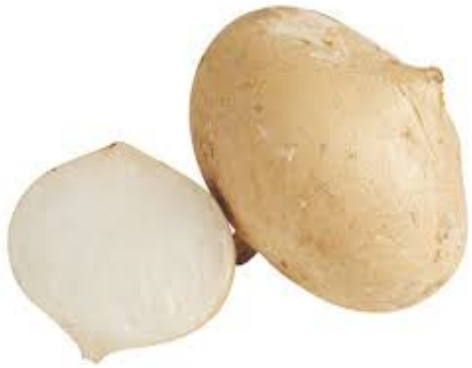

Fig. 1: Yam bean *(Pachyrhizus erosus)*

Storage of jicama roots at 10°C resulted in characteristic chill-induced changes in pulp color and texture after 7-14 days. Discoloration or browning of the pulp occurred first in exterior pulp tissue and then progressed to the interior tissue. Skin whitening compounds are in a close relationship with melanin. Radicals play important roles in the activation of tyrosinase in human skin and therefore enhance melanin biosynthesis. Lukitaningsih (2014) identified bioactive compounds in yam bean (*Pachyrhizus erosus*) as antioxidant and tyrosinase inhibiting agents. Yam bean is one of legume well adaped to climate change. It has great potential to contribute to overall food security and improve local diets. With the purpose of effective utilization of huge yam bean cultivation, we investigated to produce one kind of beverage from yam bean root.

MATERIALS AND METHODS

We collected yam bean roots in Soc Trang Province, Vietnam. They must be cultivated following VietGAP to

ensure food safety. After harvesting, they must be conveyed to laboratory within 8 h for experiments. Beside yam bean roots, we also used other materials during the research such as Pectinex Ultra (pectinase), Viscozym L (hemicellulase), Cellulast 1.5 L (cellulase). Lab utensils and equipments included grinder, pH meter, drying oven, autoclave, colorimeter, weight balance and homogenizer.

Investigate the effect of pectinase in juice extraction

pH of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 4.0, 4.5, 5.0, 5.5, 6.0. Yam bean juice was treated by pectinase 0.2% w/w in 45 min at 30°C. The extracted juice which was treated by pectinase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal pH for extraction.

Temperature of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase 0.2%w/w in 45 min at 30, 35, 40, 45 50°C. The extracted juice which was treated by pectinase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal temperature for extraction.

Time of extraction Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase 0.2% w/w in 15, 30, 45, 60, 75 min at 45°C. The extracted juice which was treated by pectinase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal time for extraction.

Pecentage of enzyme: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase 0.05, 0.10, 0.15, 0.20, 0.25% w/w in 45 min at 45°C. The extracted juice which was treated by pectinase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal percentage of enzyme for extraction.

Investigate the effect of hemicellulase in juice extraction

pH of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 4.0, 4.5, 5.0, 5.5, 6.0. Yam bean juice was treated by hemicellulase 0.2%w/w in 45 min at 30°C. The extracted juice which was treated by hemicellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal pH for extraction.

Temperature of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by hemicelluase 0.2%w/w in 45 min at 30, 35, 40, 45, 50°C. The extracted juice which was treated by hemicellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal temperature for extraction.

Time of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by hemicellulase 0.2%w/w in 15, 30, 45, 60, 75 min at 40°C. The extracted juice which was treated by hemicellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal time for extraction.

Pecentage of enzyme: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by hemicelluase 0.05, 0.10, 0.15, 0.20, 0.25% w/w in 45 min at 40°C. The extracted juice which was treated by hemicellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal percentage of enzyme for extraction.

Investigate the effect of cellulase in juice extraction

pH of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 4.0, 4.5, 5.0, 5.5, 6.0. Yam bean juice was treated by cellulase 0.2%w/w in 45 min at 30°C. The extracted juice which was treated by cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal pH for extraction.

Temperature of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by cellulase 0.2%w/w in 45 min at 30, 35, 40, 45, 50°C. The extracted juice which was treated by cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal temperature for extraction.

Time of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by cellulase 0.2%w/w in 15, 30, 45, 60, 75 min at 40°C. The extracted juice which was treated by cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal time for extraction.

Pecentage of enzyme: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by cellulase 0.05, 0.10, 0.15, 0.20, 0.25% w/w in 45 min at 40°C. The extracted juice which was treated by cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery and viscosity of juice were tested to find out the optimal percentage of enzyme for extraction.

Investigate the effect of pectinase combined with hemicellulase in juice extraction

Ratio of pectinase: hemicellulase: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase: hemicellulase in different ratios such as 0.2:0.2, 0.3:0.1, 0.1:0.3%w/w, respectively in 45 min at 40°C. The extracted juice which was treated by pectinase:hemicellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out the optimal ratio of pectinase:hemicellulase for extraction.

Time of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase:hemicellulase in ratios such as 0.2:0.2%w/w, respectively in 15, 30, 45, 60, 75 min at 40°C. The extracted juice which was treated by pectinase: hemicellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out the optimal time for extraction.

Investigate the effect of pectinase combined with cellulase in juice extraction

Ratio of pectinase:cellulase: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase:cellulase in different ratios such as 0.2:0.2, 0.3:0.1, 0.1:0.3%w/w, respectively in 45 min at 40°C. The extracted juice which was treated by pectinase: cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out the optimal ratio of pectinase:cellulase for extraction

Time of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase:cellulase in ratios such as 0.2:0.2%w/w, respectively in 15, 30, 45, 60, 75 min at 40°C. The extracted juice which was treated by pectinase: cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out the optimal time for extraction.

Investigate the effect of hemicellulase combined cellulase in juice extraction

Ratio of hemicellulase; cellulase: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by hemicellulase:cellulase in different ratios such as 0.2:0.2, 0.3:0.1, 0.1:0.3%w/w, respectively in 45 min at 40°C. The extracted juice which was treated by hemicellulase:cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out optimal ratio of hemicellulase:cellulase for extraction.

Time of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by hemicellulase:cellulase in ratios such as 0.2:0.2%w/w, respectively in 15, 30, 45, 60, 75 min at 40°C. The extracted juice which was treated by hemicellulase: cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out the optimal time for extraction.

Investigate the effect of pectinase combined with hemicellulase and cellulase in juice extraction

Ratio of pectinase:hemicellulase:cellulase: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase:hemicellulase: cellulase in different ratios such as 0.2:0.2:0.2, 0.2:0.2:0.4, 0.2:0.4:0.2, 0.4:0.2:0.2%w/w, respectively in 45 min at 40°C. The extracted juice which was treated by pectinase: hemicellulase:cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out the optimal ratio of pectinase:hemicellulase:cellulase for extraction.

Time of extraction: Yam bean roots were thoroughly grinded and adjusted pH to 5.0. Yam bean juice was treated by pectinase: hemicellulase: cellulase in different ratios such as 0.2:0.2:0.2, 0.2:0.2:0.4, 0.2:0.4:0.2, 0.4:0.2:0.2%w/w, respectively in 15, 30, 45, 60, 75 min at 40°C. The extracted juice which was treated by pectinase: hemicellulase: cellulase would be heated to 100°C in 2 min to inactivate enzyme. Recovery of juice was tested to find out the optimal time for extraction.

Investigate the effect of sucrose and citric acid supplementation to yam bean beverage

Effect of sucrose supplemented to yam bean beverage: The extracted yam bean fluid which was treated by enzymes would be then supplemented with 2, 4, 6, 8, 10% sucrose. Sensory characteristics were evaluated to identify the optimal sucrose supplementation.

Effect of citric acid supplemented to yam bean beverage: The extracted yam bean fluid which was treated by enzymes would be then supplemented with 0.02, 0.04, 0.06, 0.08, 0.1% citric acid. Sensory characteristics were evaluated to identify the optimal citric acid supplementation.

Physical, chemical and sensory analysis: We collected 100 mL of each sample for testing. We analyzed fluid viscosity by viscosity mter, total sugar content by Phenol, acidity by pH meter, sensory acceptance score evaluation.

Statistical analysis: Data were statistically summarized by statgraphics.

RESULTS AND DISCUSSION

Effect of pectinase in juice extraction

pH of extraction: From Table 1, we selected pH 5.0 for pectinase extraction

Temperature of extraction: From Table 2, we selected 40°C for pectinase extraction.

Time of extraction: From Table 3, we saw that 45 min was enough for pectinase extraction.

Percentage of enzyme: From Table 4, we noticed the optimal pectinase percentage at 0.2% sufficient for yam bean fluid extraction.

Effect of hemicellulase in juice extraction:

pH of extraction: From Table 5, we selected pH 5.0 for hemicellulase extraction.

Temperature of extraction: From Table 6, we selected 40°C for hemicellulase extraction.

Table 1: Effect of pH to pectinase extraction on yam bean fluid

pH	4.0	4.5	5.0	5.5	6.0
Recovery (%)	56.79^{d}	58.42^{b}	**60.25^{a}**	58.28^{b}	57.13^{c}
Viscosity (cp)	5.65^{a}	4.14^{c}	**3.82^{d}**	4.29^{c}	5.15^{b}

Table 2: Effect of temperature to pectinase extraction on yam bean fluid

Temperature (°C)	30	35	40	45	50
Recovery (%)	56.92^{d}	58.50^{b}	**60.49^{a}**	58.54^{b}	57.27^{c}
Viscosity (cp)	5.46^{a}	4.32^{c}	**3.61^{d}**	4.25^{c}	5.03^{b}

Table 3: Effect of time to pectinase extraction on yam bean fluid

Time (min)	15	30	45	60	75
Recovery (%)	56.92^{c}	58.50^{b}	**61.15^{a}**	61.19^{a}	61.23^{a}
Viscosity (cp)	5.39^{a}	4.57^{b}	**3.73^{c}**	3.71^{c}	3.69^{c}

Table 4: Effect of enzyme percentage on the extraction of yam bean fluid

	Pectinase percentage (%)				
Criteria	0.05	0.10	0.15	**0.20**	0.25
Recovery (%)	56.75^{d}	58.16^{c}	59.04^{b}	**61.20^{a}**	61.22^{a}
Viscosity (cp)	5.14^{a}	4.87^{b}	4.26^{c}	**3.72^{d}**	3.70^{d}

Table 5: Effect of pH to hemicellulase extraction on yam bean fluid

pH	4.0	4.5	5.0	5.5	6.0
Recovery (%)	56.68^{d}	58.39^{b}	**60.38^{a}**	58.21^{b}	57.19^{c}
Viscosity (cp)	5.62^{a}	4.11^{c}	**3.79^{d}**	4.25^{c}	5.13^{b}

Table 6: Effect of temperature to hemicellulase extraction on yam bean fluid

Temperature (°C)	30	35	40	45	50
Recovery (%)	56.88^{d}	58.45^{b}	**60.43^{a}**	58.51^{b}	57.19^{c}
Viscosity (cp)	5.42^{a}	4.29^{c}	**3.57^{d}**	4.20^{c}	5.05^{b}

$^{a-d}$The values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Time of extraction: From Table 7, we saw that 45 min was enough for hemicellulase extraction.

Percentage of enzyme: From Table 8, we noticed the optimal hemicellulase percentage at 0.2% sufficient for yam bean fluid extraction.

Effect of cellulase in juice extraction

pH of extraction: From Table 9, we selected pH 5.0 for cellulase extraction.

Temperature of extraction: From Table 10, we selected 40°C for cellulase extraction.

Time of extraction: From Table 11, we saw that 45 min was enough for cellulase extraction.

Percentage of enzyme: From Table 12, we noticed the optimal hemicellulase percentage at 0.2% sufficient for yam bean fluid extraction.

Effect of pectinase combined with hemicellulase in juice extraction

Ratio of pectinase:hemicellulase: From Table 13, we realized the optimal extraction on yam bean fluid happened on pectinase 0.2%:hemicellulase 0.2%.

Table 7: Effect of time to hemicellulase extraction on yam bean fluid

Time (min)	15	30	45	60	75
Recovery (%)	56.85^{c}	58.48^{b}	**61.02^{a}**	61.08^{a}	61.11^{a}
Viscosity (cp)	5.36^{a}	4.54^{b}	**3.69^{c}**	3.68^{c}	3.67^{c}

Table 8: Effect of enzyme percentage on the extraction of yam bean fluid

	Hemicellulase percentage (%)				
Criteria	0.05	0.10	0.15	**0.20**	0.25
Recovery (%)	56.61^{d}	58.05^{c}	59.08^{b}	**61.15^{a}**	61.18^{a}
Viscosity (cp)	5.09^{a}	4.83^{b}	4.19^{c}	**3.65^{d}**	3.68^{d}

Table 9: Effect of pH to cellulase extraction on yam bean fluid

pH	4.0	4.5	5.0	5.5	6.0
Recovery (%)	56.75^{d}	58.41^{b}	**60.44^{a}**	58.28^{b}	57.25^{c}
Viscosity (cp)	5.66^{a}	4.15^{c}	**3.81^{d}**	4.29^{c}	5.16^{b}

Table 10: Effect of temperature to cellulase extraction on yam bean fluid

Temperature (°C)	30	35	40	45	50
Recovery (%)	56.94^{d}	58.47^{b}	**60.52^{a}**	58.55^{b}	57.24^{c}
Viscosity (cp)	5.37^{a}	4.23^{c}	**3.51^{d}**	4.18^{c}	5.01^{b}

Table 11: Effect of time to cellulase extraction on yam bean fluid

Time (min)	15	30	45	60	75
Recovery (%)	56.90^{c}	58.51^{b}	**61.19^{a}**	61.22^{a}	61.24^{a}
Viscosity (cp)	5.32^{a}	4.51^{b}	**3.63^{c}**	3.62^{c}	3.60^{c}

$^{a-d}$The values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Table 12: Effect of enzyme percentage on the extraction of yam bean fluid

	Cellulase percentage (%)				
Criteria	0.05	0.10	0.15	**0.20**	0.25
Recovery (%)	56.68^{d}	58.14^{c}	59.11^{b}	**61.29^{a}**	61.32^{a}
Viscosity (cp)	5.03^{a}	4.80^{b}	4.15^{c}	**3.47^{d}**	3.46^{d}

Table 13: Effect of pectinase:hemicellulase ratio on the extraction of yam bean fluid

	Pectinase:hemicellulase ratio (%)		
Criteria	0.2:0.2	0.3:0.1	0.1:0.3
Recovery (%)	70.45^{a}	65.49^{c}	67.23^{b}

Table 14: Effect of time extraction on the extraction of yam bean fluid treated by pectinase 0.2%: hemicellulase 0.2%

	Time of extraction (min)				
Criteria	15	30	**45**	60	75
Recovery (%)	65.39^{c}	68.52^{b}	**70.45^{a}**	70.49^{a}	70.52^{a}

Table 15: Effect of pectinase:cellulase ratio on the extraction of yam bean fluid

	Pectinase:cellulase ratio (%)		
Criteria	0.2:0.2	0.3:0.1	0.1:0.3
Recovery (%)	70.65^{a}	65.58^{c}	67.94^{b}

Table 16: Effect of time extraction on the extraction of yam bean fluid treated by pectinase 0.2%:cellulase 0.2%

	Time of extraction (min)				
Criteria	15	30	**45**	60	75
Recovery (%)	65.33^{c}	68.58^{b}	**70.65^{a}**	70.69^{a}	70.72^{a}

Table 17: Effect of hemicellulase:cellulase ratio on the extraction of yam bean fluid

	Hemicellulase:cellulase ratio (%)		
Criteria	0.2:0.2	0.3:0.1	0.1:0.3
Recovery (%)	70.55^{a}	65.47^{c}	67.73^{b}

$^{a-d}$The values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Time of extraction: From Table 14, we noticed that 45 min was enough for by pectinase 0.2%:hemicellulase 0.2% on the extraction of yam bean fluid.

Effect of pectinase combined with cellulase in juice extraction

Ratio of pectinase:cellulase: From Table 15, we realized the optimal extraction on yam bean fluid happened on pectinase 0.2%:cellulase 0.2%.

Time of extraction: From Table 16, we noticed that 45 min was enough for by pectinase 0.2%:cellulase 0.2% on the extraction of yam bean fluid.

Effect of hemicellulase combined with cellulase in juice extraction

Ratio of hemicellulase:cellulase: From Table 17, we realized the optimal extraction on yam bean fluid happened on hemicellulase 0.2%:cellulase 0.2%.

Table 18: Effect of time extraction on the extraction of yam bean fluid treated by hemicellulase 0.2%:cellulase 0.2%

	Time of extraction (min)				
Criteria	15	30	**45**	60	75
Recovery (%)	65.21^{c}	68.01^{b}	**70.55^{a}**	70.57^{a}	70.60^{a}

Table 19: Effect of ratio of pectinase:hemicellulase:cellulase on the extraction of yam bean fluid

	Ratio of pectinase:hemicellulase:cellulase (w/w%)			
Criteria	0.2:0.2:0.2	0.2:0.2:0.4	0.2:0.4:0.2	0.4:0.2:0.2
Recovery (%)	74.58^{a}	73.01^{b}	73.69^{c}	72.15^{d}

Table 20: Effect of time extraction on the extraction of yam bean fluid treated by pectinase 0.2%:hemicellulase 0.2%:cellulase 0.2%

	Time of extraction (min)				
Criteria	15	30	**45**	60	75
Recovery (%)	67.48^{c}	70.22^{b}	**74.58^{a}**	74.61^{a}	74.65^{a}

Table 21: Effect of sucrose supplemented to sensory characteristics of yam bean beverage

	Sucrose supplementation (%)				
Criteria	2	4	6	**8**	10
Sensory score (1-5)	3.10^{d}	3.52^{c}	3.95^{b}	**4.55^{a}**	4.01^{b}

$^{a-d}$The values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Time of extraction: From Table 18, we noticed that 45 min was enough for by hemicellulase 0.2%:cellulase 0.2% on the extraction of yam bean fluid.

Effect of pectinase combined with hemicellulase and cellulase in juice extraction

Ratio of pectinase:hemicellulase:cellulase: From Table 19, we realized the optimal extraction on yam bean fluid happened on pectinase 0.2%:hemicellulase 0.2%:cellulase 0.2%.

Time of extraction: From Table 20, we noticed that 45 min was enough for by pectinase 0.2%:hemicellulase 0.2%:cellulase 0.2% on the extraction of yam bean fluid.

Effect of sucrose and citric acid supplementation to yam bean beverage

Effect of sucrose supplemented to yam bean beverage: Yam bean beverage had the best palate while supplementing with 8% sucrose, so, we choosed this value for futher application.

Effect of citric acid supplemented to yam bean beverage: Yam bean beverage had the best palate while supplementing with 8% sucrose, so, we choosed this value for futher application.

Table 22: Effect of citric acid supplemented to sensory characteristics of yam bean beverage

	Citric acid supplementation (%)				
Criteria	0.02	0.04	0.06	**0.08**	0.10
Sensory score (1-5)	3.15^{d}	3.63^{c}	4.02^{b}	**4.67^{a}**	4.12^{b}

[a-d]The values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant ($\alpha = 5\%$)

CONCLUSION

Yam bean underground starchy root is one of the popular edible tuber-vegetables. The tuberous roots of yam bean contained large quantities of respective components. It is one of the very low-calorie root vegetable, finest sources of dietary fiber; particularly excellent source of oligofructose inulin, a soluble dietary fiber. With its refreshing, crispy ice-white appearance; fruit-flavored tuber can be successfully processed into instant nutritional beverage.

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