



The Quality Improvement of Kava Beverage by a Non-thermal Dense Phase Carbon Dioxide Pasteurization

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ABSTRACT

Kava is a traditional Polynesian beverage, popular in Hawaii and many South Pacific locations. Traditional, unpasteurized kava drinks have a shelf life of less than three days with refrigeration at 4°C. A new cold pasteurization technology, dense-phase carbon dioxide (DP-CO₂) has been shown to effectively reduce bacteria counts, up to a 5-log reduction, while retaining a fresh-like taste in several fruit drinks. This study was to examine the effectiveness of DP-CO₂ on the bacteria reduction in a freshly prepared kava extract. A continuous DP-CO₂ system, located at the University of Florida, was used. Kava extract was prepared on site in Florida, with material shipped frozen from Hawaii. The treatment condition was set at a pressure of 34.5 MPa, 13% (v/v) CO₂ injection, and a residence time of 7 minutes. The initial pH of the kava extract was 6.3 and was reduced to 5.5 after processing. The microbial counts for before and after treatment were approximately 4.0 × 10⁶ CFU/mL and 1.0 × 10³ CFU/mL, respectively. The DP-CO₂ system was able to produce an initial 3-log reduction. After 8 weeks refrigerated storage at 4°C, the microbial count was 4.0 × 10³ CFU/mL. The study demonstrated that at the current setting the bacterial reduction is not sufficient to produce a shelf-stable product. The high amount of starch suspension and type of bacteria species present in the kava could have resulted a less than expected bacteria count.

OBJECTIVES

- To develop a non-thermal process to pasteurize kava beverage.
- To investigate the effects of DP-CO₂ process on the reduction of bacteria in kava.

INTRODUCTION

Kava – Piper methysticum

- Perennial shrub native to island of the South Pacific.
- Cultivated for its rootstock where the psychoactive compounds are located.
- Kavalactones are water insoluble, structurally related lipophilic lactone (Figure 4).
- Traditionally consumed as a drink prepared for social or religious ceremonies.
- Kava beverage, traditionally prepared from fresh ground roots and stump mixed with water and strained (Figure 3).
- Fresh, unpasteurized kava beverage spoils in less than 3 days.
- Kava beverage has a high starch content which gels upon heating at or above the required traditional pasteurization temperature.
- Effective thermal pasteurization cannot be achieved without destroying the smooth mouth-feel associated with the kava drink due to the starch particle.
- Tastes bitter, peppery, astringent, earthy with a pH of 6.3-6.5.
- Causes numbing of lips and tongue and relaxation (Lebot and Simeoni, 2004).

Figure 1. Rootstock with stems and lateral roots

Figure 2. Rootstock without lateral roots

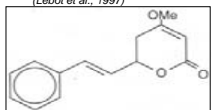


Figure 3. Traditional kava beverage

Table 1. Rootstock composition (Lebot et al., 1997)

Component	Percentage (wt. base)
Starch	43%
Fibrous Tissues	20%
Kavalactones	15%
Water	12%
Sugars/Proteins/Minerals	10%

Figure 4. Chemical structure of a kavalactone (Lebot et al., 1997)



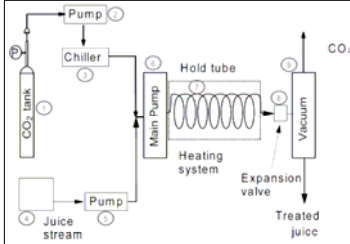
Dense-Phase Carbon Dioxide Technology (DP-CO₂)

- A non-thermal technology that affects microorganisms and enzymes through effects of CO₂ under pressures below 50 MPa.
- Operates at temperatures low enough to avoid thermal effects of pasteurization.
- Mechanism of microbial inactivation is the pH lowering effect due to production of carbonic acid when pressurized CO₂ is dissolved in the aqueous part of the food.
- CO₂ easily permeates microbial cell walls to reduce the internal pH (Damar et al., 2005).
- Demonstrated the required 5-log pathogen reduction which is the core of Hazard Analysis Critical Control Point program for processors of unpasteurized beverages (US-FDA, 2001).
- Previous work on DP-CO₂ processing of orange juice demonstrated a 5-log pathogen reduction while retaining a fresh-like product with color and flavor equal to fresh-squeezed juices (Kincal et al., 2005).

Table 2. Comparing differences between DP-CO₂ and High Pressure Process

	Dense-Phase Carbon Dioxide (DP-CO ₂)	High Pressure Process (HPP)
Pressure	< 50 MPa	300 to 600 MPa
Carbon Dioxide	Applied from 10% to 13% (v/v)	Not Applied
Temperature	Ambient and can be controlled from 25°C to 40°C	Ambient and can be controlled from 35°C to 60°C
Advantages	• Fresh-like quality • Inactivate enzymes	Sensory quality preserved
Disadvantages and Limitation	Can only deal with liquid food and small solid foods	• no effect on enzyme inactivation • high materials and operating costs

Figure 5. A continuous flow DP-CO₂ system (Kincal et al., 2005)



DP-CO₂ system

- First, juice/CO₂ mixture is brought to the desired operating pressure through the main pump.
- Second, mixture goes through a 12 m x 3.8 mm holding tube to maintain pressure and dissolved CO₂ at a particular residence time.
- Third, mixture is depressurized and CO₂ is released when passing through the expansion valve and separated from treated juice by vacuum.

MATERIALS AND METHODS

A. Kava stump

- See Figure 2
- Variety: *Awa Moi*
- 15 kg stumps
- Shipped frozen from Hawaii to Florida
- Kept frozen until used

B. Kava extract composition

- pH adjusted from 6.3 to 3.0 with 1% citric acid
- Centrifuged: 3000 rpm for 20 minutes at 24°C
- Precipitate and supernatant analysis

C. DP-CO₂ processing condition

- CO₂: 13% (v/v)
- Pressure: 34.5 MPa
- Residence Time: 7 minutes
- Temperature: ambient
- Vacuum not applied

D. Microbial analysis

- 3M Petrifilm™ Aerobic count plate
- Plated at Week 0, 6, 7, 8.
- Serial dilutions from 10¹ to 10⁶
- 1 mL of each dilution plated in duplicate
- Incubated for 48 hours at 35°C
- Enumerated

Step by step procedure development

Thaw and wash stumps

Chop and grind

Mix in blender with distilled water

Ratio: 1 Kg of grounded kava : 4.5 L of water

Strain and filter with layered cheese-cloth

Collect initial microbial count (N_i)
18 Liters of kava extract

DP-CO₂ pasteurize

2 processing runs: 9 Liters each

Collect and refrigerate (4°C)

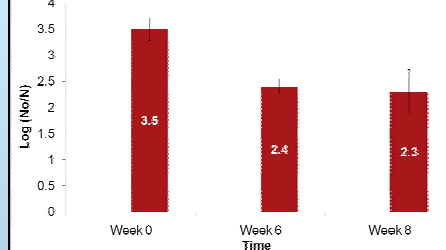
Collect 4 Liters from each run
Post-treatment aerobic bacteria count (N)

Figure 6. DP-CO₂ processed kava beverage



RESULTS

Figure 7. Log reduction in kava beverage after DP-CO₂ treatment



- The log reduction is expressed as log (N_i/N), where N_i and N are initial and post-treatment microbial counts, respectively.
- All values reported are the arithmetic averages of two replicates.
- Initial microbial count: 4.0 × 10⁶ CFU/mL

Table 3. pH level of Kava beverage

Kava beverage	pH Level
Before DP-CO ₂	6.3
After DP-CO ₂	5.5
Week 6	5.3
Week 8	5.2

- Sensory descriptors developed by trained panelists
- Fresh kava = before cheese cloth filtration

Table 4. Sensory descriptors developed for fresh and DP-CO₂ treated kava beverage

Fresh kava	DP-CO ₂
Bitter	
Peppery	
Astringent	
Earthy	Carbonated
Nutty	Sour
Floral	
Mouth-feel: creamy-smooth	Mouth-feel: watery-smooth

Table 5. Stump, precipitate, supernatant composition

	Stump	Precipitate	Supernatant
Moisture	68.20%	65.90%	95.60%
Protein	0.57%	0.51%	0.18%
Lipid	3.21%	1.40%	0.47%
Fibers	10.90%	0.68%	1.70%
Starch	15.80%	30.40%	0.58%
Calcium	140mg/100g	403mg/100g	0.23/100g
Magnesium	35mg/100g	7mg/100g	3.5mg/100g
Potassium	487mg/100g	38mg/100g	55.8mg/100g
Sodium	16mg/100g	13.6mg/100g	2.4mg/100g
Iron	8.8mg/100g	69.5mg/100g	0.02mg/100g

DISCUSSION

- The DP-CO₂ processing system initially reduced the total aerobic count in the kava beverage by 3.5 orders of magnitude.
- Treated beverage's microbial counts reached to 10³ during 4°C storage.
- The 5-log reduction pasteurization standard was not reached to prevent disease outbreaks.
- The pH was lower than 5.5 under processing pressure which facilitated microbial inactivation.
- Lower pH during processing facilitated microbial inactivation.
- Final pH was lowered by CO₂ at atmospheric pressure.
- CO₂ was not vacuumed. Treated kava beverage was carbonated.
- Pressurized CO₂ can penetrate into porous materials to reduce microbes inside food, but there is a difficulty in penetrating starch particles compared to soft orange juice pulp.
- Fresh stump is mostly moisture, fibers and starch. The extract is high in starch.
- Stump and kava beverage have very little protein content and low lipid content.
- Kavalactones are water insoluble and part of the lipid content of the precipitate.
- Addition of citric acid caused an increase of calcium and iron precipitate content in the kava extract due to presence of acid salt.

CONCLUSIONS

- DP-CO₂ is capable of decreasing microbial load in kava beverage by 3 orders of magnitude due to its high pressure and pH lowering effect.
- The implications of injury/repair of microorganisms during storage is not certain.
- Further testing is needed to optimize the processing conditions and to further evaluate sensory qualities.
- Additional filtration steps are required to better facilitate the processing of kava beverage while maintaining the smooth mouth-feel associated with drinking kava.

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