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Application of Extrusion Cooking Technology in the Manufacture of Herbal Porridge and some Observations on Product Composition and Shelf Life

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ABSTRACT. Studies were conducted on the application of extrusion cooking technology in the manufacture of herbal porridge containing green leaves of Asparagus falcatus L. (Hathawariya–S, Kilavari–T)), soyabean [Glycine max (L.) Merr.] and rice (Oryza sativa L.). The materials were cooked at 145°C with a retention time of 6 to 8 sec at the metering zone of the extruder. A cooked product with 5.8 to 6.6% moisture on dry matter basis (db) was obtained. Moisture sorption studies of the product indicates that for the prevention of the proliferation of micro–organisms moisture must be maintained below 5.92% corresponding to a water activity of 0.43 at 30°C. The mono layer values were found to vary from 4.03 to 5.13 indicating safe level of moisture to prevent fatty acid oxidation and hydrolysis. The sorption energy at 6% db moisture was 2086 calories mole^{-1} indicating the hygroscopic nature of the product and necessity of moisture proof materials for packaging. The high temperature, short time (HTST) cooking treatment was effective in the reduction of Nitrogen solubility index (NSI), trypsin inhibitors and microbial counts. The shelf life of the product is about nine months. As a beverage it is low in energy but rich in protein. Green leaves provide β carotene, iron and unknown biologically active ingredients.

INTRODUCTION

Herbal porridge, which is also referred to as *kola kenda*, is a popular traditional food in Sri Lanka, where the green leaf component is the most valued. Traditional method of preparation involves heating a water extract of ground and filtered green leaves with rice and coconut milk. It is consumed as a warm beverage with sugar or juggery. Ingredients such as garlic, pepper

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are added and there are regional differences in Sri Lanka as to the type of ingredients added. In some occasions herbal porridge is given for therapeutic purposes.

Some of the most commonly used plants are *Acalypa indica* L. *(Kuppamania–S, Kuppamani–T), Aerva lanata* L. *(Polpala–S, Siripuli–T), Asparagus falcatus* L. *(Hathawariya–S, Kilavari–T), Cardiospermum halicacabum* L. *(Wel penela–S, Kottawari–T), Cassia auriculata* L. *(Ranawara–S, Avarum–T), Centella asiatica* L. *(Heen gotukola–S, Vallarai–T), Hemidesmus indicus* L. *(Iramusu–S, Arakkam–T), Lasia spinosa* L. *(Kohila–S, Khowila–T), Leucus zeylanica* L. *(Getathumba–S, Mudithumpai–T), Melastoma octandra* L. *(Heenbovitiya–S, Kurevina–T) and Solanum nigram* L. *(Kalukanveriya–S, Manattakali–*T). The therapeutic properties of herbs have been documented (Jayaweera, 1980) but the nature of biologically active ingredients associated with them are relatively unknown.

The preparation of *kola kenda* in Sri Lanka at domestic level is fast disappearing due to difficulties in obtaining desirable leaves. Further, preparation is time and labour consuming. However, its popularity is evident as it is served in many boutiques in villages and towns in Sri Lanka. The objective of this study was to evaluate the applicability of extrusion cooking technology for large scale manufacture of the above commodity. This paper reports the food technological aspects pertaining to the production of *kola kenda*, its composition, moisture sorption properties and shelf life.

MATERIALS AND METHODS

Processing of raw materials

Dehulled soya bean [*Glycine max* (L.) Merr. *var.* Pb 1], raw red rice (Oryza *sativa* L. *var.* BG–350) and leaves of *Asparagus falcatus* L. were used in the experiments. Soya bean and rice were milled to US 40 mesh particles. Green leaves were cut into 3 to 4 mm pieces and partially dehydrated at 55°C. The moisture in the ingredients was adjusted to 18% dry matter basis (db). The ingredients shown in Table 1 were processed at 145°C using an INSTA PRO 500 single screw autogenous extruder with a shaft rotation of 550 rpm and a discharge end die of 8 mm dia. The dwell time in metering zone was 6–8 sec. When the product leaves the extruder at 145°C, moisture splashes out as steam thus, instantly cooling the product to 78–85°C.

The product was cooled to room temperature and milled to a coarse powder thus, 95% pass through US mesh 60 screen. Dehydrated, quick cooking rice was incorporated at 8% db.

Moisture sorption studies

Moisture sorption studies using saturated solutions of salts of known relative humidities were conducted at 0, 30 and 40^{0}C. The relationship between water activity (A_w), and water content (m) db were established (Figure 1). The data were used to determine Bruhaner–Emett–Teller (BET) monolayer values using the following equation (Iglesias and Chirife, 1983).

$$1/(1-A_w)\,m = 1/m_0 C + (C-1)\,A_w/m_0$$

where m = moisture content (db) at water activity A_w and temperature T; C = constant; and m_0 = monolayer value. The equation was rearranged by mathematical transformation to the following form.

$$A_w/(1-A_w)\,m = I + S\,A_w$$

where $I = 1/m_0$, C = intercept, and $S = C-1/m_0$ = slope. Thus, a graph of $A_w/(1-A_w)$ *vs* A_w gives a straight line. Monolayer value $m_0 = 1 / I+S$ (Figure 2). The BET monolayer values at 0, 30 and 40^{0}C were determined. Heat of sorption expressed in calories per mole of water sorbed was determined using Clausius Claperone equation as given below;

$$\ln(A_{w2}/A_{w1}) = -Q_s/R\,(1/T_2 - 1/T_1)$$

where A_{w1} and A_{w2} are water activities at temperature T_1 and T_2, respectively; Q_s is heat of sorption in calories mole^{-1}, and R is the gas constant. To predict quality losses and to calculate water activity at a given temperature a graph was drawn to show the relation between in A_w and 1/T (Figure 3).

Shelf life

Vacuum sealed samples packeted in triple laminated aluminium bags were held at 0, 30 45^{0}C for a period of 48 weeks. Samples were with drawn at four week intervals and their peroxide values (PV) and content of free fatty acids (FFA) were determined.

Sensory properties

The product was reconstituted with water (10 g with 80 ml of water) and boiled. A second sample was reconstituted with the first extract of coconut milk under identical conditions. A third sample was made with water extract of green leaves, coconut milk and rice similar to a product processed at home. Product flavour, aroma, colour, intensity of each factor, mouthfeel and overall impression was recorded (Larmond, 1977). Product stored for shelf life studies were reconstituted with water and their sensory properties were recorded.

Composition and total plate counts

Raw ingredients and cooked products were analyzed for moisture, protein, fat, fibre, carbohydrates, β–carotene, calcium, iron, trypsin inhibitor content, nitrogen solubility indices (NSI) and total plate counts.

Methods described in Association of Official Analytical Chemists, (AOAC, 1980) were used except for the determination of free fatty acids which was analysed according to the method described by Pearson (1991).

RESULTS AND DISCUSSION

Product composition and thermal treatment

The composition of raw materials used for processing are shown in Table 1. The results indicate the amount of trypsin inhibitors found in ingredients, β–carotene, Nitrogen solubility index (NSI) and the total plate count.

As shown in the Table 1 moisture in the green leaves is too high for an autogenous extruder to achieve the desirable cooking temperature and therefore, green leaves need to be partially dehydrated to a level of 18 to 22% moisture in the feed materials. The composition of the extrusion cooked materials are shown in Table 2. Further, trypsin inhibitors remaining in the product, the NSI value and total plate counts are also shown in Table 2. Reduction of NSI was primarily due to thermal denaturation of proteins in ingredients and is an indicator of degree of cooking.

Table 1. **Raw material composition, trypsin inhibitor content, nitrogen solubility index and the total plate count prior to extrusion.**

Commodity	Composition of wet material %	Moisture in raw ingredients %	Dry Matter %
Rice	40	11.2	62.40
Soya bean	15	9.6	24.04
Green leaves	45	83.0	13.56

Trypsin inhibitor content	= 11.52 mg g^{-1} (21.89 TIU g^{-1})
Nitrogen solubility index	= 72
Total plate count	= 48,000 counts g^{-1}
β-carotene	= 53,00 mcg/100g

Table 2. **Composition of herbal porridge and indications of thermal processing.**

Composition	%	Quantities	
Moisture	5.8	Calcium	214 mg 100 g^{-1}
Protein	17.3	Iron	54 mg 100 g^{-1}
Fat	6.8	β–carotene	4800 mcg 100 g^{-1}
Fibre	3.4	Trypsin Inhibitor	0.35 mg g^{-1} (0.665 TIU g^{-1})
Ash	3.2	Nitrogen solubility index	16%
Carbohydrates	63.5	Total plate counts	13 g^{-1}

Starch undergo modifications in extrusion cooking. In extrusion cooked starch based products, paste viscosity and water absorption indices tend to increase from 90 to 155°C. Above 150°C starch tend to dextrinise, thus decreasing paste viscosity (data not shown). There is complete starch gelatinisation while extrusion at a temperature of 145°C.

Other thermal process indicators were reduction of total plate counts to a level of 15 g^{-1}, trypsin inhibitors to safe levels and β–carotein by 10.5%. When herbal porridge is drum or spray dried, the reduction of β–carotein was found to be in the region of 4–6% (data not shown).

A comparison of the availability of major nutrients from a serving of 25 g of the commodity with the recommended daily allowances for Sri Lankans (Food Balance Sheet, 1994) indicates that the commodity may provide 8.5 to 18% protein, 4 to 12% calories, 19 to 56% vitamin A as retinol and 28 to 88% iron. These results depend on age, sex and situations such as pregnancy and lactation. Therefore, herbal porridge is a good source of protein, vitamin A and iron.

Sensory properties

The extrusion cooked product reconstituted with coconut milk was superior in flavour and aroma than the product reconstituted with water. On the other hand there was no perceptible difference in flavour and aroma between home processed product and reconstituted commodity with coconut milk. As for mouthfeel, home processed commodity was less viscous than the extrusion cooked products. Colour intensity was more in home processed commodity. Similar observation were recorded when analyzed by multiple comparison tests involving 12 panelists for named characteristics such as flavour, aroma, and mouthfeel (data not shown). Simulation of all the characteristics of home processed commodity in extrusion cooked product is difficult. However, the overall impression was found to be satisfactory.

Moisture sorption properties and significance

Moisture sorption behaviour of the processed product at 0, 30 and 40°C is illustrated in Figure 1. The results clearly indicate that the A_w values shift from lower to higher levels with increasing temperature. However, at high A_w values in the ranges above 0.75 the slightest growth of micro–organisms, particularly molds, may liberate moisture as a respiratory

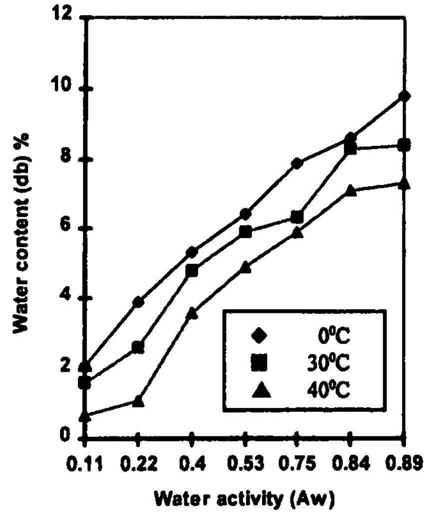

Figure 1. Moisture sorption characteristics of herbal porridge.

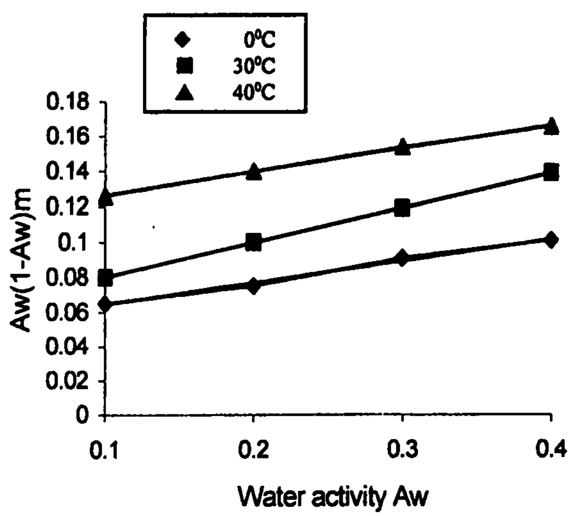

Figure 2. BET Monolayer plot for herbal porridge.

by product resulting in further increase in A_w which is detrimental to the commodity. Beuchart (1981) observed that maintaining A_w values below 0.65 may provide microbial safety to a commodity with a chemical composition similar to a product that is shown in Table 2. Further, the same author observed that microbial proliferation as far as organisms significant to public health may not take place when A_w is maintained below 0.78. Therefore, the moisture in the product of the isotherm of 40°C corresponding to an A_w value of 0.65 was taken as the safe level to prevent microbial growth, which was 5.3% on wet basis (wb).

Bruhaner, Emmet, Teller (BET) monolayer stability values

The monolayer values represent the water bound to chemical constituents in a product. This water is not available for chemical reactions as a solvent or a reactant. An increase in temperature causes absorption of kinetic energy sufficient for the molecules to escape resulting in reduction in monolayer value and availability of free water. The monolayer values for the processed commodity were 5.13, 4.51 and 4.03 g of water per 100 g at 0, 30 and 40°C, respectively. Studies on the rates of chemical reactions in foods have shown that for most dry foods there is a critical moisture content below which the rates of the quality losses are negligible. This moisture content correspond to the monolayer value (mo) as determined from BET isotherm equation and is generally around an A_w of 0.2 to 0.4 (Labuza, 1981). In the herbal porridge the variation of moisture is from 2.6 to 4.8% in the sample held at 30°C. Since the herbal porridge has 6.8% fat, presence of free water may be detrimental as water may act as a reactant for hydrolysis of fats. On the other hand, water at monolayer value may act as a protective shield against fatty acid oxidation in the presence of oxygen. Therefore, the rate of oxidation increases if product moisture is below the monolayer value. Parameters that govern the shelf life of a product of the nature of herbal porridge are free fatty acid formation, fat oxidation, caking, non–enzymatic browning reactions and discolouration of chlorophyll.

Heat of sorption

The heat of sorption at 2, 4, 6 and 8% moisture levels were found to be 4672, 3074, 2086 and 1164 calories $mole^{-1}$ of water sorbed. The results clearly indicate that when the per cent moisture in the processed commodity is low, the corresponding sorption energies are remarkably high. The monolayer values exist between 4 to 5% moisture. When this level is exceeded water is not bound and therefore easy to expel and sorption energies become low. When the product has a sorption energy of 2086 calories $mole^{-1}$ at 30°C the product is expected to be hygroscopic and therefore, needs moisture proof packaging.

Use of Clausius Clayperon Equation

The variation of water activity with temperature at known moisture levels is illustrated in Figure 3. In industrial applications, the relation of A_w and 1/T is useful to predict shelf life of a product. The results indicate that an A_w value of 0.52 at 30°C may shift to 0.82 if the product is exposed to 45°C.

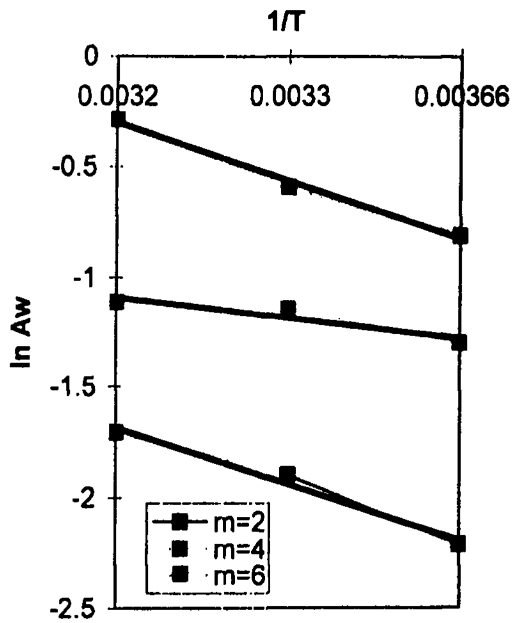

Figure 3. Variation of ln Aw with 1/T.

Shelf life

Formations of peroxides and free fatty acids are shown in Figures 4 and 5, respectively. For most cereal foods maximum limits of peroxides are

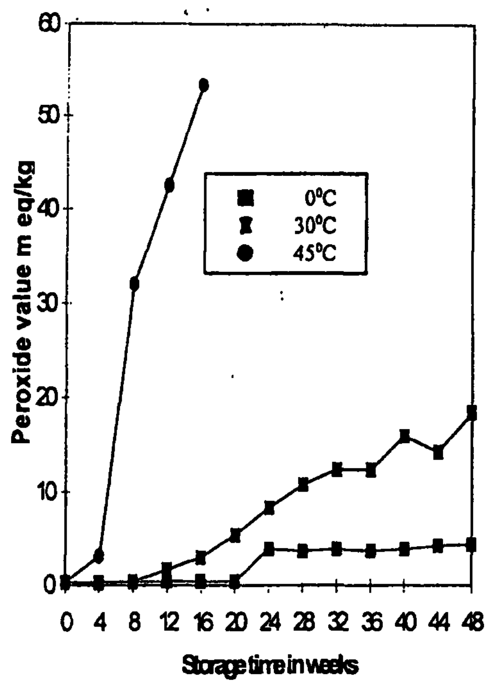

Figure 4. Peroxidase formation at 0, 30 and 45°C.

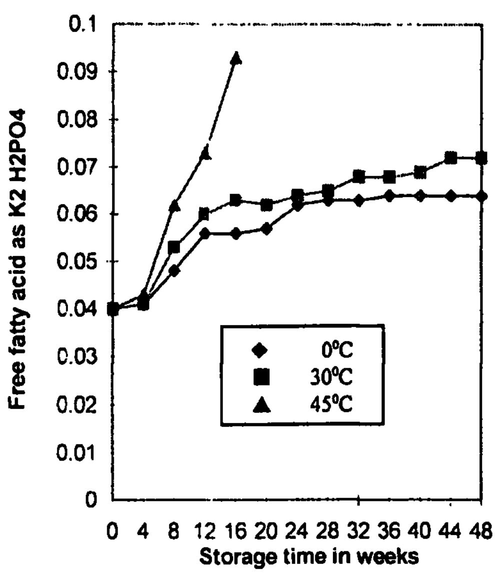

Figure 5. Free fatty acid formation at 0, 30 and 45°C.

in the region of 20 meq. For the product stored at room temperature for 44 weeks, the corresponding value tend to increase however, remain below 20 meq. The commodity stored at 45^{0}C showed off odour and taste in two weeks and the peroxide values varied from 26 to 32 meq. Free fatty acids associated with the commodity tend to increase with time and increasing temperature, but within the acceptable limits except for the sample stored at 45^{0}C. Therefore, for the commodity without anti-oxidants and other preservatives, a storage time of nine months can be recommended.

CONCLUSIONS

The results indicated the possibility of adopting extrusion cooking technology for large scale production of herbal porridge. The product is stable at room temperature for periods exceeding nine to ten months. There are possibilities to use other medicinal plants to make culturally acceptable foods similar to herbal porridge by application of extrusion cooking technology.

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