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Nutritional characteristics and phytochemical screening of traditional panai (*Borassus flabellifer*) olai kozhukattai

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ABSTRACT

Objectives: Panai Olai Kozhukattai (POK) or simply palm leaf dumpling is a traditional south Indian delicacy which is very much popular in Tamil Nadu, India. POK preparation by traditional methods involves mixing all the ingredients to form a thick paste, which is then wrapped in tender palm leaf strips and cooked using steam under pressure. The present paper is the first-ever attempt on studying the nutritional characteristics of POK.

Material and Methods: The nutritional analysis of POK involves proximate analysis, and vitamin and mineral composition.

Results: The proximate analysis results demonstrated that POK is nutritionally predominant over the other South Indian breakfast foods. High levels of fat-soluble vitamins were present in POK. Water-soluble vitamins including niacin, pyridoxine, thiamine, and riboflavin were found in POK and with a high percentage of riboflavin. Among the mineral elements analyzed, the concentration of potassium in POK sample was the highest followed by magnesium, phosphorous, manganese, zinc, iron, and selenium. The study also documented a protocol of POK preparation. It is believed that the steaming in the palm leaves gives the palm leaf flavor to POK and it also transfers phytonutrients into the product from the palm leaves. Hence, the paper also focuses on investigating the presence of essential bioactive compounds in POK using qualitative phytochemical tests. The phytochemical screening of methanol extracts of POK revealed the presence of certain phytochemicals such as flavonoids, alkaloids, glycosides, and saponins and total flavonoid content of POK was estimated to be 148.25 mg/100 g.

Conclusion: Overall, the study leads to the documentation of a preparation protocol along with the nutritional and phytochemical aspects of traditional POK with a view to promoting its consumption in other parts of the world.

Keywords: Palm jaggery, Palm leaves, Panai Olai Kozhukattai (POK), Phytochemicals, *Borassus flabellifer*

INTRODUCTION

Foods made from cereals and millets have been a part of essential diet for centuries among various cultures. Among them, Panai Olai Kozhukattai (POK) or simply palm leaf dumpling is a traditional South Indian delicacy that is typically consumed in several regions of Tamil Nadu especially during the Thirukarthigai day (Karthigai Dheepam festival) in the districts of Tirunelveli, Tuticorin, and Kanyakumari. A century-long practice is followed till date by rural and sub-urban population for the preparation of POK, that is, steaming the prepared ingredients under pressure. The practice of steam cooking is said to have originated in East Asia and was introduced to India during the trade and merchandizing. Ingredients for POK include white rice flour (*Oryza sativa*), palm leaves (non-edible part), and palm jaggery or palm sugar from palmyra palm tree (*Borassus flabellifer*), green gram flour (*Phaseolus aureus*), and cardamom powder. Ideally, POK is made by mixing all the ingredients to form a thick paste, which is then wrapped in tender palm leaf strips and cooked in steam. The practice of making kozhukattai differs in different parts of India with respect to

its composition and time-temperature range of steaming and cooking. The steaming of POK at 110–140°C for 10–15 min also sterilizes it.

Palm leaves and palm jaggery from the palmyra palm tree (*Borassus flabellifer*) are the two special key ingredients of POK, which give POK its unique taste with plenty of medicinal property. Palm jaggery is one of the most extensively used sugar sources in Asian countries. It exhibits a very low glycemic index than refined cane sugar.[1] Since palm jaggery is derived from plants, it is naturally rich in polyphenols and other phytochemicals. The nutrition composition of palm jaggery (per 100 g) as reported by Rao, Panemangalore, and Rajagopalan[2] is: 8.3 g moisture; 1.04 g protein; 0.19 g fat; 87.32 g carbohydrates; 0.861 g calcium; 0.051 g phosphorus; 82.6 g total sugars; 1.7 g reducing sugars, and nearly 364.4 kcal calories. Palm leaves are commonly used for thatching and making mats, baskets, fans, hats, umbrellas and also used as writing material. Besides these general uses, palm leaves are proven to have antimicrobial and antioxidants and have the potential to treat infectious diseases as these leaves have phytochemicals such as flavonoids, glycosides and tannins in them.[3] Kaliyaperumal et al., demonstrated that the alcohol made from palm leaf extract is beneficial for anticonvulsant activity.[4] It is believed that steaming the POK paste in palm leaves gives it the palm leaf flavor and transfers phytonutrients into the product. Therefore, one of the aims of this study was to investigate the presence of major chemical constituents in POK using qualitative phytochemical tests. Rice is a dietary staple food and considered to be one of the most important cereal crops, especially for people in Asia, but its consumption in other parts of the world has also increased recently.[5] On the other hand, the green gram is a legume and one of the protein-rich food sources that have 25% protein, almost three times more than that of the cereals. The biological value improves greatly when the wheat or rice is combined with the green gram because of the complementary relationship of the essential amino acids.[6] Apart from proteins, the green gram is also rich in vitamins such as B1, B2, and minerals such as iron. The composition of green gram flour (per 100 g) as reported by Ref.[7] is as follows: protein 24 g; fat 1.3 g; minerals 3.5 g; fiber 4.1 g; carbohydrates 56.7 g; energy 334 kcal; calcium 124 mg; phosphorus 326 mg; and iron 4.4 mg. Hence, it is no wonder that kozhukattai has supplemented nutrients in its natural and habitual state of diet.

Few studies have already been established so far based on the standardization and organoleptic evaluation of kozhukattai, when incorporated with *Tribulus terrestris* fruit powder[8] and Sridevi and Kowsalya[9] evaluated the overall acceptability of black rice in sweet and karakozhukattai. Later, Vijayarani et al.,[10] reported the phenolic content and flavonoid content of millet-based kozhukattai. All these studies addressed information pertaining to organoleptic properties of only rice-based kozhukattai. But so far, not a single study has been published reporting the authentic, nutrition content of POK as practiced at household level. Hence, the current paper primarily reports proximate nutrient composition and micronutrient composition of the POK for the first time.

MATERIAL AND METHODS

Ingredients

Fresh palm leaves were collected, washed, kept in the deep freezer and were used after thawing when needed. White rice flour, palm jaggery, green gram flour, and cardamom powder were purchased from local vendors and stored in an airtight container. The appropriate composition used for the recipe preparation is listed here: Palm leaves (10–15 strips), white rice flour (200 g), palm jaggery (150 g), green gram (100 g) and cardamom powder (3–5 g).

Preparation

The preparation method of POK is depicted in Figure 1. The palm jaggery was crushed using mortar and pestle and was transferred into a pan. A little water was added and then the jaggery was allowed to cook for a few minutes, till jiggery it melted. The prepared palm jaggery syrup was strained out to remove the impurities and was kept aside. Then, the green gram was roasted in a fresh pan at low flame until it turned slightly brown. The roasted green gram was ground to a coarse mixture to which white rice flour and cardamom powder was added. The prepared palm jaggery syrup was gradually added into the mixture to get a thick paste which should neither be dry nor too sticky. If the paste looked dry, water could be sprinkled over the paste and mixed to get the appropriate texture. Then, the tender palm leaves were washed in running water for 2–3 minutes to clean the adhering dirt. The center portion of the palm leaves were cut for about 4–5 inches long. After which, each palm leaf strip was opened and stuffed with the thick paste. The stuffed

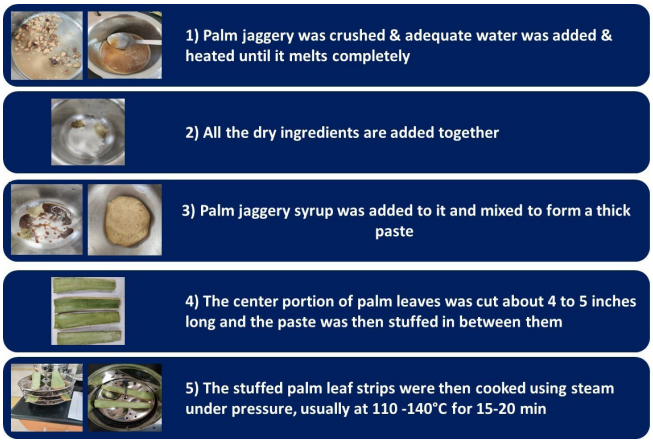

Figure 1: Preparation method of POK.

palm leaves were kept in a steamer pot or idli cooker. Finally, the stuffed palm leaf strips were cooked using steam under pressure, at 110–140**°C** for 15–20 min. After cooking, the product (i.e., kozhukattai) was carefully opened and stripped off from the palm leaves.

Determination of nutritional constituents

POK samples were analyzed for their nutritional composition. The percentage moisture content of the sample was estimated by hot air oven method and the protein content (g%) by the Kjeldahl method. The total fat content was determined using solvent extraction method. Soxhlet extractor was utilized to determine total fat content using petroleum-ether solvent by the AOAC 954.02 protocol.[11] The Crude fiber of the samples was determined gravimetrically after isolation of dietary fiber by chemical digestion and solubilization of other constituents present in the sample. The ash content was determined by complete ignition of POK. The carbohydrate content in POK was calculated from the rest of the major nutritional composition. All estimations were done in triplicates. The results obtained were evaluated using basic statistical characteristics mean, standard deviation. IBM SPSS Statistics 20.0 was used for the statistical analysis.

Mineral and vitamin analysis

The mineral and vitamin contents were analyzed by the spectroscopic method and HPLC method, respectively in their mean wavelength range. The fat-soluble vitamins were analyzed by HPLC methods using column of 4.6 × 75 mm, with its mobile phase A = water, B = methanol, UV detector with variable wavelength detector in 210 nm, standard cell, and column compartment temperature at 20°C.[12] The water-soluble vitamins were analyzed using a C18 column. The mobile phase solvent (20%) used here was vitamins – 0.05 M KH_2PO_4 in water maintained at pH level of 2.5 and the other solvent (80%) is acetonitrile.[13]

Phytochemical screening and total flavonoid content

The phytochemical screening was qualitatively analyzed by chemical and HPLC methods. POK samples were qualitatively examined for its phytochemical content as directed by Ref.[14] Tests for alkaloids, glycosides, saponins, phenols, terpenoids, and glycosides were performed. All the tests were carried with the prepared extract out of POK samples. POK sample extract was dissolved in dilute HCl, and the filtered extract was mixed with few drops of Mayer's reagent (a solution prepared by mixing potassium mercury iodide with water). Precipitation of creamy white mass indicated the presence of alkaloids. Borntrager's test was done for the presence of glycosides in POK samples. A few milligram of the prepared POK extract was hydrolyzed with concentrated HCl on a water bath for 2 hours and was filtrated. To the 2 mL of a filtrate, 3 mL of chloroform were added and shaken. The chloroform layer was separated and 10% ammonia solution was added to it. The pink color indicated the presence of glycosides. For the saponin test, 20 mg of extract was diluted with distilled water and made up to 10 mL. The suspension was shaken in a graduated cylinder for 15 min. A prominent layer of foams indicated the presence of saponins. Test for phenols was done by dissolving and filtering the extract. To the filtrate, a few drops of 5% ferric chloride solution were added. The dark green color indicated the presence of phenolic compounds in the POK samples.

The total flavonoid content of POK was estimated by colorimetric methods as discussed in Ref.[15]

RESULTS AND DISCUSSION

Nutritional composition

The nutrient composition of POK was compared with six common South Indian breakfast foods including dosa, idli, upma, puttu, idiyappam, appam, and kheer[16-19] and the comparison are tabulated in Table 1. Among these foods, POK was observed to have an average carbohydrate content of 61.10% and the carbohydrate content increased in the above dishes in the following order: upma < appam < puttu = idiyappam < POK < dosa < idli. Although POK was made with palm sugar, its carbohydrate content was less than the rice-based fermented food products such as idli and dosa and was comparable with other food products such as appam, puttu, and idiyappam. The highest protein content was found to be present in POK (11.96%) followed by upma (11.82%). The high protein content is due to the addition of green gram flour in addition to rice flour and semolina and black gram in POK and upma, respectively. The results have demonstrated the following increasing order of protein content: appam < idiyappam = puttu < dosa < idli < kheer < upma < POK. The fat content results have proved that POK had low fat content and fat content increased in the following order: POK < puttu < idiyappam < appam < idli < dosa < upma < kheer. As there is no requirement for the addition of any fat externally during POK preparation, the fat content in this product remains low compared to other products whereas the other South Indian breakfast foods compared in this study require the addition of little quantity of oil in their processing.

POK has a relatively higher fiber content of 1.42% and the decreasing trend of fiber content is follows: dosa > POK > upma > idli > puttu = idiyappam = appam. This difference in fiber content was due to the different ingredients used other than rice and processing condition used for different food products compared. The ash content of POK was observed to be 1.05% and an increasing order of ash content is as follows: POK < kheer < idli < upma < dosa. The increase in mineral

Table 1: Nutritional composition of different varieties of South Indian breakfast foods.

South Indian Breakfast Foods	Moisture (%)	CHO (%)	Protein (%)	Fat (%)	Crude Fiber (%)	Ash (%)	Ref.
POK	24.12 ± 0.08	62.10	11.96 ± 0.27	0.34 ± 0.11	1.42 ± 0.41	1.05 ± 0.06	–
Dosa	27.52	73.4	6.6	1.96	1.43	2.09	[16]
Idli	62.2	75.6	7.2	0.84	1.09	1.59	[16]
Upma	40.21	38.44	11.82	6.3	1.18	2.05	[17]
Puttu	–	60.2	5.3	0.7	0.2	–	[19]
Idiyappam	–	60.2	5.3	0.7	0.2	–	[19]
Appam	–	58.9	5.2	0.7	0.2	–	[19]
Kheer	–	–	7.22	7.69	–	1.288	[18]

content was due to the palm sugar added in POK.[20] Among these South Indian breakfast foods, POK was recognized to have the lowest moisture content of 24.12% and are considered to fall under the group of Intermediate Moisture Foods (IMF).

Vitamin and mineral content

Vitamins play a vital role in many intermediary metabolisms and also in the metabolism of specific organs. Their inadequate intake can result in a variety of deficiency syndromes. They cannot be synthesized and must be provided in the diets which are known to be converted into more complex molecules that function as co-enzymes.[21] The overall vitamin composition of POK is tabulated in Table 2. The fat-soluble vitamins detected were vitamin A (retinol acetate), vitamin D_3 (cholecalciferol), vitamin E (α- tocopherol), and vitamin K (phytonadione). Among these, vitamin-D3 was found in higher concentrations (0.165 mg) followed by vitamin K (0.012 mg), vitamin A (0.002 mg), and vitamin E (0.001 mg) in POK.

The presence of B complex vitamins, which includes niacin, pyridoxine, thiamine and riboflavin, in POK was estimated and it was found that among these, the concentration of riboflavin was 0.224 mg whereas thiamine and niacin were 0.012 mg and 0.001 mg, respectively and pyridoxine was found below the detectable level.

Numerous minerals are required for normal metabolism and are of greater importance for human consumption. The mineral contents in POK samples were analyzed by the spectroscopic method in the respective wavelength. Determination of minerals from POK sample is expressed in Table 2. Among the mineral elements analyzed, it is observed that potassium (1373 mg/kg) is present in higher concentration followed by magnesium (237.8 mg/kg), phosphorous (29.34 mg/kg), manganese (4.079 mg/kg), zinc (3.909 mg/kg), iron (2.386 mg/kg), and selenium was found below the detectable level. Potassium levels are higher in POK sample as palm sugar is a rich source of potassium with a concentration of about 1056 mg/100 g of palm sugar.[22]

Phytochemical screening

Phytochemicals are regarded as essential bioactive compounds for health benefits and are derived from natural sources like plants. Therefore, qualitative screening of phytochemicals was performed in POK samples. The phytochemical screening of methanol extracts of POK revealed the presence of certain phytochemicals such as flavonoids, alkaloids, glycosides, and saponins [Table 3]. Alkaloids are the active therapeutically significant plant substances which are excellent spasmolytic and anesthetic agents.[23] A dense creamy white precipitate was formed when Mayer's reagent was added to the POK

Table 2: Concentration of vitamins and minerals in POK.

Sl. No.	Name of the vitamin	Concentration (mg/g)	Name of mineral	Concentration (mg/kg)
1.	Vitamin A (Retinol Acetate)	0.002	Mg	237.8
2.	Cholecalciferol (D3)	0.165	K	1373
3.	Alpha-Tocopherol (E)	0.001	P	29.43
4.	Vitamin K	0.012	Mn	4.079
5.	Niacin	0.001	Fe	2.386
6.	Pyridoxine	Below detection limit	Zn	3.909
7.	Thiamine	0.012	---	---
8.	Riboflavin	0.224	---	---

Table 3: Phytochemical screening of POK sample.

Sl. No.	Parameters	POK sample (methanol extraction)
1.	Saponins	+
2.	Tannins	−
3.	Phenols	−
4.	Terpenoids	−
5.	Alkaloids	+
6.	Glycosides	+

extract. The precipitate confirmed the presence of alkaloid. Saponins are the anti-nutritional factors that help in reducing the uptake of cholesterol and glucose and reduce the chances of developing intestinal cancer.[24] When the extract was shaken with distilled water, the appearance of foams indicated the presence of saponin content in POK samples. Flavones, flavanols, and their glycosides are found to inhibit the tumor promotion and play a protective role in carcinogenesis.[25] When Borntrager's reagent was added to the prepared filtrate, the formation of pink color confirmed the presence of glycosides. Flavonoids are antioxidants, anti-inflammatory, antitumor, antimutagenic, cardioprotective, antihepatotoxic, antimicrobial, antiviral, enzyme inhibitors, anticancer, and also possess action on the central nervous system and thus are beneficial to the human body in the maintenance of health and prevention of diseases. The total flavonoid content of POK was estimated by Chang, Yang[15] method and was observed to be 148.25 mg/100 g. This can be evidenced by considerably high amounts of flavonoids present in palm jiggery.[1] Thus, POK can exhibit better antioxidant properties, as evidenced by the high flavonoid content and presence of other natural phytonutrients.

CONCLUSION

In this article, primarily we have seen the nutritional characteristics and phytochemical aspects of POK which is an ethnic food of Tamil Nadu, India. The proximate analysis results have proven that POK is a highly nutritive food than other South Indian rice-based foods. The study also documented a process of POK preparation. Considerable levels of fat-soluble and water-soluble vitamins were detected in POK. Among the mineral analyzed, the concentration of potassium, magnesium, phosphorous, manganese, zinc, iron were found in detectable level while selenium was found below the detectable level. The phytochemical screening of methanol extracts of POK revealed the presence of certain phytochemicals such as flavonoids, alkaloids, glycosides, and saponins. While the tedious traditional methods of POK preparation somewhat meet the requirements for good sensory properties, it is unable to produce consistently high-quality POK in short time. Therefore, research work should be done on processing methods with optimized cooking temperature and time for obtaining the final vacuum dried semi-cooked POK to the most increment of the sensory attributes. Thus, by developing an instant POK, not only the nutritive richness of such ethnic foods is preserved, but also their preparation and consumption would make simple and easy for people who prefer fresh and healthy product just by steaming for a short time.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no Conflicts of Interest.

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