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Development and Evaluation of *Phyllanthus amarus* based Fruit Spread : Nutritional, Sensory and Shelf-Life Assessment

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Abstract

Phyllanthus amarus, a medicinal plant known for its anti-inflammatory, antimicrobial, antioxidant and hepato protective properties, has been traditionally used in *Ayurvedic* medicine. This study aimed to develop and evaluate a nutrient-rich, immune-boosting fruit spread incorporating *Phyllanthus amarus* plant parts (whole plant, cluster of fruits and leaves, stem and root) at varying concentrations (5, 10 and 15%). Sensory evaluation using a 9-point hedonic revealed that lower concentrations (5 and 10%) were more acceptable, whereas higher concentrations (15%) scored least with respect totaste and texture. Among the formulations, the root-based spread (10%) exhibited superior sensory characteristics, enhanced protein, fiber and β-carotene content and better shelf stability. Microbial analysis confirmed safety up to 45 days, with minimal bacterial and fungal growth due to the natural antimicrobial properties of *Phyllanthus amarus*. Changes in moisture content, peroxide value and free fatty acids were monitored to assess product stability. Cost analysis and consumer acceptability trial sindicated strong market potential, particularly for lower concentrations. This study highlights the feasibility of *Phyllanthus amarus* in functional food products, providing a scientific basis for its nutritional and therapeutic benefits.

Keywords : *Phyllanthus amarus*, Functional food, Fruit spread formulation, Sensory evaluation, Nutrient composition, Shelf-life assessment

Phyllanthus amarus is a distinguished botanical plant which is being used worldwide since many years because of its rich medicinal importance. It is an erect annual herb having large number of phytochemicals that are attributed to its leaves, stems and roots. The young shoots of plant are administered in the form of an infusion for the treatment of chronic dysentery. Fresh leaf paste has wound healing capacity and used to cure white spots on skin and jaundice. The stem juice is also used as wound healers. The whole plant extract is used in urinary tract problems and swelling of liver. The root extract is used to cure stomach pain. The flower paste of *Phyllanthus amarus* is applied externally as antidote against snake gite (Devi *et al.*, 2017).

Phyllanthus amarus- Whole plant

Phyllanthus amarus - Cluster of leaves and fruits

Phyllanthus amarus- Stem

Phyllanthus amarus- Roots

Plate 1 : Different parts of *Phyllanthus amarus* plant

A wide array of studies conducted, the anti-inflammatory, anti-diabetic anti-microbial, anti-hyperlipidemic, anti-oxidant, anti-spasmodial, chemoprotective, anti-hypercalciuric, anti-viral and diuretic properties is being associated with *P. amarus*. It is an important plant of Indian *Ayurvedic* system of medicine which is used in the problems of stomach, genitourinary system, liver, kidney and spleen. It is bitter, astringent, stomachic, diuretic, febrifuge and antiseptic. It is useful in gastropathy, diarrhoea, dysentery, intermittent fevers, ophthalmopathy, scabies, ulcers and wounds (Jay *et al.,* 2011). *Phyllanthus amarus* is valued in many countries for its broad spectrum of pharmacological activities on a variety of ailments (Pius *et al.,* 2015). Thus, this study aims at development of immune boosting food products using *Bhumi Amla*. Some of the vernacular names of *Phyllanthus amarus* are Stonebreaker, gale of wind; In *Sanskrit*, *Bahupatra, Tamalaki*; In *Hindi*, *Bhumi amla, Jangliamlai; In Kannada, Bhu nelli, Nelanelli.*

Value addition to the food products helps to enhance their palatability and nutritional value or increase the shelf life of perishables by altering ormodifying their color, form, manufacturing process and other attributes. *Phyllanthus amarus* plant parts can be incorporated into different value-added products, since value addition to food products has assumed vital importance in recent days.

Material and Methods

Procurement of Raw Materials

The present research was carried out in the Department of Food Science and Nutrition, University of Agricultural Sciences, GKVK, Bengaluru, India. The *Phyllanthus amarus* plant used for the study were procured from Department of Horticulture, GKVK, UAS, Bengaluru and other ingredients for product development were purchased from the local markets of Bengaluru.

Formulation of *Phyllanthus amarus* Plant-based Fruit Spread

Phyllanthus amarus plant-based fruit spread was formulated and standardized using dehydrated *Phyllanthus amarus* based powders such as whole plant, cluster of leaves and fruits, stem and roots based powders. The preparation included different levels of incorporation of various suitable ingredients and dehydrated powder of *Phyllanthus amarus* whole plantor its parts and subjected to sensory evaluation. The best accepted products were selected for nutrient analysis and shelf-life study.

Fruit spread was prepared by incorporating *Phyllanthus amarus* plant powder (dried at 45° C in a tray dryer) and itsparts at different levels (5, 10 and 15%) and compared with its control. For the variations, gooseberry was replaced with *Phyllanthus amarus* based plant powders at different levels using four variations such as whole plant, cluster of leaves and fruits, stem and root-based powders.

Organoleptic Evaluation of Best Accepted Products During Shelf-life Study

The best accepted variations of *Phyllanthus amarus* based fruit spread along with its control were analyzed for changes in organoleptic parameters during storage bya panel of trained and semi-trained members (43 judges). A 9-point hedonic scale was used for organol eptice valuation. The products were evaluated for their appearance, flavour, taste, consistency and overall acceptability. The organoleptic evaluation was carried out on initial, 15th, 30th and 45thday for both the products using the standard score card with 9-point hedonic scale.

Microbial Analysis for Shelf-Life Study (Tate, 1995)

The microbial analysis of the developed products was carried out as per the standard method by using the Eosin Methylene Blue Agar (EMBA) for coliforms, Nutrient Agar (NA) for bacteria and Martin's Rose Bengal Agar (MRBA) for fungi. The results were recorded for all best accepted products during storage at 1st, 15th, 30th and 45thday.

Moisture Content of Developed Products During Shelf-Life Study

The changes in the moisture content of the best accepted variations of *Phyllanthus amarus* plant-based fruit spread along with its control were recorded during storage at 1st, 15th and 30thday.

Determination of Peroxide Value (Raguramulu *et al*., 2003) and Free Fatty Acid Value

The peroxide value measured oil's primary oxidation. Between 0.5-1 g of fat was melted, dissolved in an acetic acid-chloroform mixture and treated with potassium iodide. After adding water, it was titrated with sodium thiosulphate and the value was calculated using [((Titre - blank) × N × 1000) / Weight (g)].

The free fatty acid value was determined by dissolving 10 g of oil in an alcohol-ether mix with phenolphthalein, titrating with KOH and calculating using [(Titre×0.00561×100000)/Weight (g)].

Statistical Analysis

All the results were presented as mean Duncan's Multiple Range test (DMRT). F test statistical analyses were performed using OP Stats.

Results and Discussion

Formulation of *Phyllanthus amarus* Plant-Based Fruit Spread

Fruit spreads are semi-solid food products made from fruit pulp. Unlike traditional jams and jellies, fruit spreads typically contain a higher proportion of fruit content and lower amounts of sugar, making them a healthier alternative for consumers. These spreads are commonly used as toppings for bread, pastries and desserts. The formulation of the fruit spread was standardized by using ingredients like Indian gooseberries, jaggery, ghee, cardamom, cumin and pepper. Fruit spread was prepared by incorporating *Phyllanthus amarus* based dehydrated powders such as whole plant, cluster of leaves and fruits, stem and roots powder at different levels (5, 10 and 15%). In the variations of 5, 10 and 15 per cent of the Indian

Whole plant powder | Cluster of leaves and fruits powder | Stem powder | Root powder

Plate 2 : Dehydrated powders of *Phyllanthus amarus* whole plant and its parts

gooseberry was replaced by dehydrated powders at 5, 10 and 15 per cent respectively.

Organoleptic Evaluation of *Phyllanthus amarus* Plant-Based Based Fruit Spread

Organoleptic evaluation of any product is described and measured through sense organs. Organoleptic evaluation describes and quantifies the characteristics of a product as they are experienced by the five senses of sight, hearing, smell, taste and touch. Under standing sensory data enables one to provide recommendations for food product development as to which property should be prioritised while making judgments about product development. In addition to describing food's colour, texture, flavour, aftertaste, scent, tactile response and even auditory response, sensory evaluation also includes 'tasting' the food.

The Table 1 presents a comprehensive evaluation of various plant based fruit spread samples with different concentrations in terms of appearance, flavour, taste, texture and overall acceptability. The control sample CFST0 (Control fruit spread) with Indian gooseberry with no added *Phyllanthus amarus* plant parts, consistently received high scores across all parameters, making it the benchmark for comparison.

For the whole plant-based fruit spreads, the scores varied significantly with concentration. WFST1 (Whole plant - based fruit spread) maintained relatively good scores for appearance and texture (7.19 and 6.8, respectively), but as the concentration increased to 10 per cent and 15 per cent (WFST2 and WFST3), there was a noticeable decline in flavour and taste, resulting in overall acceptability scores of 5.90 and 5.54, respectively. This suggests that higher

Table 1

Sensory evaluation of *Phyllanthus amarus* based fruit spreads and control fruit spread

Products	Organoleptic characteristics				
	Appearance	Flavour	Taste	Texture	Overall acceptability
CFST0	8.09 a	8.09 a	8.19 a	8.23 a	8.15 a
WFST1	7.19 a	6.42 abc	6.19 bc	6.8 a	6.65 abcd
WFST2	7.22 a	5.60 bcd	4.40 de	6.40 a	5.90 bcd
WFST3	6.89 a	4.20 d	4.20 de	6.90 a	5.54 cd
LFST1	7.57 a	6.8 abc	6.76 abc	7.04 a	7.04 abcd
LFST2	7.31 a	5.29 cd	5.61 cd	6.60 a	6.34 abcd
LFST3	6.90 a	4.33 d	2.96 e	6.80 a	5.19 d
SFST1	7.57 a	6.80 abc	6.76 abc	7.04 a	7.04 abcd
SFST2	7.31 a	5.29 cd	5.61 cd	6.60 a	6.34 abcd
SFST3	6.90 a	4.33 d	2.96 e	6.80 a	5.19 d
RFST1	7.61 a	7.47 a	7.57 ab	7.20 a	7.48 ab
RFST2	7.57 a	7.52 a	7.71 ab	7.52 a	7.55 ab
RFST3	7.33 a	7.19 ab	7.23 abc	6.95 a	7.17 abc

Note : Similar superscripts indicate non-significant difference as per DMRT ($p =< 0.05$)

CFST0= Control fruit spread, WFST1= Whole plant - based fruit spread (5%) WFST2= Whole plant -based fruit spread (10%) WFST3= Whole plant-based fruit spread (15%) LFST1= cluster of leaves and fruits-based fruit spread (5%) LFST2= cluster of leaves and fruits-based fruit spread (10%) LFST3= cluster of leaves and fruits - based fruit spread (15%) SFST1= Stem- based fruit spread (5%) SFST2= Stem- based fruit spread (10%) SFST3= Stem- based fruit spread (15%) RFST1= Root - based fruit spread (5%) RFST2= Root-based fruit spread (10%) RFST3= Root-based fruit spread (15%)

concentrations may negatively impact the sensory attributes of whole plant-based spreads.

The cluster of leaves and fruits-based spreads exhibited a similar trend. LFST1 (cluster of leaves and fruits), with a 5 per cent concentration, received satisfactory scores across the board, with an overall acceptability score of 7.04. However, increasing the concentration to 10 per cent and 15 per cent (LFST2 and LFST3) led to decreased flavour and taste scores, affecting overall acceptability. Research on plant-based foods indicates that higher concentrations can lead to diminished sensory attributes, particularly in flavor and taste (Kostyra *et al.,* 2024).

Stem-based fruit spreads (SFST) followed the same pattern as LFST, indicating that higher concentrations tend to degrade sensory attributes. SFST1 had an overall acceptability score of 7.04, while SFST2 and SFST3 showed lower scores, with overall acceptability of 6.34 and 5.19 respectively.

The root-based fruit spreads showed relatively consistent performance across different concentrations. RFST1 (Root - based fruit spread), RFST2 and RFST3 maintained similar scores with minor variations, with overall acceptability scores of 7.48, 7.55 and 7.17, respectively. Among the root-based spreads, RFST2 stood out with its favourable scores across all parameters, indicating its potential for a more consistent sensory experience even at higher concentrations.

Conversely, root-based spreads like RFST1, RFST2 and RFST3 demonstrated more consistent sensory performance across concentrations. This is supported by Mohammadi *et al.,* 2021 indicating that certain plant-based products maintain sensory quality better than others, particularly when formulated with specific ingredients.

Vaibhavi *et al*., 2019 developed mango ginger murabba and MGM4 was best accepted with sensory scores of 8.04, 7.71, 7.88, 7.00, 8.07, 7.97 and 8.02 for appearance, consistency, texture, sweetness, sourness, taste, flavor and overall acceptability respectively which is almost on par with present study.

Nutrient Composition of Best Accepted Plant-based Fruit Spread.

The Table 2 presents a comparison of nutrient content in the best accepted plant-based fruit spreads, including the control (CFST0), *Phyllanthus amarus* stem-based (SFST1) and root-based (RFST2) fruit spreads. The significant increase in protein content in the root-based spread (1.46g) compared to the control (0.61g) was recorded. Fat content remained similar across all samples. Ash and crude fiber content showed significant increase in the alternative spreads, particularly in RFST2. β–carotene content was highest in RFST2 (31.67 µg), demonstrating an increase across alternative spreads. However, Vitamin C content decreased significantly in alternative spreads, with RFST2 having the lowest value (231.52 mg).

Plate 3 : Best accepted *Phyllanthus amarus* based fruit spreads
(a) Fruit Spread- Control, (b) Stem based fruit spread (5%), (c) Root based fruit spread (10%)

TABLE 2

Nutrient composition of best accepted fruit spread

Nutrients	Fruit spread		
	CFST0	SFST1	RFST2
Moisture (%)	19.96 [a]	19.51 [a]	19.22 [a]
Protein (g)	0.61 [b]	1.25 [ab]	1.46 [a]
Fat (g)	10.28 [a]	10.35 [a]	10.31 [a]
Ash (g)	1.47 [a]	1.85 [a]	1.97 [a]
Crudefiber (g)	8.00 [b]	8.32 [ab]	8.86 [a]
Carbohydrates* (g)	93 [c]	96 [b]	99 [a]
Energy* (kcal)	485 [c]	499 [b]	512 [a]
ā–carotene (µg)	28.97 [c]	30.32 [b]	31.67 [a]
VitaminC (mg)	252.00 [a]	239.96 [b]	231.52 [c]
Calcium (mg)	109.00 [b]	110.72 [a]	110.34 [a]
Iron (mg)	11.40 [b]	11.57 [b]	21.21 [a]

Note : Mean of triplicate samples, *-computed value, similar superscripts indicate non-sgnificant differenceas per DMRT ($p<0.05$) CFST0 = Control fruit spread, SFST1= *Phyllanthus amarus* stem- based fruit spread (5%) RFST2=*Phyllanthus amarus* root-based fruit spread (10%)

Calcium and Iron content recorded showed a increase in notable the alternative spreads, with RFST2 having the highest iron content (21.21 mg).

The study by Bhos *et al*., 2019, revealed that a spread developed from sweet tuber, beetroot and guava, had 10.27g fibre, 2.3g of ash, 86.6g of carbohydrates and 16.95 mgiron per 100g of samples which is similar to that of the present study.

Rohini *et al.,* 2022 developed a pumpkin seed based fruit spread and the moisture content ranged from 15.23 per cent to 15.64 per cent which is slightly lower than that of the present study. The slight variation in moisture could be attributed to the water content of the fruit and the other raw materials used.

Organoleptic Evaluation of the *Phyllanthus amarus* based Fruits Pread during Shelf-Life Study

Shelf-lifestudy was carried out for the best accepted variations of *Phyllanthus amarus* based fruit spreads. The products were packed in polypropylene pouches and store dat room temperature for 45 days.

Results with reference to shelf-life study are depicted in Table 3. Control received significantly higher scores for all sensory attributes. The overall acceptability for the control fruit spread CFST0 scored 8.15 on the 1st day and reduced to 7.05 on 15th day and on 30th day, a variable fungal growth was observed, hence was not evaluated for sensory scores. Whereas, the *Phyllanthus amarus* stem-based fruit spread scored 8.10 on the 1st day and reduced to 7.37 on 45th day. Also, for *Phyllanthus amarus* root based fruit spread scored 7.55 on the 1st day

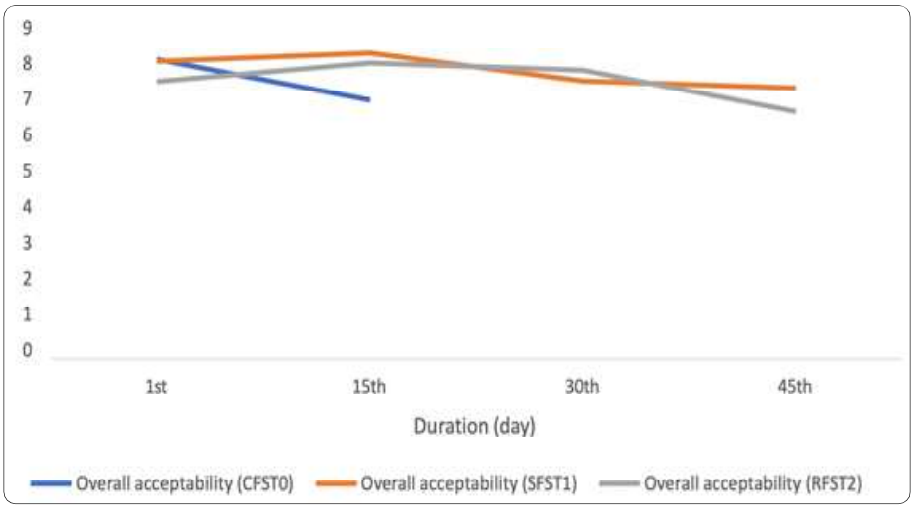

Fig. 1 : Overall acceptability of *Phyllanthus amarus* based fruit spreads and control fruit spread during shelf-life study

and reduced to 6.73 on the 45th day. There was significant difference during storage period for flavour, consistency and overall acceptability for control and appearance, flavour and overall acceptability for stem-based fruit spread (SFST1) and for appearance, flavour and overall acceptability for root-based fruit spread (RFST2) at 5 per cent level. For other parameters, a non-significant difference was recorded between the storage period. Hence, the products can be stored up to 45 days. The reduction in overall acceptability scores for *Phyllanthus amarus* based fruit spreads in comparison to that of control spread during shelf-life study is shown in Fig. 1.

Moisture Content of *Phyllanthus amarus* based Fruit Spread during Shelf-Life Study.

Phyllanthus amarus based fruit spread was prepared and packed in polypropylene pouches and stored at room temperature (27 °C) for 90 days. Moisture content of the spread was analysed regularly at 15 days interval *i.e.*, at 1st, 15th, 30th, 45th, 60th, 75th and 90th day and results for the same are presented in Table 4. The moisture content of control spread increased on 1st day form 14.67 per cent to 15.25 per cent on 30th day of storage. However, the increase in moisture content for samples of *Phyllanthus amarus* plant-based fruit spreads such as SFST1 and RFST2 observed to have initial moisture content of 12.75

TABLE 3

Organoleptic properties of *Phyllanthus amarus* based fruit spreads and control fruit spread during shelf-life study

Products	Duration (days)	Appearance	Flavour	Taste	Consistency	Overall Acceptability
CFST0	1st	8.09	8.09	8.19	8.23	8.15
	15th	6.92	7.13	7.09	6.18	7.05
	F-value	NS	*	NS	*	*
	S.Em ±	0.020	0.142	1.02	0.632	0.57
	CD at 5%	0.013	0.001	0.24	0.041	1.01
SFST1 (5%)	1st	8.14	8.09	8.23	7.95	8.10
	15th	7.81	7.93	8.07	7.18	8.32
	30th	7.72	7.65	7.47	6.05	7.56
	45th	6.91	7.49	7.25	5.66	7.37
	F-value	*	*	NS	NS	*
	S.Em ±	0.44	0.03	0.03	0.0016	0.42
	CD at 5%	0.20	0.06	0.28	0.0003	0.19
RFST2 (10%)	1st	7.57	7.52	7.71	7.52	7.55
	15th	7.92	7.83	8.19	8.08	8.05
	30th	7.63	7.74	7.90	7.95	7.85
	45th	6.94	6.41	6.85	6.74	6.73
	F-value	*	*	NS	NS	*
	S.Em ±	0.28	0.33	0.35	0.36	0.28
	CD at 5%	0.56	0.64	0.71	0.35	0.64

Note : CFST0=Control fruit spread, SFST1= *Phyllanthus amarus* stem- based fruit spread (5%)
RFST2= *Phyllanthus amarus* root-based fruit spread (10%)

TABLE 4

Moisture content of *Phyllanthus amarus* based fruit spread and control fruit spread during shelf-life study

Duration (day)	Moisture (%)		
	Control	SFST1	RFST2
1st	14.67 ^{b1}	12.75 ^{c3}	13.54 ^{c2}
15th	15.25 ^{a1}	13.61 ^{b3}	14.26 ^{b2}
30th	-	14.43 ^{a2}	15.76 ^{a1}

Note : Mean of triplicate samples, similar superscripts indicate non-significant difference as per DMRT (p=<0.05), *i.e.,* 1, 2, 3, depicts between samples and a, b, c depicts between duration. CFST0 = Control fruit spread SFST1 = *Phyllanthus amarus* stem- based fruit spread (5%) RFST2 = *Phyllanthu samarus* root-based fruit spread (10%)

per cent and 13.54 per cent on 1st day and increased to 14.43 per cent and 15.76 per cent on 30th day of storage respectively. The increase in moisture content can be attributed due to storage conditions and due to the hygroscopic nature of the ingredients used in the product.

Bashir *et al*., 2022 studied that prolonged storage leads to an increase in moisture content due to water-vapor migration. This phenomenon is particularly pronounced in hygroscopic materials, which readily absorb moisture from the environment.

Vijayanand *et al.* (2000), studied on Storage stability of guava fruit bar and observed similar results as in the present study.

Peroxide and Free Fatty Acid Content of *Phyllanthus amarus* based Fruit Spread During Shelf Life Study

The peroxide value and the free fatty acid content were analysed for *Phyllanthus amarus* based fruit spreads during the storage period of 30 days. The control products were stored for 15 days and experimental products for 30 days due to appearance of fungal growth. The results are depicted in the Table 5. There is an increase in the peroxide value and free fatty acid value during the storage period. Peroxide and free fatty acid content of control sample increased on 1st day from 0.21 mEq/kg to 0.81 mEq/kg on the 15th day, whereas, both SFST1 and RFST2 samples also showed an increase in peroxide and free fatty acid content.

Peroxide and free fatty acid content in SFST1 sample increased from 1st to 30th day *i.e.*, 0.94 mEq/kg to 1.61 mEq/kg and 0.11 mEq/kg to 6.8 mEq/kg respectively. Peroxide and free fatty acid content in RFST1 sample increased from 1st to 30th day *i.e.*, 1.28 mEq/kg to 2.72 mEq/kg and 0.27 mEq/kg to 6.4 mEq/kg respectively. There is a significant difference in peroxide value and free fatty acids between the storage period on 1st and 30th day. And non-significant difference was found between stem based (SFST1) and root based (RFST2) fruit spread. Hence, as the peroxide value and free fatty acids content increased, the shelf life of the samples decreased. According to FSSAI, peroxide value of

TABLE 5

Peroxide and free fatty acid content of *Phyllanthus amarus* based fruit spreads and control fruit spread during shelf-life study

Duration (day)	Peroxide value (mEq/kg)			Free fatty acid value (% oleic acid)		
	CFST0	SFST1	RFST2	CFST0	SFST1	RFST2
1st	0.21 ^{b4}	0.94 ^{b2}	1.28 ^{b1}	0.56 ^{b3}	0.11 ^{b4}	0.27 ^{b4}
15th	0.81 ^{a3}	1.42 ^{a2}	2.46 ^{a1}	0.92 ^{a3}	0.31 ^{b4}	0.34 ^{b4}
30th	-	0.61 ^{c3}	2.72 ^{c1}	-	6.8 ^{a3}	6.4 ^{a4}

Note : Mean of triplicate samples, similar superscripts indicate non-significant difference as per DMRT (p = < 0.05), *i.e.,* 1, 2, 3, depicts between samples and a, b, c depicts duration CFST0= Control fruit spread, SFST1= *Phyllanthus amarus* stem- based fruit spread (5%), RFST2= *Phyllanthus amarus* root - based fruit spread (10%)

food should not be more than 10 milli equivalents of active oxygen /Kg Oil. Hence, the product was safe for consumption.

Similar results were observed by Capanoglu and Boyacioglu (2008) where the peroxide values stayed almost constant at the early stages of storage and increased exponentially as the storage time progressed, at all storage temperatures in stored almond paste. Clearly, increase in storage temperatures and duration resulted in higher peroxide values in all samples.

Microbial Load During Storage of *Phyllanthus amarus* based Fruit Spread

Microbial load (bacteria, mould and coliforms) for control and the best accepted products during storage period was estimated using standard plate count method and results are depicted in Table 6. The control and the best accepted variation (SFST1 and RFST2) were kept for storage under room temperature (27°C) up to 90 days. Microbial population was checked at each 15 days interval up to 90 days *i.e.*, 1st, 15th, 30th, 45th, 60th, 75th and 90th day.

On 30th day there was a visible fungal growth hence, the shelf-life study was discontinued for the control sample. For samples SFST1 and RFST2, the shelf-life study was carried out till 45th day as on 60th day a visible fungal growth was observed and the storage study was discontinued. Samples of SFST1 and RFST2 had better shelf life with no visual microbial growth for additional 15 days when compared to the control which could be because of anti-microbial properties present in *Phyllanthus amarus* based dehydrated powders.

The study by Bhat *et al*., 2015, showed that the ethanolic extract of *P. amarus* demonstrates significant antimicrobial activity against various pathogens, particularly gram-negative bacteria such as *Escherichia coli* and *Shigella* spp.

Control showed the highest increase in microbial population. The bacterial population increased from 0 to $3.52*10^2$ cfu/g in control sample, whereas the microbial load of SFST1 and RFST2 were less than the control *i.e.*, the bacterial population showed an increase from 0 to $3.46*10^2$ cfu/g and 0 to $3.65*10^2$cfu/

TABLE 6

Microbialload during storage of *Phyllanthus amarus* based fruit spread

		Duration (day)		
	Samples	1st	15 th	30 th
Bacteria (×102CFU/g)	Control	Nil	3.52 ^{a3}	-
	SFST1	Nil	2.56 ^{b2}	3.46 ^{a1}
	RFST2	Nil	2.69 ^{b2}	3.65 ^{a2}
Moulds (×102CFU/g)	Control	Nil	3.98 ^{a1}	-
	SFST1	Nil	2.72 ^{b2}	3.75 ^{a1}
	RFST2	Nil	2.26 ^{c2}	3.83 ^{a1}
Coliforms (×102CFU/g)	Control	Nil	Nil	-
	SFST1	Nil	Nil	Nil
	RFST2	Nil	Nil	Nil
	Mean	Nil	Nil	Nil

Note : Mean of triplicate samples,similar superscripts indicate non-significant difference as per DMRT (p =<0.05), *i.e.,*1,2, 3, depicts between samples and a, b, c depicts between duration. SFST1 = *Phyllanthus amarus* stem-based fruit spread (5%) RFST2 = *Phyllanthus amarus* root-based fruit spread (10%)

g and the mould count from 0 to 3.75*10^2cfu/g and 0 to 3.83*10^2 cfu/g respectively on 45th day of storage period. There was a significant difference observed in microbial growth from 15th and 30th day.

The control and the best accepted variations (SFST1 and RFST2) showed no coli form growth throughout storage period of 30 days. A similar study conducted by Raju *et al.* 2024 on millet-based pasta also reported the absence of coliforms for 30, 60 and 90 days. However, all these microbial counts are within the safe limits as recommended by FSSAI (Total bacterial Count not more than 50,000 per g, fungi and coliforms should be absent). Thus, the products can be stored upto 30 days.

Consumer Acceptability and Cost Economics

The cost analysis of fruit spreads revealed that the control fruit spread (CFST0) is the least expensive (Rs. 22.62 per 100 g), with a marketable price of Rs. 29 with a 30 per cent profit margin. The *Phyllanthus amarus* stem-based fruit spread (SFST1, 5%) is Rs.31. Meanwhile, the *Phyllanthus amarus* root-based fruit spread (RFST2, 10%) is Rs.32 as shown in Table 7.

The consumer acceptability was carried out for the control and best accepted products and graphically represented in Fig. 2. The control fruit spread (CFST0) was the most preferred, with 87 per cent of respondents rating it as highly acceptable, 11 per cent as acceptable and only 2 per cent rated as not acceptable. The *Phyllanthus amarus* stem-based fruit spread (SFST1, 5%) had highly acceptable scores by 72 per cent of consumers, with 20 per cent as it acceptable and 8 per cent as not acceptable. Mean while, the *Phyllanthus amarus* root-based fruit spread (RFST2, 10%) received the lowest consumer

TABLE 7

Cost economics of best accepted fruit spreads (per 100 g)

Products		Cost of production (Rs.)	Profit @ 30 per cent (Rs.)	Marketable price (Rs.)	Round off price (Rs.)
Fruitspread	Control	22.62	6.78	29.4 ^{c}	29
	SFST1	23.66	7.09	30.75 ^{b}	31
	RFST2	24.70	7.41	32.11 ^{a}	32

Note : Similar superscripts indicate non-significant difference as per DMRT (p=<0.05) CFST0 = Control fruit spread, SFST1 = *Phyllanthus amarus* stem- based fruit spread (5%) RFST2 = *Phyllanthus amarus* root- based fruit spread (10%)

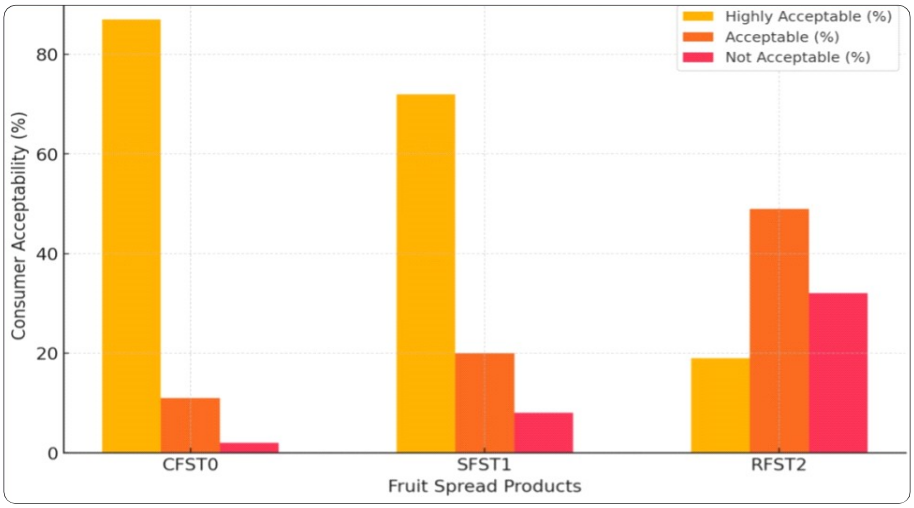

Fig. 2 : Consumer acceptability of developed fruit spread products

preference, with only 19 per cent rating as acceptable, while 49 per cent rated acceptable and a relatively high *i.e.,* 32 per cent rated as not acceptable as compared to the control fruit spread suggesting that higher concentrations of *Phyllanthus amarus* may negatively impact consumer acceptance. Graphically represented in Fig. 2.

The study has found that the *Phyllanthus amarus* (*Bhumi amla*) basedvalue-added products help in exploring the therapeutic and medicinal characteristics. Conclusively, this study has found that the fruit spreads from *Phyllanthus amarus* plant and its different parts is potentially rich in nutrients and bioactive components. However, the plant is having a remarkable deed but it is restricted to use because of its astringent and after taste bitterness and also it is treated as a weed. The present study illustrated that the dehydrating plant, cluster of leaves and fruits, stem and roots of *Phyllanthus amarus* can be utilized to prepare shelf stable and palatable product, giving scientific context to the traditional knowledge of the plant.

REFERENCES

BASHIR, O., HUSSAIN, S. Z., AMEER, K., AMIN, T., BEENISH, AHMED, I. A. M., ALJOBAIR,M. O., GANI, G., MIR, S. A., AYAZ, Q. AND NAZIR, N., 2022, Influence of anticaking agents and storage conditions on quality characteristics of spray dried apricot powder: shelf life prediction studies using Guggenheim-Anderson-de Boer (GAB) model. *Foods*, **12** (1) : 171.

BHAT, S. S., HEGDE, K. S., CHANDRASHEKHAR, S., RAO, S. N. AND MANIKKOTH, S., 2015, Preclinical screening of *Phyllanthus amarus* ethanolic extract for its analgesic and antimicrobial activity. *Pharmacogn Res.*, **7** (4) : 378.

BHOS, K. V., MOTE, G. V. AND SAHOO, A. K., 2019, Development of nutritious spread and itsstorage study. *J. Pharmacogn phytochem,* **8** (4) : 752 - 759.

CAPANOGLU, E. AND BOYACIOGLU, D., 2008, Improving the quality and shelf life of Turkish almond paste. *J. Food Qual*., **31** (4) : 429 - 445.

CAPANOGLU, E., BEEKWILDER, J., BOYACIOGLU, D., HALL, R. AND DE VOS, R., 2008, Changes in antioxidant and metabolite profiles during production of tomato paste. *J. Agric. Food Chem.* , **56** (3), pp. : 964 - 973.

DEVI, S., RASHID, R. AND KUMAR, M., 2017, Phyto chemistry and pharmacological properties of *Phyllanthus amarus Schum*: A review. *Pharma Innov. J.*, **6** (12) : 169 - 172.

JAY, R. P., PRIYANKA, T., VIKAS, S., NAGENDRA, S. C. AND VINOD, K. D., 2011, *Phyllanthus amarus*: ethnomedicinal uses, phytochemistry and pharmacology: a review. *J. Ethnopharmacol*., **138** (2) : 286 - 313.

KOSTYRA, E., GAWLIÑSKA, K., ZAKOWSKA-BIEMANS, S., PIOTROWSKA, A.,GANTNER, M., KULIK, K. AND SWIADER, K., 2024, Exploring the Sensory Characteristics of the Soybean Spreads Enhanced with Vegetables and Spices. *Appl.Sci.*, **14** (3) : 096.

MOHAMMADI-MOGHADDAM, T. AND FIROOZZARE, A., 2021, Investigating the effect of sensory properties of black plum peel marmalade on consumers acceptance by Discriminant Analysis. *Food Chemistry: X*, **11** : 100126.

PIUS, O., BABAWALE, O., SOLA, E. A. A. AND COMFORT, O., 2015, A comparative studyof nutritional and phytochemical composition of *Phyllanthus amarus* leaf and seed. *Am. J.Toxicol. Sci.*, **7** : 321 - 327.

RAGURAMULU, N., MADHAVANNAIR, K. AND SUNDARAN, S., 2003, A laboratory technique, NIN, ICMR publications, Hyderabad.

RAJU, C., BEGUM, S.S., NAGARAJA, T. AND SHOBHA, D., 2025, Development and quality evaluation of foxtail millet (*Setaria italica*) Based Extruded Product. *Mysore J. Agric. Sci*, **59** (1) : 278 - 291.

REDDY, A.H. AND CHIKKASUBBANNA, V., 2009, Studies on the storage behaviour of amla jam. *Int. J. Agric. Sci.*, **5** (1) : 55 - 59.

ROHINI, C., GEETH, P. S., VIJAYALAKSHMI, R. AND PASUPATHI, E., 2022, Nutritional and rheological properties of pumpkin seed-based fruits spread. *J. Appl. & Nat. Sci.,* **14** (SI) : 155 - 160.

VAIBHAVI, V., KULKARNI, K., VIJAYALAXMI, K.G. AND SUVARNA, V. C., 2019, Physico chemical parameters and shelf life study of Murabba, developed from mango ginger (*Curcuma amada*), *Mysore J. Agric. Sci*) : 99 - 106.

VIJAYANAND, P., YADAV, A. R., BALASUBRAMANYAM, N. AND NARASIMHAM, P., 2000, Storage stability of guava fruit bar prepared using a new process. *LWT - Food Sci. Technol.,* **33** (2) : 132 - 137.