Research Article

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Fruit rind constituents in nutmeg (*Myristica fragrans*) morphotypes

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Abstract

Rind or pericarp is the outermost part of nutmeg fruit which is thick and fleshy. Fresh rind, contributing 80 to 85 per cent of total fruit weight, has an astringent taste with aromatic flavour. Due to these qualities, the use of rind for food purpose is restricted. At the same time its therapeutic property, especially its anti-oxidant, anti-microbial and anti-diarrhoeal effects, have generated interest in nutmeg rind. Major interest of the processors is the biochemical constitution of the rind. In the present study, 17 distinctly featured nutmeg accessions selected from core collections in central Kerala were employed for biochemical analysis of rind. A total of 10 constituents of ripe rind were estimated using standard analytical techniques. Data were statistically analysed and sub groups formed using DMRT. The range of variation was 87.1 to 89.1 (mg 100 g^{-1}) for ascorbic acid, 0.2 to 1.08 per cent for pectin content (calcium pectate), 0.21to 1.85 (g 100 g^{-1}) for protein, 0.3 to 1.23 (g 100 g^{-1}) for starch, 27.8 to 57.6 (mg 100 g^{-1}) for total phenol, 143.3 to 750.0 (mg 100 g^{-1}) for tannin, 2.01 to 2.57 per cent for total minerals and 2.06 to 3.65 per cent for crude fibre. Since varied overlapping sub-groups were obtained constituents wise, the method to make decisions jointly on a number of dependant characters was co-opted. The final score is an indicator of the relative superiority of the accessions in terms of the biochemical constituents of rind. The accessions were categorized for various end uses based on the score obtained for each constituent. The variation in biochemical composition may be due to inherent genetic character of the tree as also the geographic location and management practices followed. Based on the composition, the nutmeg rind, which at present is discarded as a farm waste, could be utilized for value addition in the food, nutraceutical and pharmaceutical sectors.

Keywords: Nutmeg, rind, biochemical constituents, value added products, waste management

Introduction

Nutmeg (*Myristica fragrans* Houtt.) is an important spice of commerce, valued for its flavouring and medicinal properties. It is cultivated in the Malayan Peninsula, Penang and the Malaya Islands. In India, nutmeg is mainly grown in Kerala, Tamil Nadu and Karnataka (Anandraj *et al*., 2005). Nutmeg is a unique spice as it produces two economically important spices, nutmeg and mace. The fruit is ovoid, sub-globose or pyriform. After harvest, the pericarp/outer fleshy rind is removed and the mace, which envelops the shell, is peeled off. In general, the average weight of a single fruit is 60 grams of which the seed weighs 8-12 grams, mace 3-4 grams and the rest is rind. The rind, nut and mace possess various constituents of economic importance. The rind is the outermost part of nutmeg fruit which is thick and fleshy. Fresh rind contributing 80 to 85 per cent of total fruit weight has an astringent taste with aromatic flavour. Due to these qualities, the use of rind for food purpose is restricted. Its carminative, anti-oxidant, anti-microbial and anti-diarrhoeal effects have generated interest. Major interest of the processors is the biochemical constitution of the rind. Biochemical analysis of the rind gives valuable information to assess the quality of the sample. Based on the composition and quality of the rind, which at present is discarded as a farm waste, could be utilized for making value added products like jam, jelly, syrup,

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wine *etc.* In Grenada, rind of nutmeg is used to make a jam called *morne delice* and in Indonesia, the fruit is sliced finely, cooked and crystallized to make a fragrant and sweet candy called *manisan pala* (Leela, 2008). In India, processing techniques for products like nutmeg rind leather, wine, pickle, syrup, jam, cake, powder and candy have been standardised (Teena, 2015). These studies are oriented towards effective utilization of nutmeg rind so as to transform it into value added products. However, despite its important role as ingredients for many value added products, very few studies exist on the biochemical analysis of nutmeg rind. Thus, the present study was designed to evaluate the rind quality of distinctly featured nutmeg morphotypes selected from core collections in central Kerala.

Materials and methods

The study was carried out in the Department of Plantation Crops and Spices, Kerala Agricultural University, Thrissur during 2012-2015. The core collections of nutmeg selected form central Kerala formed the material for the study. These nutmeg accessions included forty two females and four monoecious types. Two trees per accession were selected for recording observations. Forty six accessions (Acc), were included for recording fruit characteristics. Based the diversity analysis of morphological characters, 17 morphotypes were selected from the initial 46 accessions. These morphotypes had distinctive characteristic features ensuring adequate representation of all the quantitative clusters. These seventeen distinctly featured accessions only were further employed for biochemical analyses of rind. A total of 10 constituents of rind were estimated using standard analytical techniques (Table 1). Freshly collected split opened nutmeg rind was used for the analysis. Analysis of variance was performed for all the biochemical data with completely randomised design using SPSS v.16 software package (SPSS, 2007).

Multiple comparisons among the treatments were done using Duncan's Multiple Range Test (DMRT). Accessions were sub-grouped into high and low based on significance of the values. Since varied overlapping subgroups were obtained constituents wise, the method to make decisions jointly on a number of dependant characters as proposed by Arunachalam and Bandyopadhyay (1984) was co-opted.

Results and discussion

Data on biochemical constituents of rind of 17 morphotypes are presented in Table 2. Significant difference was observed among the morphotypes for the 10 biochemical constituents analysed in the rind. Accessions varied significantly for moisture content of rind. Average moisture content recorded in the study was 88 per cent, and it ranged between 87.1 and 89.4 per cent. Eighty six per cent moisture content was reported in nutmeg rind by Jayashree and Zachariah (2014). Teena (2015) observed the average moisture content of nutmeg rind as 89.2 per cent. The titrable acidity is an important physicochemical parameter which affects the product quality and also acts as a protectant against the development of micro-organisms to a large extent. In the present study, acidity content ranged

Table 1. Biochemical estimation methods employed for nutmeg rind analyses

Sl. No.	Component	Analytical method	Reference
1	Moisture (%)	Oven dry method	Ranganna (1986)
2	Acidity (titrable acidity, %)	Titration method	Ranganna (1997)
3	Ascorbic acid (mg 100 g^{-1})	Volumetric method	Sadasivam and Manickam (2010)
4	Pectin (calcium pectate, %)	Gravimetric method	Ranganna (1986)
5	Protein (g 100 g^{-1})	Lowry's method	Sadasivam and Manickam (2010)
6	Starch (g 100 g^{-1})	Colorimetric method	Hedge and Hofreiter (1962)
7	Total phenol (mg 100 g^{-1})	Floin ciocalteau reagent method	Sadasivam and Manickam (2010)
8	Tannin (mg 100 g^{-1})	Folin-Denis method	Schandrel (1970)
9	Total minerals (%)	Volatilizing organic matter method	Ranganna (1986)
10	Crude fibre (%)	Acid - alkali digestion method	Chopra and Kanwar (1978)

Table 2. Biochemical constituents of fruit rind in nutmeg morphotypes

Accessions	Moisture (%)	Acidity (%)	Ascorbic acid (mg 100 g^{-1})	Pectin (% Calcium pectate)	Protein (g 100 g^{-1})	Starch (g 100 g^{-1})	Total Phenol (mg 100 g^{-1})	Tannin (mg 100 g^{-1})	Total mineral (%)	Crude fibre (%)
Acc.1	87.1^{e}	1.68^{ab}	7.63^{ab}	0.59^{efg}	1.28^{c}	0.78^{cde}	42.8^{e}	400.5^{e}	2.15^{d}	2.41^{ef}
Acc.5	89.4^{a}	1.73^{ab}	7.14^{ab}	0.32^{hi}	0.96^{f}	0.46^{fg}	44.3^{e}	143.3^{j}	2.07^{d}	2.47^{ef}
Acc.8	88.4^{cd}	1.92^{a}	8.33^{a}	0.86^{bc}	1.24^{cd}	0.30^{g}	31.0^{fg}	216.6^{i}	2.29^{bc}	2.75^{cd}
Acc.9	87.2^{e}	1.92^{a}	9.52^{a}	1.08^{a}	1.30^{c}	0.63^{ef}	43.3^{e}	293.3^{fg}	2.32^{c}	3.65^{a}
Acc.11	87.1^{e}	1.60^{ab}	8.12^{a}	0.91^{abc}	0.78^{h}	0.72^{de}	44.2^{e}	313.3^{f}	2.09^{d}	2.66^{de}
Acc.14	87.2^{e}	1.60^{ab}	7.57^{ab}	0.52^{fgh}	0.35^{j}	0.88^{cd}	49.4^{cd}	436.6^{c}	2.50^{a}	2.75^{cd}
Acc.18	87.3^{e}	1.60^{ab}	9.09^{a}	0.80^{bcd}	0.21^{k}	0.86^{cd}	57.6^{a}	276.6^{g}	2.17^{cd}	2.45^{ef}
Acc.21	88.4^{cd}	1.60^{ab}	4.71^{bc}	0.78^{bcd}	0.90^{fg}	0.91^{cd}	27.8^{g}	253.3^{h}	2.05^{d}	2.42^{f}
Acc.23	88.2^{d}	1.60^{ab}	9.09^{a}	0.36^{hi}	1.85^{a}	1.23^{a}	51.0^{bc}	430.0^{cd}	2.50^{a}	3.48^{a}
Acc.24	87.4^{e}	1.60^{ab}	9.09^{a}	0.21^{i}	1.13^{e}	1.14^{ab}	51.7^{bc}	750.0^{a}	2.46^{ab}	2.15^{g}
Acc.30	89.4^{a}	1.65^{a}	7.14^{ab}	0.62^{def}	0.97^{f}	0.86^{cd}	46.7^{de}	230.0^{hi}	2.21^{cd}	2.22^{g}
Acc.35	89.1^{b}	1.66^{ab}	6.95^{ab}	0.41^{gh}	0.92^{fg}	0.96^{bc}	45.2^{e}	388.4^{e}	2.10^{d}	2.06^{g}
Acc.36	88.6^{c}	1.60^{ab}	7.83^{ab}	0.42	1.46^{b}	0.72^{de}	33.3^{f}	710.0^{b}	2.01^{d}	2.17^{g}
Acc.37	87.1^{e}	1.65^{ab}	7.14^{ab}	0.73^{cde}	0.84^{gh}	0.30^{g}	28.3^{g}	230.6^{hi}	2.04^{d}	2.65^{de}
Acc.38	87.3^{e}	1.60^{ab}	9.09^{a}	0.51^{fgh}	0.65^{i}	0.77^{cde}	55.0^{ab}	410.0^{de}	2.08^{d}	3.05^{b}
Acc.(H)1	88.2^{d}	1.60^{ab}	4.54^{c}	0.40^{gh}	1.14^{de}	0.91^{cd}	42.2^{e}	406.6^{de}	2.57^{a}	2.93^{bc}
Acc.(H)4	88.9^{b}	1.28^{c}	9.41^{a}	0.96^{ab}	0.94^{fg}	0.73^{de}	31.7^{fg}	313.3^{f}	2.01^{d}	2.47^{ef}

Values not sharing a common superscript in the row differ significantly with each other ($P < 0.05$).

from 1.28 (Acc. H4) to 1.92 (Acc. 8 and Acc. 9) per cent. Accessions with low acidity could be useful in processing industries. Gopalakrishnan (1992) had reported higher acidity of nutmeg rind compared to that of kernel and mace. The ascorbic acid content varied from 4.5 to 9.5 (mg 100 g^{-1}). Highest ascorbic content was recorded in Acc. 9 and minimum was in Acc (H)1. Ascorbic acid content is an indication of the antioxidant property of the material and hence is a much favoured characteristic contributing to the medicinal value of the rind. In an earlier study, Teena (2015) has reported 13.3 (mg 100 g^{-1}) of ascorbic acid content in nutmeg rind. Presence of vitamin C also adds nutritive value to the final produce.

Nutmeg rind possessed slightly lower range of protein, ranging from 0.21 to 1.85 (g mg^{-1}). Accessions 23 and 36 registered higher values of protein content. Total phenol content differed significantly and ranged from 27.8 mg 100 mg^{-1} (Acc. 21) to 57.6 mg 100 mg^{-1} (Acc. 18). Phenolics are another group of naturally occurring compounds widely distributed in the plant kingdom and are beneficial components of daily human diet. They are important constituents of plants with multiple functions. At the same time they act as dietary phytochemicals for humans, displaying a broad range of functional and biological activities (Le *et al*., 2007). Teena (2015) reported 0.44 mg g^{-1} of total phenol in nutmeg rind. Tannin content varied among the accessions studied. Highest tannin content was recorded in Acc. 24 (750 mg 100 g^{-1}) and lowest in Acc. 5 (143.3 mg 100 g^{-1}). Tannins are responsible for the astringent taste of nutmeg rind and low concentration of this constituent could be useful in making value added products from rind. Starch is the most vital carbohydrate in the human diet and is the major constituent of staple foods such as potato, rice, wheat, cassava, and corn. In nutmeg rind, starch content ranged from 0.30 to 1.23 (g 100 g^{-1}).

Crude fibre content was maximum in Acc. 9 (3.65%) closely followed by Acc. 23 (3.48%). In an earlier work, Teena (2015) obtained 3.75 per cent crude fibre in nutmeg rind. Varghese (2000) reported that kernel possessed the highest crude

Table 3. Ranking of nutmeg morphotypes based on biochemical constituents of fruit rind*

Accessions	Moisture	Acidity	Ascorbic acid	Pectin	Protein	Starch	Total phenol	Tannin	Total minerals	Crude fibre	Total score
Acc. 1	1.0	0.5	0.5	0.7	0.3	0.6	0.7	0.5	1.0	0.8	6.5
Acc. 5	0.2	0.5	0.5	0.9	0.6	0.9	0.7	1.0	1.0	0.8	7.9
Acc. 8	0.7	0.3	0.3	0.3	0.3	1.0	0.9	0.9	0.6	0.5	5.9
Acc. 9	1.0	0.3	0.3	0.1	0.3	0.8	0.7	0.7	0.8	0.1	5.1
Acc. 11	1.0	0.5	0.3	0.2	0.7	0.6	0.7	0.6	1.0	0.6	6.4
Acc. 14	1.0	0.5	0.5	0.7	0.9	0.5	0.5	0.3	0.3	0.5	5.6
Acc. 18	1.0	0.5	0.3	0.3	1.0	0.5	0.1	0.7	0.9	0.8	6.2
Acc. 21	0.7	0.5	0.8	0.3	0.6	0.5	1.0	0.8	1.0	0.9	7.1
Acc. 23	0.8	0.5	0.3	0.9	0.1	0.1	0.4	0.4	0.3	0.1	3.9
Acc. 24	1.0	0.5	0.8	1.0	0.5	0.2	0.4	0.1	0.4	1.0	5.8
Acc. 30	0.2	0.3	0.5	0.6	0.6	0.5	0.6	0.9	0.9	1.0	6.0
Acc. 35	0.4	0.5	0.5	0.8	0.6	0.4	0.7	0.5	1.0	1.0	6.4
Acc. 36	0.6	0.5	0.5	0.8	0.2	0.6	0.9	0.2	1.0	1.0	6.3
Acc. 37	1.0	0.5	0.5	0.4	0.7	1.0	1.0	0.9	1.0	0.6	7.6
Acc. 38	1.0	0.5	0.3	0.8	0.8	0.6	0.2	0.5	1.0	0.3	6.0
Acc. (H)1	0.8	0.5	1.0	0.8	0.4	0.5	0.7	0.5	0.3	0.4	5.8
Acc. (H)4	0.4	1.0	0.3	0.2	0.6	0.6	0.9	0.6	1.0	0.8	6.5

* Ranking based on DMRT

fibre content of 11.7 per cent and that of mace was 3.9 per cent. Nutmeg rind powder is a rich source of minerals like iron and some other micro and macro nutrients (Gopalan *et al*., 1984). In the present study, highest total mineral content was observed in Acc. (H)1 (2.57%), followed by Acc. 14 (2.5%), Acc. 23 (2.5%) and Acc. 24 (2.46%).

A valuable by-product that can be obtained from nutmeg rind is pectin. In the present study, pectin content of fresh pericarp ranged from 0.21 to 1.08 per cent (calcium pectate). Acc. 9 recorded significantly higher pectin content in the fresh rind followed by Acc. (H)4 and Acc. 11. Pectin occurs in varying amounts in fruit cell walls and has got both nutritional and industrial properties, because of its ability to form gels (Westerlund *et al*., 1991). Pectin is used in the manufacture of many value added products like jams, jellies, marmalades, preserves and also used as a thickening agent in sauces, ketchups and flavoured syrups. Besides, it finds many uses in pharmaceutical preparations such as pastes, cosmetics *etc.* Perhaps, the high pectin content of the rind is responsible for its antidiarrhoeal effects, reported in ayurvedic treatises (Preethi and Krishnankutty, 1986; Latha *et al*., 2005).

From the analyses of data, varied overlapping sub-groups were obtained constituent-wise, which makes it difficult to select the best morphotypes for final usage. The final score obtained for each character, which is an indicator of the relative superiority of the accessions in terms of the biochemical constituents, is presented in Table 3. Acc. 8, 9 and 30 were characterised by low acidity in the rind which is a desirable attribute for value addition. With respect to tannin content, Acc. 24 registered the lowest score, followed by Acc. 36, 14 and 23. Needless to mention that low tannin is also a highly preferred attribute from the value addition point of view. For extraction of pectin, Accession 24 which recorded the highest score could be chosen followed by Acc. 5 and 24. Highest score for ascorbic acid content was recorded in Acc. (H)1 and 24; for protein in Acc. 18 and 14; for starch in Acc. 8 and 37 and for total minerals in Acc. 1, 5, 11, 21, 35, 36, 37, 38 and H4, and crude fibre in Acc. 24, 30, 36 and 36. These accessions assume value from the nutritional point of view. Acc. 21

and 37 which got highest score for total phenols could be utilised for the antioxidant property. This variation in biochemical composition may be due to inherent genetic character of the tree, the geographic location and management practices followed. Based on the composition, the nutmeg rind, which at present is discarded as a farm waste, could be utilized for value addition in the food, nutraceutical and pharmaceutical sectors.

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