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Formulation and Physicochemical Evaluation of a Herbal Dentifrice Formulated with *Myristica fragrans* (Nutmeg): An In Vitro Study

Research Article

Kavisha Mahajan[1*], Sanket S Kunte[2]

1. PG Scholar, 2. Professor, Department of Pediatric and Preventive Dentistry,
Bharati Vidyapeeth (Deemed To Be University) Dental College and Hospital, Pune. India.

Abstract

Aim: Dental plaque is the primary etiological factor of two of the most commonly encountered global oral health problems; dental caries and periodontal disease. The toothbrush-dentifrice combination is an essential aid in preventing them. There are several commercial chemical toothpastes available, but as of late herbal toothpastes have become more popular amongst people. Thus, the aim of this study was to formulate a novel herbal dentifrice with *Myristica fragrans* (Houtt.) (nutmeg), and compare its physicochemical properties with a commercially available herbal dentifrice without nutmeg. Material and method: A pilot study was conducted wherein the toothpaste was formulated under sterile conditions using various concentrations of nutmeg, tulsi leaves powder and clove powder as the main herbal ingredients. All herbal ingredients were 100% organic and certified by the Food Safety and Standard Authority of India (FSSAI). Its properties were compared and evaluated with a commercial herbal toothpaste and the most optimum formulation was then selected to be a part of the study. The properties evaluated were organoleptic parameters (colour, texture, appearance, taste, odour), pH, foamability, abrasiveness, gritty matter, homogeneity, stability and spreadability. Results: The results revealed that in comparison to the commercial herbal toothpaste, the formulated herbal toothpaste with nutmeg exhibited improved foaming ability, abrasivity, spreadability; and comparable texture, consistency, colour, gritty matter, homogeneity and stability properties. However, it had less favourable odour and taste. Conclusion: The overall results of the research provide convincing evidence of the satisfactory physicochemical properties of the nutmeg toothpaste. However, further research is warranted to test other significant properties of the toothpaste.

Keywords: Herbal toothpaste, *Myristica fragrans,* Nutmeg, Physicochemical properties.

Introduction

Dental plaque is the key etiological factor in two of the most prevalent global oral health problems: dental caries and periodontal disease. (1,2) Hence, efficient plaque control is a crucial component of the prevention of these diseases. A combination of mechanical plaque control along with antiplaque and antibacterial agents is the most effective method for controlling plaque. (1,3) This is best achieved by the toothbrush-dentifrice combination.

There are various commercial chemical toothpastes available in the market today. However, the use of herbal products in toothpastes has gained more popularity amongst people lately. The unfavourable side effects of the chemical components and the individual benefits provided by the herbal ones can be credited for this. (4,5) Also, numerous studies demonstrating the equivalent effectiveness of adding these agents to oral health care products corroborate it. (5,6) The need for alternative options for oral health care products that are safe, effective, and affordable is also because of the rise in disease incidence, pathogenic bacterial resistance to currently used antibiotics and chemotherapeutics, opportunistic infections in immunocompromised individuals, and financial concerns in developing countries. (7)

Myristica fragrans (Houtt.), commonly known as nutmeg, has been used both domestically and in the food industry as a spice and flavouring agent for years. It has gained recognition for its various therapeutic benefits due to its complex molecular structure. It therefore has the potential to be used as a natural anti-microbial agent in dental care products. (8)

Nutmeg is known to be mildly abrasive on the skin, but sufficient studies have not been conducted to conclude its efficacy on teeth. Thus, this study aims to formulate a novel herbal dentifrice with *Myristica fragrans* (Houtt.) (nutmeg), and compare its physicochemical properties with a commercially available herbal dentifrice without nutmeg.

*** Corresponding Author:**
Kavisha Mahajan
PG Scholar,
Bharati Vidyapeeth (Deemed To Be University)
Dental College and Hospital, Pune. India.
Email Id: kavishamahajan95@gmail.com

Materials and Methods

Tooth paste formulation

A pilot study was conducted in which three different formulations of the nutmeg toothpaste were developed. (table 1, figure 1) After conducting various tests on these formulations, using the same methodology that has been mentioned in the next section, the most optimum formulation was selected to be a part of this study, as shown in table 2. Dabur red was chosen as the standard commercial herbal toothpaste, based on an article published by the Government of India. (9) (figure 2).

The following ingredients were used to formulate the toothpaste in sterile conditions: (table 3).

All herbal ingredients are 100% organic and certified by the Food Safety and Standard Authority of India (FSSAI). They were bought commercially from the Green Pharmacy, Pune and the chemical constituents were procured from the AISSMS College of Pharmacy, Pune. (figure 3 a) and b))

Physicochemical evaluation

Organoleptic parameters

Organoleptic parameters including the colour, texture, appearance, taste and odour were evaluated by sensory and visual inspection of both the toothpastes. (10)

pH levels

10 g of each toothpaste was dissolved in 10 ml of deionised water and stirred well to make a suspension in a 100 ml beaker. The pH was then measured using an EI pH meter. (10)

Foaming ability

5 g of each toothpaste was weighed into a 100 ml glass beaker. 10 ml of distilled water was added to it and allowed to stand for 30 minutes (allowing the toothpaste to disperse in the water). The contents were stirred and the slurry was transferred to a 250 ml graduated measuring cylinder. The residue in the beaker was rinsed and transferred with 5-6 ml portion of the water to the cylinder. The contents of this cylinder were then stirred in order to get a uniform suspension. A stopper was placed on the cylinder and subjected to 12 shakes. It was then allowed to stand for 5 minutes and the volume of foam was calculated using the following formula:

Foaming ability = L1 - L2

L1 = volume in ml of foam with water

L2 = volume in ml of water only. (10)

Abrasiveness

A pea size amount of both the toothpastes was placed on separate clean plastic microscope slides and one drop of distilled water added to it. A clean cotton swab was rubbed on the toothpaste sample in a back-and-forth motion 30 times using short strokes. This was followed by carefully rinsing the slide and drying it with a soft tissue. The slide was examined under a dissecting microscope illuminated from above to determine the number of scratches on the surface of the slide. It was rated on a scale of 0 (no scratch) to 5 (high degree of scratches). (10)

Gritty matter

A small amount of each toothpaste was rubbed into a piece of butter paper. The number and intensity of scratches that appeared on the butter paper was recorded as being absent or present. (10)

Homogeneity

A normal amount of force was applied on both the toothpastes which were contained in separate tubes at room temperature. It was observed whether the toothpaste extruded homogeneously from the tube or not. (10)

Stability

Some amounts of the toothpastes were transferred into 3 glass test tubes and a stopper was placed on them. These test tubes were heated at 45 degrees Celsius for 72 hours, allowed to cool and the content was examined visually for homogeneity, signs of fermentation and other deterioration results. It was reported as pass or fail. (10)

Spreadability

The Brookfield CT3 texture analyzer (Brookfield Engineering Laboratories, Middleboro, MA, USA) was used to measure the spreadability of the two toothpastes. (figure 4) The test was performed using the fixture base table and spreadability accessor. A conical shaped sample holder was filled evenly with the sample while the cone analytical probe was forced down into each sample at a defined test speed (2 mm/s) and to a defined depth (15 mm). The hardness of both toothpastes was recorded from the graph obtained, which is inversely proportional to their spreadability. (11)

Table 1: Three different formulations of the nutmeg toothpaste

Ingredients	Concentration (% w/w)		
	NT 1	NT 2	NT 3
Nutmeg powder	5	5	10
Tulsi leaves powder	0.8	0.8	1.6
Clove powder	0.2	0.2	0.4
Methyl paraben	0.2	0.2	0.4
Menthol	0.1	0.1	0.2
Titanium dioxide	0.4	0.4	0.8
Sodium lauryl sulphate	2.5	2	5
Honey	0.5	0.5	0.5
Water	7 ml	7 ml	15 ml

(NT 1: Nutmeg Toothpaste1, NT 2: Nutmeg Toothpaste 2, NT 3: Nutmeg Toothpaste 3)

Table 2: Results of the pilot study

Criteria	Results			
	NT 1	NT 2	NT 3	Standard toothpaste (Dabur Red)
Foamability	5.8 cm	4.1 cm	4.3 cm	5.32 cm
Spreadability	Present	Present	Present	Present
		· Requires more pressure · Difficult to spread		
pH	5.85	6.01	6.09	4.68

(NT 1: Nutmeg Toothpaste1, NT 2: Nutmeg Toothpaste 2, NT 3: Nutmeg Toothpaste 3)

Table 3: Nutmeg toothpaste constituents

Constituent	Percentage (w/w)	Property
Nutmeg powder	28.41	Antibacterial and abrasive agent
Tulsi leaves powder	4.55	Prevents halitosis
Clove powder	1.14	Anti-inflammatory agent
Methyl paraben	1.14	Preservative
Menthol	5.68	Cooling agent
Titanium dioxide	2.27	Whitening agent
Sodium lauryl sulphate	14.20	Detergent
Honey	2.84	Humectant
Water q.s.	39.77	Vehicle

Table 4: Results of the physicochemical evaluation of the nutmeg and standard toothpastes.

Sr. No.	Property	Nutmeg toothpaste	Standard toothpaste
1	**Organoleptic parameters:** **a) Colour** **b) Texture** **c) Appearance** **d) Taste** **e) Odour**	a) Brownish b) Smooth c) Paste-like d) Slightly bitter e) Pungent	a) Red b) Smooth c) Paste-like d) Sweet e) Pleasant
2	**pH**	6.6	8.8
3	**Foaming ability** (foam in cm)	33 (acceptable)	39 (acceptable)
4	**Abrasiveness** (on a scale of 0-5)	2	4
5	**Gritty matter**	Absent	Absent
6	**Homogeneity** (pass/fail)	Pass	Pass
7	**Stability** (pass/fail)	Pass	Pass
8	**Spreadability** (inversely proportional to hardness) (figure 5)	Hardness: 39.9 g (more spreadability)	Hardness: 45.5 g (less spreadability)

Figure 1: Three different formulations of the nutmeg toothpaste (pilot study)

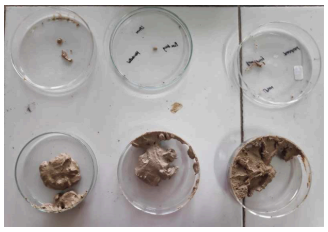
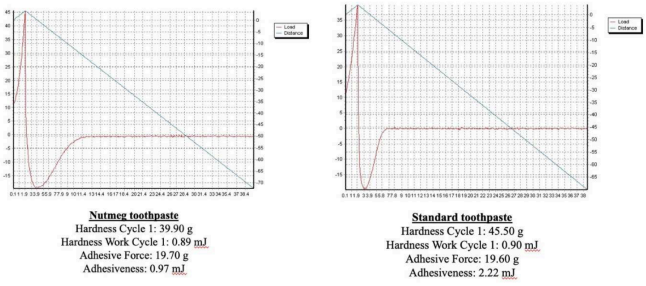


Figure 2: Standard commercial toothpaste (Dabur Red) and the formulated nutmeg toothpaste

Figure 3 a) and b): Toothpaste constituents

Figure 4: Brookfield CT3 Texture Analyzer

Figure 5: Spreadability results of the nutmeg and standard toothpastes using the Brookfield CT3 Texture Analyzer



Results

Results of the physicochemical evaluation of the nutmeg toothpaste and the standard toothpaste have been summarised in table 4.

Discussion

In recent years, there has been a paradigm shift from the usage of chemical to herbal products amongst the public. This could be due to the individual benefits offered by the herbal ingredients and the harmful effects of the chemical ones.

A variety of ingredients have been used to formulate herbal toothpastes, with the exception of *Myristica fragrans* (Houtt.) or nutmeg. According to studies, nutmeg contains 25–30% fixed oils and 5–15% volatile oils, including substances like elimicin, myristic acid, dihydroguaiaretic acid, myristicin, lignan compounds, and various volatile oils. Recent research indicates that the mace, or aril of *Myristica fragrans* (Houtt.), has antibacterial effectiveness against the cariogenic Streptococcus mutans. However, nutmeg (the seed kernels of *Myristica fragrans* (Houtt.)) has not been used widely in studies against oral microorganisms. (2) It is also mildly abrasive on the skin but sufficient studies have not been conducted to conclude its efficacy on teeth. Therefore, the present study aimed at incorporating nutmeg to formulate a novel herbal toothpaste.

The nutmeg toothpaste was formulated and compared with the standard Dabur Red toothpaste against various parameters. The nutmeg toothpaste had a brownish colour, a slightly bitter taste, and a pungent odour owing to the presence of nutmeg. Singh et al reported that red-coloured dentifrices such as Dabur red contain red ochre which is responsible for their abrasive action as well as the colour. (12)

Both toothpastes had an alkaline pH which is known to be desirable as it causes less adverse change to the tooth surface. (10) A lower acidic pH which is caused by the carbohydrate metabolism of the oral microorganisms can compromise the microbial flora and further lead to formation of dental plaque, caries, and other periodontal diseases. Maintaining favourable microbial flora is desirable for the well-being of an individual's oral health, which can be achieved by practicing proper oral hygiene measures. Thus, keeping the pH of the teeth at an alkaline range may prevent the development of these dental problems. (13) It is desirable to have the pH within 5.5-10.5 units. (9)

Foaming ability measures the cleansing power of toothpastes, which is affected by the presence of surfactants like Sodium Lauryl Sulphate (SLS). SLS produces foam which lowers the surface tension of the film on the surface of teeth, thereby aiding in removal of debris. Toothpastes with good foaming ability provide a good cleansing action of the teeth. (13) The nutmeg and standard toothpastes both showed an acceptable amount of foaming ability, with the nutmeg toothpaste having a lower amount than the standard. (9) A major concern according to the American Dental Association is increased oral irritation associated with the use of SLS causing canker sores in prone individuals. (14) Thus, toothpastes with less SLS, such as the nutmeg toothpaste, will be beneficial for such individuals. This is also true for children with special health care needs for whom expectoration while toothbrushing poses to be a challenge. (15)

A toothpaste needs to have some amount of abrasivity in order to be effective. However, the uncontrolled use of abrasive agents can have deleterious effects on the tooth enamel and dentin, which lead to hypersensitivity and recession. (16) This is important to consider in the deciduous dentition since the tooth enamel is thinner and can increase the risk of caries progression in these teeth. (11) In the present study, the formulated nutmeg toothpaste has lesser abrasivity than the standard, which could be advantageous for children with mixed dentition owing to the thickness of enamel.

The gritty matter test helps to determine the presence of solids in the formulation. This is important as regular usage of formulation with gritty matter can cause enamel wear and injury to the hard and soft tissues. (10) This was found to be absent in both toothpastes.

Both toothpastes passed the homogeneity test, proving that obtaining the formulation from the tube by extrusion posed no difficulty.

The stability test is a good approximation of the shelf life of the products. Both the toothpastes passed the test at the end of 72 hours.

Spreadability is a measure of how well the product can penetrate different areas of the oral cavity after application. High spreadability guarantees high chances of wide-range performance. (9) The nutmeg toothpaste had better spreadability than the standard. This was measured using the Brookfield CT3 Texture Analyzer based on the fact that spreadability and hardness are inversely related.

Conclusion

The results of the present study reveal that in comparison to the standard Dabur Red toothpaste, the formulated novel nutmeg toothpaste exhibits significant foaming ability, abrasivity, spreadability; and comparable texture, consistency, colour, gritty matter, homogeneity and stability properties. However, it exhibits less favourable odour and taste.

Thus, within the limitations of this study, it can be concluded that there is convincing evidence for the satisfactory physicochemical properties of the nutmeg toothpaste. However, further research is warranted to test other significant properties of the toothpaste.

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