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DESIGN AND EVALUATION OF NUTRACEUTICAL HERBAL CHOCOLATE AS A PALATABLE DELIVERY SYSTEM FOR BITTER PHYTOCONSTITUENTS USING DATE SYRUP

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ABSTRACT

The creation of functional foods enhanced with extracts from medicinal plants has drawn a lot of interest because of its possible health advantages. A popular confection that can effectively transport bioactive chemicals from medicinal plants is chocolate. The creation and assessment of herbal chocolates made using papaya (Carica papaya) and kalmegh (Andrographis paniculata) leaves is the main topic of this study. Flavonoids, phenolics, and alkaloids found in papaya leaves have antibacterial, immune-stimulating, and antioxidant qualities. Because of its hepatoprotective, anti-inflammatory, and immunomodulatory properties, kalmegh is a well-known medicinal plant used in traditional medicine.

In this investigation, various amounts of papaya and kalmegh leaf powders were added to dark chocolate compositions. The physicochemical qualities, sensory attributes, antioxidant activity, and nutritional makeup of the produced chocolates were assessed. In order to improve palatability and provide nutritional value, date syrup was used as a natural sweetener and taste-masking agent to counteract the natural bitterness of kalmegh and papaya leaves.

The results demonstrated that adding powdered herbs leaves to chocolate greatly improved its functional qualities and antioxidant activity. According to sensory study, the taste and texture of herbal powders at moderate concentrations were satisfactory. The created herbal chocolate has the potential to be a revolutionary nutraceutical confection with health advantages.

KEYWORD: Medicated Chocolate, Chocolate formulation, Papaya leaf powder, kalmegh powder, Paediatrics.

INTRODUCTION

Overview Foods that include bioactive chemicals and offer health advantages beyond basic nutrition are known as functional foods. The development of food products enhanced with extracts from

medicinal plants has garnered more attention in recent years.[1] One of the most widely consumed confections in the world is chocolate. Significant levels of flavonoids and polyphenols, which have potent antioxidant qualities and support cardiovascular health, are found in dark chocolate. Chocolate is an appropriate vehicle for beneficial substances because of these qualities. A tropical plant that is extensively grown in many nations is the papaya (Carica papaya).[2] The leaves are abundant in bioactive substances such flavonoids, alkaloids, phenolic compounds, enzymes, vitamins, and minerals, despite the fruit's widespread consumption. Papaya leaves have therapeutic qualities because of these compounds.[3]

According to studies, papaya leaves include phenolic acids including caffeic acid and chlorogenic acid in addition to flavonoids like quercetin, kaempferol, and myricetin. PMC Papaya leaves have long been used to cure stomach issues, infections, and dengue fever.[4] Because of their rich phytochemical content, they also show antibacterial and antioxidant properties. Another significant medicinal plant that is frequently utilized in Ayurvedic medicine is MDPI Kalmegh (Andrographis paniculata). Because of its intense bitter flavor, it is frequently referred to as the “King of Bitters.” Kalmegh’s medicinal qualities are attributed to bioactive substances such andrographolide, flavonoids, diterpenoids, and polyphenols. The plant is used to treat immune-related illnesses, infections, inflammation, and liver problems.[5]

The strong bitterness of herbal actives like papaya and kalmegh is one of the main obstacles to using them, since it reduces patient compliance. In addition to enhancing flavor, natural sweeteners like date syrup offer further nutritional advantages including antioxidants, minerals, and a low glycemic response.[6] Therefore, using date syrup has the twin benefits of improving functionality and disguising flavor.

The bitter taste of papaya and kalmegh leaves restricts direct intake, despite their substantial medical benefits. These herbal powders may enhance chocolate’s flavor and provide health advantages. The goal of this study is to create herbal chocolate enhanced with papaya and kalmegh leaves and assess its sensory and physicochemical qualities.[7]

OBJECTIVE

1.To create herbal chocolates with powdered papaya and kalmegh leaves.
2.To examine the prepared chocolates' physicochemical characteristics.
3.To assess the herbal chocolates' sensory qualities.
4.To ascertain the chocolates' antioxidant activity.
5.To evaluate herbal chocolate's potential as a functional food.[8]

LITERATURE REVIEW

1.PAPAYA

Synonyms: Papaya , Pawpaw / Papaw , Melon tree , Papayotin (for papain enzyme), Vegetable pepsin

Biological Source : Papain is the dried and purified latex obtained from the unripe (green) fruits and leaves of Carica papaya Linn. The latex is collected by making longitudinal incisions on nearly mature green fruits and drying the exuded latex to obtain papain[9]

Family : Caricaceae

Potential Health Benefits of Papaya

1. Antioxidant support
2. Immune system enhancement
3. Digestive aid
4. Platelet count increases
5. Anti-inflammatory effects
6. Detoxification support
7. Skin health improvement
8. Possible promotion of hair growth.[10]

1. **Antioxidant Support**: Papaya leaf juice is a powerful source of antioxidants that help the body fight off dangerous free radicals, shielding cells from oxidative damage and lowering the risk of chronic illnesses like cancer and heart disease.[11]
2. **Immune System Enhancement**: Papaya leaf juice's vitamins and phytochemicals boost immune cell formation and activity, fortifying the body's defences against diseases and infections.[12]
3. **Digestive aid:** Papain and other enzymes found in papaya leaf juice help break down proteins, improving nutrient absorption and reducing constipation, bloating, and indigestion symptoms.[13]
4. **Increased Platelet Count:** Research indicates that papaya leaf juice may help raise platelet counts, especially in diseases like dengue fever where platelet counts drastically decline.[14]
5. **Anti-inflammatory Effects:** Papaya leaf juice contains compounds with anti-inflammatory qualities that help lower inflammation in the body and lessen the symptoms of inflammatory diseases including asthma and arthritis.[15]
6. **Support for Detoxification:** Papaya leaf juice functions as a natural detoxifier, helping the body get rid of pollutants and toxins. Its diuretic qualities improve general detoxification and enhance kidney function.[16]
7. **Skin Health Improvement:** By encouraging exfoliation, cell regeneration, and reducing oxidative stress, topical application of papaya leaf juice or its extracts may help improve skin health. A cleaner, healthier-looking complexion may result from its potential to relieve a variety of skin issues.[17]
8. **Hair Growth Promotion:** Papaya leaf juice may prevent hair loss and encourage hair growth, according to some anecdotal data.[18]

Papaya Leaves As Functional Food Ingredients:

Papaya Leaves as Useful Food Components Papaya leaves are rich in vitamins, minerals, proteins, and carbs. Papaya leaves have been found to contain considerable amounts of flavonoids and phenolic compounds that contribute to antioxidant action, along with about 25% crude protein.[19]

Many beneficial chemicals have been found in papaya leaves by MDPI phytochemical research, including Flavonoids Alkaloids Acids with phenols Tannins Glycosides and Enzymes These substances have immunomodulatory, antibacterial, anti-inflammatory, and antioxidant properties. Additionally, research shows that papaya leaf extracts have high radical scavenging activity in FRAP and DPPH tests, indicating their potential as antioxidants.[20]

Image.1. Papaya Leaves

2.KALMEGH:

Synonyms : Andrographis, Creat, King of Bitters, Bhuinimba (Sanskrit), Kirayat (Hindi).
Biological Source : It consists of the dried aerial parts (leaves and stems) or the whole plant of Andrographis paniculata (Burm. F.) Nees.
Family : Acanthaceae
Active Constituent : The primary therapeutic marker is Andrographolide (a diterpene lactone).Medicinal Properties of Kalmegh.[21]

Kalmegh Medicinal Properties :
Kalmegh Medicinal Properties Traditional medical systems like Ayurveda and Traditional Chinese Medicine make extensive use of Kalmegh (Andrographis paniculata).[22] Key bioactive substances found in Kalmegh consist of: Andrographolide Neoandrographolide Diterpenoids Flavonoids These substances have a variety of pharmacological effects, such as: Anti-inflammatory Hepatoprotective, antimicrobial, and antioxidant Immunomodulatory These qualities have led to the widespread usage of kalmegh in nutraceutical and herbal preparations.[23]

Image.2. Kalmegh

3.Chocolate as a Functional Food:

Synonyms : Cocoa, Cacao, Chocolate beans, Food of the Gods.
Biological source: It consists of the processed, fermented, and dried seeds of Theobroma cacao Linn.[24]
Family : Malvaceae (formerly Sterculiaceae).
Active Constituents : Theobromine (a methylxanthine), caffeine, and flavonoids (specifically epicatechin and procyanidins).[25]

Chocolate properties: Chocolate as a Useful Food Cocoa solids, which include flavonoids and polyphenols, are abundant in dark chocolate. Numerous health advantages, such as better cardiovascular health, decreased oxidative stress, and increased cognitive function, have been linked to cocoa flavonoids. In order to create functional confections with extra health benefits, the use of plant extracts in chocolate has been extensively researched.[26]

Image.3.Dark chocolate

4.Role of Natural Sweetener in Formulation:

A key tactic in the creation of herbal formulations is the use of natural sweeteners, especially when it comes to improving palatability and patient compliance. Although herbal medicines like Andrographis paniculata and Carica papaya are widely known for their medicinal benefits, their strong bitterness sometimes limits their appeal, particularly in younger and older populations.[27]

4.1 Taste Masking Strategies in NDDS:

In Novel therapeutic Delivery Systems, where formulation design seeks to increase patient compliance without compromising therapeutic efficacy, taste masking is a crucial factor. Unpleasant taste has been covered up using a variety of techniques, such as:

- Use of sweeteners and flavoring agents
- Coating and encapsulation techniques
- Complexation and adsorption methods
- Use of viscosity enhancers to reduce drug–taste receptor interaction.[28]

Among them, using natural sweeteners is said to be an easy, secure, and economical strategy. Through competitive interaction at taste receptor sites, sweetness reduces bitterness. This is how

sweeteners work. Furthermore, higher viscosity may minimize the impression of bitter phytoconstituents by reducing their diffusion toward taste receptors.[29]

4.2 Natural Sweeteners as Functional Excipients:

Because of their many uses, natural sweeteners are becoming more popular than refined and synthetic sugars. Natural sweeteners, in contrast to sucrose, offer nutritional and medicinal advantages in addition to sweetness. They are full of bioactive substances that can improve the formulation's overall functional profile, including flavonoids, phenolics, vitamins, and minerals.[30] Among them, date syrup has drawn interest as a potentially useful excipient in pharmacological and functional food applications.[31]

4.3Advantages of Date Syrup over Refined Sugar:

- Natural Origin and Safety:

Phoenix dactylifera fruit is used to make date syrup, which is regarded as a clean-label ingredient because it doesn't undergo the same chemical processing as refined sugar. This increases its acceptability in herbal and nutraceutical compositions.[32]

- Nutritional and Bioactive Richness:

Date syrup contains:

- High levels of **glucose and fructose** (readily available energy sources)
- Essential minerals such as potassium, magnesium, and calcium
- Bioactive compounds including **phenolic acids and flavonoids**

These components increase the formulation's therapeutic potential by contributing to its antibacterial, anti-inflammatory, and antioxidant qualities.[33]

4.4 Effective Taste Masking:

Date syrup's natural flavor ingredients and high sugar content effectively conceal the taste of harsh herbal medications. While its viscous structure restricts the interaction of bitter chemicals with taste receptors, sweetness perception decreases bitterness.[34]

4.5 Relevance to Functional Foods and Herbal Delivery Systems:

Date syrup's use into herbal remedies is consistent with the idea of functional foods, in which components offer both health and nutritional advantages. Date syrup can be regarded as a dual-purpose excipient in this situation, acting both a nutraceutical enhancer and a taste-masking agent.[35] The inclusion of date syrup in this study enhanced the herbal chocolate's taste profile and added antioxidant qualities, suggesting its usage as a cutting-edge nutraceutical delivery method.[36]

MATERIALS AND METHODS

1.Materials

The ingredients used in the preparation of herbal chocolate included:

Sr. No.	Ingredient	Function
1.	Cocoa powder	Flavor and antioxidant source
2.	Cocoa butter	Texture and fat content
3.	Date syrup	Natural Sweetener
4.	Milk powder	Creaminess
5.	Papaya leaf powder	Functional ingredient
6.	Kalmegh leaf powder	Functional ingredient
7.	Vanilla essence	Flavor
8.	Lecithin	Emulsifier

2. Preparation of Leaf Powder

The following methods were used to gather and prepare fresh papaya and kalmegh leaves:

- Distilled water was used to properly wash the leaves.
- For four to five days, the leaves were shade-dried. A fine powder was made from dried leaves.
- Airtight containers were used to store powders.[37]

3. Preparation of Herbal Chocolate

- A double boiler was used to melt the cocoa butter.
- The melted cocoa butter was mixed with Date syrup and cocoa powder.
- The mixture was constantly mixed. Powdered papaya and kalmegh leaves were added in varying amounts.
- Lecithin and vanilla essence were added.
- Molds were filled with the mixture.
- After cooling, the chocolate solidified.[38]

4. Formulation of Herbal Chocolate

The following procedures were used to make the herbal chocolate:

a)Cocoa Butter Melting :

A double boiler apparatus was used to melt cocoa butter at a temperature of about 45 to 50°C.To avoid burning the chocolate and degrading the crystals of cocoa butter, direct heating was avoided.[39]

b)Dry Ingredient Mixture Preparation:

To create a homogenous dry mixture, cocoa powder, powdered Date syrup, and milk powder were weighed in accordance with the recipe and well combined.
When making chocolate, the mixing procedure guarantees that the ingredients are distributed evenly and keeps lumps from forming.[40]

c) Including Herbal Powders:

According to the formulation design, papaya and kalmegh leaf powders were added to the dry mixture in the necessary amounts. To guarantee that the herbal ingredients were evenly distributed throughout the concoction, the powders were properly combined. For the finished chocolate product to have consistent flavour and nutritional qualities, uniform dispersion is crucial.[41]

d) Combining with Melted Cocoa Butter :

Stirring constantly, the dry ingredient combination was gradually combined with the melted cocoa butter. To create a smooth chocolate paste, mechanical stirring was done for ten to fifteen minutes. In order to increase overall sensory acceptance and cover up the bitterness of the herbal powders, date syrup was added during mixing as a natural sweetener.[42]
A homogenous chocolate matrix and consistent inclusion of herbal powders are ensured by careful mixing.

e) Lecithin, an emulsifier:

was added to the mixture at a concentration of 0.3–0.5%. Lecithin increases the smoothness of chocolate, lowers viscosity, and boosts flow characteristics.[43]

f) Addition of Flavour :

To enhance flavour and cover up the bitterness of papaya leaf and kalmegh powders, 0.2–0.3% vanilla essence was used. Herbal chocolate's sensory appeal is further improved by flavouring.[44]

g) The Process of Conching :

For around 30 to 60 minutes, the chocolate mixture was conched. By decreasing particle size and eliminating unwanted volatile components, conching enhances the smoothness of chocolate. Additionally, this procedure improves the chocolate's smoothness and flavour development.[45]

h) Tempering:

A crucial stage in the production of chocolate is tempering, which stabilises the crystals of cocoa butter.[46]

The following is how the tempering procedure was executed:
Chocolate mixture is cooled to 27°C.
Warming up to 31–32°C

Appropriate tempering enhances:
Shine , Texture snap , Stability of shelves , Resistance to the blossoming of fat[47]

i) Moulding Tempered chocolate :
was poured into variously shaped polycarbonate moulds. To ensure even filling and eliminate air bubbles, the moulds were lightly tapped.[48]

j)Solidification and Cooling :
The filled moulds were refrigerated at 10 to 12 degrees Celsius for 30 to 40 minutes, or until the chocolate had fully solidified. The chocolates were taken out of the moulds once they had solidified.[49]

k) Storage and Packaging :
To shield them from light, moisture, and oxygen, the prepared chocolates were wrapped in food-grade packaging or aluminium foil. Before being examined further, the boxed chocolates were kept at room temperature (25±2°C).[50]

5) Quality Factors Taken Into Account During Formulation

During the formulation process, a number of quality characteristics were taken into account.

1. **Texture :** Smooth texture and a pleasing mouthfeel are guaranteed by appropriate fat content and emulsification.
2. **Harmony of Flavours :** To counteract the bitterness of the herbal components, Date syrup and vanilla were added.[51]
3. **Improvement of Nutrition :** The phytochemical and antioxidant content is increased by the addition of papaya and kalmegh powders.[52]
4. **Stability of the Shelf :** Proper packing and tempering extend shelf life and stop fat bloom.[53]
5. **Taste masking:** Date syrup successfully lessened the bitterness of papaya and kalmegh, increasing consumer acceptability.[54]
6. **Nutritional enhancement:** Date syrup gave the formulation more energy value, minerals, and antioxidants.[55]

Advantages

From a medicinal and nutraceutical standpoint, the created herbal chocolate formulation that uses date syrup and papaya and kalmegh leaves has several benefits.[56]

1.Effective Taste Masking and Improved Palatability:

The use of natural sweeteners is essential for disguising bitterness. Patient compliance is significantly impacted by taste masking, particularly when it comes to bitter phytoconstituents.[57] By altering taste receptors and enhancing organoleptic qualities, sweeteners and flavoring chemicals lessen the sense of bitterness.

Date syrup efficiently lowers bitterness and increases sweetness because of its high glucose and fructose content.[58]

2. Nutraceutical and Functional Benefits:

The formulation's medicinal efficacy is increased by date syrup's abundance of polyphenols, antioxidants, minerals, and bioactive substances. Its addition enhances the antioxidant activity and general functional qualities of food.[59]

3. Improved Sensory and Textural Properties:

Date syrup's humectant and binding qualities enhance food systems' viscosity, mouthfeel, and cohesion, improving sensory acceptance.[60]

4. Natural and Safe Excipient:

Date syrup, in contrast to artificial sweeteners, is a natural, safe, and biocompatible ingredient that may be consumed over an extended period of time, meeting the current need for plant-based and clean-label formulations.[61]

5. Enhanced Patient Compliance:

Particularly in pediatric and elderly populations, where bitterness is a substantial obstacle to compliance, palatable dose forms greatly increase adherence to medication.[62]

Limitations

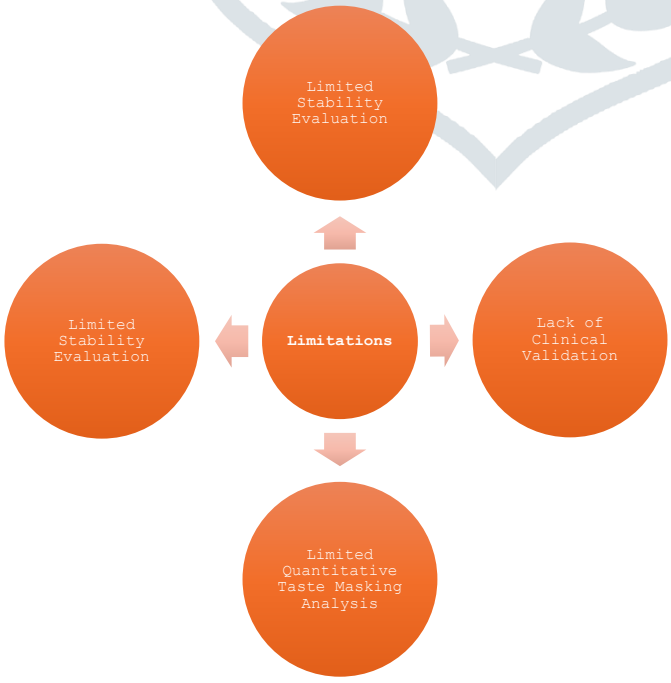

Fig.1.Limitation

Challenges

1. Bitterness of Herbal Constituents:

Taste masking is a significant formulation difficulty because to the strong bitter phytochemicals found in papaya and kalmegh. One of the main factors influencing patient acceptability of oral dose forms is bitter taste.[63]

2. Optimization of Sweetener Concentration:

Although date syrup enhances flavor, overuse may change the product's texture, color, and general acceptability.[64] Higher concentrations of date-based sweeteners have been shown to have detrimental effects on sensory qualities.[65]

3. Physicochemical Stability Issues:

Because they are hygroscopic and interact with other substances, natural sweeteners like date syrup can affect moisture content, viscosity, and shelf stability.[66]

4. Standardization of Herbal Raw Materials:

The consistency and repeatability of the formulation may be impacted by variations in the phytochemical content of papaya and kalmegh leaves.[67]

5. Scale-Up and Processing Constraints:

To preserve quality and stability, industrial-scale manufacturing may need to optimize processing factors including tempering, mixing, and storing.[68]

Future Perspectives

Fig.2.Future Perspective

Conclusion

The study shows that it is possible to successfully make and assess herbal chocolates that contain papaya and kalmegh leaf powders. Chocolate's nutritional qualities and antioxidant activity were greatly improved by the inclusion of herbal powders.

Moderate concentrations of herbal powders demonstrated strong consumer approval, but larger doses somewhat decreased sensory acceptability due to bitterness.

The created herbal chocolate has the potential to be a functional food product with immune-boosting and antioxidant properties.

A innovative approach to the formulation of herbal chocolate is the use of date syrup as a natural taste-masking agent, which increases nutritional value and improves palatability.

Future studies ought to concentrate on:

Optimising the concentration of herbs

Clinical assessment of health advantages manufacturing herbal chocolate goods for commercial use.

REFERENCES

1. Subenthiran S, Choon TC, Cheong KC, Thayan R, Teck MB, Muniandy PK, et al. Carica papaya leaves juice significantly accelerates the rate of increase in platelet count among patients with dengue fever and dengue haemorrhagic fever. Evid Based Complement Alternat Med. 2013;2013:616737. doi:10.1155/2013/616737.

2. Sathasivam K, et al. Antioxidant activity of Carica papaya leaf extracts. J Med Plants Res. 2012. doi:10.5897/JMPR11.1321.

3. Otsuki N, Dang NH, Kumagai E, Kondo A, Iwata S, Morimoto C. Aqueous extract of Carica papaya leaves exhibits anti-tumor activity and immunomodulatory effects. J Ethnopharmacol. 2010;127(3):760-767. doi:10.1016/j.jep.2009.11.024.
4. Aravind G, Bhowmik D, Duraivel S, Harish G. Traditional and medicinal uses of Carica papaya. J Med Plants Stud. 2013;1(1):7-15.
5. Nguyen TT, et al. Phenolic compounds in papaya leaves. Food Chem. 2015. doi:10.1016/j.foodchem.2014.10.029.
6. Baskaran C, et al. Phytochemical evaluation of Carica papaya leaf. Int J Pharm Sci Rev Res. 2012.
7. Senthilvel P, et al. Dengue management using papaya leaf extract. Asian Pac J Trop Biomed. 2013. doi:10.1016/S2221-1691(13)60155-8.
8. Kovendan K, et al. Bioactivity of Carica papaya extracts. Parasitol Res. 2012. doi:10.1007/s00436-012-2854-1.
9. Akbar S. Andrographis paniculata: a review of pharmacological activities and clinical effects. Altern Med Rev. 2011;16(1):66-77.
10. Hossain MS, Urbi Z, Sule A, Rahman KMH. Andrographis paniculata (Burm. f.) Wall. ex Nees: a review of ethnobotany, phytochemistry, and pharmacology. ScientificWorldJournal. 2014;2014:274905. doi:10.1155/2014/274905.
11. Mishra SK, et al. Pharmacological properties of andrographolide. Phytother Res. 2007. doi:10.1002/ptr.2107.
12. Jayakumar T, et al. Anti-inflammatory activity of andrographolide. Biochem Pharmacol. 2013. doi:10.1016/j.bcp.2013.02.009.
13. Gupta S, et al. Immunomodulatory effects of Andrographis paniculata. J Ethnopharmacol. 2017. doi:10.1016/j.jep.2016.11.033.
14. Saxena RC, Singh R, Kumar P, Yadav SC, Negi MPS, Saxena VS, et al. A randomized double blind placebo controlled clinical evaluation of extract of Andrographis paniculata (KalmCold) in patients with uncomplicated upper respiratory tract infection. Phytomedicine. 2010;17(3-4):178-185. doi:10.1016/j.phymed.2009.12.001.
15. Hossain MS, et al. Antioxidant properties and pharmacological activities of Andrographis paniculata. Food Chem. 2014.
16. Kumar S, et al. Hepatoprotective activity of Andrographis paniculata. Pharm Biol. 2012.
17. Chao WW, et al. Anti-inflammatory activity of andrographolide. J Ethnopharmacol. 2010.
18. Zhang XF, et al. Antimicrobial activity of Andrographis paniculata. Food Control. 2011.
19. Katz DL, Doughty K, Ali A. Cocoa and chocolate in human health and disease. Antioxid Redox Signal. 2011;15(10):2779-2811. doi:10.1089/ars.2010.3697.
20. Wollgast J, Anklam E. Polyphenols in chocolate: is there a contribution to human health? Food Res Int. 2000;33(6):449-459. doi:10.1016/S0963-9969(00)00069-7.
21. Wollgast J, Anklam E. Review on polyphenols in Theobroma cacao: changes in composition during the manufacture of chocolate and methodology for identification and quantification. Food Res Int. 2000;33(6):423-447. doi:10.1016/S0963-9969(00)00068-5.
22. Cooper KA, Donovan JL, Waterhouse AL, Williamson G. Cocoa and health: a decade of research. Br J Nutr. 2008;99(1):1-11.

23. Lippi G, Franchini M, Montagnana M, Favaloro EJ, Targher G. Chocolate and cardiovascular health. Clin Chim Acta. 2009.
24. Martín MA, Goya L, Ramos S. Cocoa polyphenols and oxidative stress. Food Chem Toxicol. 2013.
25. Grassi D, et al. Cocoa and blood pressure. Hypertension. 2005.
26. Ding EL, Hutfless SM, Ding X, Girotra S. Chocolate and prevention of cardiovascular disease: a systematic review. Nutr Metab (Lond). 2006;3:2. doi:10.1186/1743-7075-3-2.
27. Tokede OA, Gaziano JM, Djoussé L. Effects of cocoa products/dark chocolate on serum lipids: a meta-analysis. Eur J Clin Nutr. 2011;65:879-886. doi:10.1038/ejcn.2011.64.
28. Rusconi M, Conti A. Theobroma cacao L. and cocoa antioxidants. J Agric Food Chem. 2008.
29. Arranz S, et al. Cocoa flavonoids and health benefits. Nutr Hosp. 2010.
30. Rice-Evans CA, Miller NJ, Paganga G. Antioxidant properties of phenolic compounds. Free Radic Biol Med. 1997;22(7):1221-1238.
31. Roberfroid MB. Global view on functional foods: European perspectives. Br J Nutr. 2002;88(S2):S133-S138.
32. Granato D, Branco GF, Nazzaro F, Cruz AG, Faria JAF. Functional foods and nondairy probiotic food development: trends, concepts, and products. Compr Rev Food Sci Food Saf. 2010;9(3):292-302. doi:10.1111/j.1541-4337.2010.00110.x.
33. Diplock AT, Aggett PJ, Ashwell M, Bornet F, Fern EB, Roberfroid MB. Scientific concepts of functional foods in Europe: consensus document. Br J Nutr. 1999;81(S1):S1-S27.
34. Kaur S, et al. Nutraceuticals: a review. J Food Sci Technol. 2014.
35. Kalra EK. Nutraceutical—definition and introduction. AAPS PharmSci. 2003;5(3):E25.
36. Shahidi F. Nutraceuticals and functional foods: an overview. J Food Sci. 2009.
37. Bigliardi B, Galati F. Innovation trends in the food industry: the case of functional foods. Trends Food Sci Technol. 2013.
38. Biesalski HK. Nutraceuticals and functional foods for health. Eur J Nutr. 2009.
39. Halliwell B. Free radicals, antioxidants, and human disease: curiosity, cause, or consequence? Lancet. 1994;344(8924):721-724. doi:10.1016/S0140-6736(94)92211-X.
40. Prior RL, Wu X, Schaich K. Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements. J Agric Food Chem. 2005;53(10):4290-4302. doi:10.1021/jf0502698.
41. Benzie IF, Strain JJ. Ferric reducing/antioxidant power assay: direct measure of total antioxidant activity of biological fluids and modified version for simultaneous measurement of total antioxidant power and ascorbic acid concentration. Methods Enzymol. 1999;299:15-27.
42. Brand-Williams W, Cuvelier ME, Berset C. Use of a free radical method to evaluate antioxidant activity. LWT Food Sci Technol. 1995;28(1):25-30. doi:10.1016/S0023-6438(95)80008-5.
43. Scalbert A, Johnson IT, Saltmarsh M. Polyphenols: antioxidants and beyond. Am J Clin Nutr. 2005;81(1 Suppl):215S-217S.
44. Heim KE, Tagliaferro AR, Bobilya DJ. Flavonoid antioxidants: chemistry, metabolism and structure-activity relationships. J Nutr Biochem. 2002;13(10):572-584. doi:10.1016/S0955-2863(02)00208-5.
45. Pietta PG. Flavonoids as antioxidants. J Nat Prod. 2000;63(7):1035-1042.

46. Shahidi F, Ambigaipalan P. Phenolics and polyphenolics in foods, beverages and spices: antioxidant activity and health effects—a review. J Funct Foods. 2015;18:820-897. doi:10.1016/j.jff.2015.06.018.
47. McClements DJ. Delivery by design (DbD): a standardized approach to the development of efficacious nanoparticle- and microparticle-based delivery systems. Food Hydrocoll. 2015.
48. Augustin MA, Sanguansri L. Challenges and solutions to incorporating nutraceuticals in foods. Food Struct. 2015.
49. Weiss J, et al. Functional food delivery systems. J Food Sci. 2008.
50. Sohi H, Sultana Y, Khar RK. Taste masking technologies in oral pharmaceuticals: recent developments and approaches. Drug Dev Ind Pharm. 2004;30(5):429-448. doi:10.1081/DDC-120037477.
51. Lohare RS, Makka KA, Ghatole S, Roy S, Kardile PK, Kaity S. Strategies for beating the bitter taste of pharmaceutical formulations towards better therapeutic outcomes. RSC Pharm. 2025;2:59-81. doi:10.1039/D4PM00191E.
52. Aulton ME. Aulton's Pharmaceutics: The Design and Manufacture of Medicines. Elsevier.
53. Beckett ST. Industrial Chocolate Manufacture and Use. 4th ed. Chichester: Wiley-Blackwell; 2009.
54. Afoakwa EO. Chocolate Science and Technology. 2nd ed. Chichester: Wiley-Blackwell; 2016.
55. Harborne JB. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. 3rd ed. London: Chapman & Hall; 1998.
56. Evans WC. Trease and Evans' Pharmacognosy. 16th ed. Edinburgh: Saunders Elsevier; 2009.
57. Kokate CK, Purohit AP, Gokhale SB. Pharmacognosy. Pune: Nirali Prakashan.
58. World Health Organization. WHO Traditional Medicine Strategy 2014-2023. Geneva: World Health Organization; 2013.
59. Abdou RM, Fahmy HA, Khattab AR, et al. Metabolomic and antioxidant characterization of seven Egyptian and Saudi date syrups via GC-MS and UHPLC/MS with sensory bioactive insights. Sci Rep. 2025;15:32604.
60. Taleb H, Maddocks SE, Morris RK, Kanekanian AD. The antibacterial activity of date syrup polyphenols against S. aureus and E. coli. Front Microbiol. 2016;7:198. doi:10.3389/fmicb.2016.00198.
61. Kazemalilou S, Alizadeh A. Optimization of sugar replacement with date syrup in prebiotic chocolate milk using response surface methodology. Korean J Food Sci Anim Resour. 2017;37(3):449-455. doi:10.5851/kosfa.2017.37.3.449.
62. Alanazi FK. Utilization of date syrup as a tablet binder, comparative study. Saudi Pharm J. 2010;18(2):81-89. doi:10.1016/j.jsps.2010.02.003.
63. Al Qafari A, Abd El-Hady ESA, Shabib Z, Almarzooq AF, Alayouni R, Aljutaily T, et al. Utilization of date powder as a natural sweetener in milk chocolate: impacts on production process and quality attributes. Processes. 2025;13(11):3390. doi:10.3390/pr13113390.
64. Ali MIK, Elkhouly AW, Hashem SM. Nutritional and quality characteristics of chocolate spread fortified with date paste as a sucrose substitution. Discov Food. 2026;6:77. doi:10.1007/s44187-025-00469-5.