

A NUTRACEUTICAL CHOCOLATE, "AQUANUT DELIGHT" WITH THE INCORPORATION OF WATER CHESTNUT POWDER (TRAPA NATANS) (ORGANIC BLEND)

Aiman Yaseen Butt*¹

¹Department of Food Science and Technology, Jinnah University for Women, Nazimabad Karachi-74600, Pakistan.

Hafiza Bisma Saleem²

²Department of Food Science and Technology, Jinnah University for Women, Nazimabad Karachi-74600, Pakistan.

Farwah Zehra³

³Department of Food Science and Technology, Jinnah University for Women, Nazimabad Karachi-74600, Pakistan.

Dr. Anum Liaquat⁴

⁴Department of Food Science and Technology, Jinnah University for Women, Nazimabad Karachi-74600, Pakistan.

Author Details

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Corresponding E-mails & Authors*:

Aiman Yaseen Butt

Abstract

This study presents the development of "Aquanut Delight," a nutraceutical chocolate specifically designed for women experiencing menstrual discomfort, including dysmenorrhea. Unlike many chocolates currently available in the market, Aquanut Delight stands out due to its unique blend of ingredients that not only offer indulgence but also serve a functional purpose in alleviating menstrual cramps. The primary ingredient, water chestnut, is known for its health benefits, particularly in providing relief from menstrual pain. Combined with other organic and healthy ingredients, this chocolate not only eases discomfort but also acts as a mood booster, enhancing overall well-being during menstruation. To ensure the quality and

efficacy of Aquanut Delight, various tests were conducted, yielding the following results: ash content of 2.5%, moisture content of 0.01%, and a water activity level of 0.5. Additional tests, including color analysis, centrifugation, and texture analysis (31), were performed to validate the product's consistency and appeal. The chocolate's sugar content was measured at 10.5 degrees, and its pH level was found to be neutral, ensuring a balanced taste and stability, beneficial phytochemical test also performed. Aquanut Delight represents a novel approach to addressing menstrual discomfort by combining the nutritional benefits of water chestnut with the indulgence of chocolate, offering women a unique and comforting nutraceutical option.

INTRODUCTION

Chocolate is one of the most consumed confectionery products all over the world. It is valued for its sensory appeal as well as its health promoting properties. Obtained from cocoa beans of *Theobroma cacao*, chocolate comprises many bioactive compounds including flavonoids, polyphenols, methylxanthines, and minerals that contribute to antioxidant and anti-inflammatory activities (Aprotosoai *et al.*, 2016). Worldwide consumption of chocolate continues to rise, with increasing interest in products that combine health enhancing indulgence. Functional foods are defined as foods that provide health benefits extending nutritional functionality when consumed as part of a regular diet. Nutraceuticals, conversely, are food-derived products that offer medical or therapeutic benefits, including disease prevention or treatment (Damián, M. R *et al.*, 2022). Chocolate has been recognized as promising carrier for functional ingredients due to its broad market appeal, pleasant taste, and ability to mask undesirable flavors of bioactive compounds. Functional chocolate refers to chocolate supplemented with nutraceutical

components such as plant extracts, probiotics, vitamins, minerals, or dietary fiber to enhance its physiological benefits (Montagna *et al.*, 2019). Cocoa is naturally rich in flavanols such as catechin and epicatechin, which are linked with improved cardiovascular health, reduced oxidative stress, and enhanced cognitive function. People often consume chocolate under emotional stress Nehlig A. (2013). As consumer demand healthy and functional foods which urged the industry to make products like this with added bioactive ingredients (Faccinnetto-Beltrán, P *et al.*, 2021). Water chestnut (*Trapa Natans*) is a plant which is commonly found in water filled areas. It is a herbaceous plant which is famous due to its functional and medicinal property. Due to its beneficial effect on health, this plant widely used as a traditional medicine as well (Rehman, A. U *et al.*, 2024). Dysmenorrhea, a painful menstrual cramps of uterine origin happening during menstruation and is one of the most common gynecological complaints among women of reproductive age. The condition is commonly associated with increased prostaglandin production, leading to enhanced uterine contractions, inflammation, and pain (Iacovides, S *et al.*, 2015). As by the use of medications which also impact negative effects on their health, the idea has been raised for producing a product which is actually a chocolate Aquanut Delight. This chocolate which is also considered as nutraceutical chocolate because of its medicinal property and also has the property to provide comfort during dysmenorrhea and uplift the mood swing. The ingredients has been carefully chosen formulated using water chestnut (*Trapa Natans*) as a main functional component and designed to target dysmenorrhea. This product is produced to provide convenient and enjoyable dietary approach for soothing dysmenorrhea while ensuring consumer satisfaction.

Materials and Methods

Materials

The ingredients used in the product formulation were water chestnut (*Trapa natans*), coconut (*Cocos nucifera*), coconut oil (*Cocos nucifera*), milk powder (derived from *Bos taurus*), cocoa powder (*Theobroma cacao*), and sugar (*Saccharum officinarum*). All raw materials were food-grade quality and sourced from the local traditional retail market of Karachi, Pakistan. A visual assessment of the ingredients was conducted for quality, cleanliness, and absence of physical defects before use. No chemical treatment or additional purification was carried out prior to product preparation. The materials were stored under appropriate hygienic conditions at room temperature until the next stage of processing.

Methods

Preparation of Aquanut Delight Chocolate

Cocoa powder (21.4%), Milk powder (21.4%), Water chestnut (10.7%), Coconut crush (10.7%), Coconut oil (21.4%), Sugar (14.3%) were used in the production of Aquanut Delight chocolate sample.

The chocolate preparation process followed the method described by (O. Zadorozhna, 2023) with slight modification. Chocolate samples (~5 g per unit; approximately 25–30 units) were formulated using a double boiler technique. In the first stage, all dry ingredients, including cocoa powder, milk powder, sugar, and water chestnut powder, were combined and thoroughly mixed to ensure their uniformity. Slowly add coconut oil to the dry mixture and blended until a homogeneous mass was obtained. The prepared mixture was placed into a heatproof bowl placed on a double boiler and gently heated with

continuous agitation to achieve a smooth and consistent chocolate mixture. After reaching uniformity, the mixture was allowed to cool slightly at room temperature before pouring into molds for setting. The molded chocolate units allowed solidifying completely, after which they were demolded and packaged, kept under appropriate environmental conditions. (O. Zadorozhna, 2023)

Proximate Analysis

The moisture content was done by using Karl Fischer method (AOAC method). (Nielsen, S. S. 2009). Ash content was done by using dry ashing method (Muffle Furnace) (Ismail, B. P. (2024). Determination of protein was done by biuret test method that is positive (Janairo, G *et al.*, 2015) & the sugar content find out by using refractrometer (Aurica, P. 2021)

Physicochemical Analysis

Determine pH through pH strips by making a solution of chocolate with water then dip the pH strip into the sample and find out its acidity or basicity. The results appeared as neutral which contributing to its balance flavor and texture. The method of finding pH was adopted from (Jabeen, M *et al.*, 2022) Using a water activity meter, determined the water activity readings for the chocolate samples, obtained over three consecutive days, exhibit a remarkable level of consistency, highlighting the reliability of the measurement process. Over a three day span, the chocolate sample showed water activity levels of 0.497, 0.504, and 0.502, with a mean water activity of approximately 0.501 and a standard deviation of 0.00361. These results suggest that the chocolate sample maintained their consistent water activity levels when stored in the freezer. The minor fluctuations

observed may be attributed to factors such as temperature variations within the freezer or slight moisture changes over time. Overall, the stability of water activity within this range indicates that the storage conditions effectively preserved the quality of the chocolate sample. The method of finding water activity was adopted from (Cheng, J et al., 2025). Texture analyzers are used to measure hardness, brittleness, spread ability, adhesion, tensile strength, elongation, etc. of various materials. It is used to measure various properties. Through this test, find the actual texture of chocolate. Place the sample on a flat surface or in petri dish. Find the texture through texture analyzer. Through texture analyzer, the reading occurs 30N, 31N, 32N, with a mean reading of 31N and a standard deviation of 0.8. The data shows that reading power is similar but there is only a slight difference between them. On average the force is about 31 Newton's. This means that the measurements are both precise and accurate, meaning they are reliable no matter what purpose they are used for. The method for finding this is taken by (Liu *et al.*, 2019). Colorimetric is a method used to quantify the color of an object or substance based on its reflection or transmission properties. . A

Table 1 Colorimetric analysis of Aquanut Delight over three days.

Parameter	Mean Value	Standard Deviation	Interpretation
L*	59.60	0.02256	It indicated moderately light appearance of the chocolate sample.
a*	-1.92	0.00	Negative value indicates a slight greenish tint with no variation observed.
b*	-0.68	0.01601	Negative value represents a fine bluish hue with minimal variation.

colorimeter is a device commonly used in colorimetric to measure color in terms of specific parameters, such as Lab* values in the CIELAB color space. (Muharrem Keskin et al, 2017). The method involved analyzing the chocolate sample's color using a colorimeter over three consecutive days. Each day, the chocolate sample was placed in the colorimeter's measurement area, and L*, a*, and b* values were recorded. The instrument was calibrated before each measurement session to ensure accuracy. This data were then analyzed to calculate the mean values for L*, a*, and b* throughout three days and to determine the standard deviation to evaluate color consistency over time. The method was adopted from (Sandro M. Goñi & Viviana O. Salvadori., 2017).

Acid-base titration is a test used to provide information about solutions containing acids or bases. Through this test acidity/ basicity of chocolate was found. Make 0.1N of NaOH

solution. Take 5 gm sample and make a solution. Filled the NaOH solution in a burette. Add some drops of phenolphthalein. Titrate out with NaOH. Note the color change. After using 12ml, 13ml, 14ml solution, there is no color change after titration. The method was adopted from (Tyl, C., & Sadler, G. D., 2017). There are no acidic components present in chocolate. The acid-base titration results have a mean of 13, a variance of 0.66, and a standard deviation of 0.8. This shows that the data points are still close to the average.

Phytochemical Analysis

The presence of bioactive substances that contribute to Aquanut Delight's nutraceutical characteristics was ascertained through phytochemical analysis. The main phytochemicals, such as flavonoids, phenolics, tannins, alkaloids, and saponins, had been determined using standard qualitative techniques. . The alkaline reagent test was used to determine the flavonoid content; a positive result is shown by the production of yellow coloration (Muhammad, 2021). The ferric chloride test, which yields a dark green or bluish tint when phenols are present, was used to identify phenolic chemicals. The gelatin test was used to identify tannins; the presence of tannins is confirmed by the production of a white precipitate. Mayer's test was used to examine alkaloids, which were indicated by the production of a cream-colored precipitate. The foam test was used to find saponins; a positive result is indicated by the production of stable foam. (de Paula Silva, 2022). These phytochemical analysis were qualitative analysis and conducted under a controlled environment in laboratory to ensure accuracy of observations and final results (González-Barrio, 2020).

Sensory Analysis

The sensory analysis of the product Aquanut Delight performed by the hedonic scale method to evaluate the sensory attributes of the product and consumer acceptance and preference. The key parameters that assessed by the panelists are taste, color, aroma, texture and mouthfeel of the product. Each parameter individually scored from 1 (strongly unlike) to 9 (strongly like) according to the panelist acceptability for that parameter. The panelists received instruction on how to utilize the rating systems and an introduction to the assessment process prior to doing the sensory analysis. The sensory evaluation was carried out in white light at room temperature and controlled atmosphere, to avoid biasness. Before evaluating the following sample, a small amount of water and bread were used to remove any leftover taste (Angor *et al.*, 2023). Used coded samples, no discussion among panelist before and after sampling, no distraction all the test performed under carefully monitored conditions for maximum accuracy of the results (Schouteten, 2018).

Shelf life Study

5 grams of the product Aquanaut Delight were stored in petri dishes covered with foil at ambient temperature (25 C) and refrigerate temperature (4 C) to examine the changes in physiochemical and sensory characteristics of the product at different temperatures for 4 months (Tolve, 2022). At scheduled times (0, 15, 30, 45, 60, 75, 90, and 120 days after production) one petri was taken from both temperature samples and the changes observed respectively.

The set of temperatures were used to determine the texture stability, sensory attributes, and to predict the shelf life of the product. (Rothkopf, 2017).

Results and Discussions

Proximate analysis

The proximate analysis of Aquanut Delight indicates that the moisture content of the developed chocolate (0.01%) was very low, ensuring the better stability and improved shelf life by limiting the microbial growth and enzymatic reactions, reducing the degradation risk and improving the quality profile.

The ash content of the product was 2.5% indicating the presence of minerals in the developed products due to natural ingredients such as water chestnut powder that mainly contributes in the mineral content improving nutritional profile of the product predominant minerals that are found in water chestnut are calcium, iron and phosphorous respectively (Alfasane, 2011).

Protein analysis of the product performed through the qualitative method that is Biuret test, deep purplish tint appeared that proved the presences of peptide bonds in the product The plant based ingredients of the product mainly contributed for the protein content in the product, adding variety of nutrients and enhancing its nutrient profile. This proximate analysis determined low moisture content, presence of minerals and protein detection that collectively aid to prove it as a functional food and better stability.

Physiochemical analysis

The physiochemical analysis of aquanut delight conducted under control laboratory, the key parameters that evaluated were water activity, pH, total soluble solids of the product and acidity.

Water activity of the product determined thrice and the mean value was approximately 0.50 that is considered as a below threshold value for the growth of microbes, indicating

that the product Aquanaut Delight has a reduced or low risk of microbial growth and spoilage. Water activity is the important parameter of quality, its low value ensuring the better shelf life of the product. The pH of the product observed to be neutral similarly in the acidity analysis of the product by acid base titration confirming the absence of strong acid or basic components in the product's formulation, indicating its neutral pH that helps to prevent undesirable chemical reaction and product remains stable over time. The total soluble solids of the product determined as 10.5° Brix value, suggesting the formulation of the product archives an optimal balance between stability and taste.

Rheological analysis

Rheological analysis of the product Aquanaut Delight, observing the flowing behavior of the product, viscosity at different RPM by using viscometer. The final results indicated that the viscosity of the formulation decreases with increase in RPM. The visible change in the viscosity also observed, when shear rate changes. This inverse relation of viscosity and shear rate indicating the non-Newtonian flow behavior of the product, the shear thinning or pseudo plastic behavior of the product confirming by observing decrease in viscosity with increase in shear rate, this is the favorable behavior for the processing operations making the product flow more easy while maintaining its thickness during rest stage, contributes to better sensory properties and enhance mouth feel of the product.

Phytochemical analysis

The qualitative analysis of Phytochemicals such as flavonoids, tannins, phenolics, alkaloids and saponins conducted in a controlled environment of laboratory, the results concludes the presence of the multiple essential bioactive components, shown in table 2.

Table 2 Phytochemical analysis

Phytochemical Component	Test Method	Observation	Result
Flavonoids	Alkaline reagent test	Yellow coloration	Present
Phenolics	Ferric chloride test	Dark green color	Present
Tannins	Gelatin test	White precipitate	Present
Alkaloids	Mayer's test	Cream precipitate	Trace
Saponins	Foam test	Stable foam formation	Present

Strong antioxidant activity is indicated by the presence of flavonoids and phenolic chemicals, which are important in reducing inflammation and oxidative stress. This is especially helpful for treating dysmenorrhea and other menstrual problems. While saponins are recognized for their possible role in enhancing general metabolic and immunological activities, tannins contribute to the astringent qualities and may help reduce inflammation. The product's biological action is further increased by the trace levels of alkaloids. Aquanut Delight's phytochemical profile lends credence to its designation as a nutraceutical product, combining medicinal and nutritional advantages. The incorporation of water chestnut, a key functional ingredient, along with other natural components, significantly contributes to the richness of these bioactive compounds (Etaware, 2021). Water chestnut is traditionally recognized for its cooling and anti-inflammatory properties, which aligns well with the intended purpose of

relieving menstrual discomfort. The product is a promising functional food alternative for women's health because the addition of water chestnut and other natural ingredients greatly increases the presence of these bioactive chemicals.

Sensory Analysis

The sensory evaluation of functional chocolates Aquanut Delight was assessed based on texture, color, melting in the mouth, sweetness, aroma and overall acceptance.

Table 3 Sensory Evaluation (9-Point Hedonic Scale)

Sensory Attribute	Mean Score	Standard Deviation	Interpretation
Color	8.2	0.40	Highly acceptable
Aroma	7.8	0.52	Very good
Taste	8.5	0.35	Excellent
Texture	8.1	0.45	Highly acceptable
Overall Acceptability	8.4	0.38	Excellent

According to the findings, the panelists found Aquanut Delight to be very acceptable for every feature that was assessed. The final results concluded that the taste of the product was highly scored parameter, indicating the balance between ingredients, better mouth feel, balance sweetness and flavor due to the natural blend of chocolate with its natural ingredients such as water chestnut powder, coconut powder that were the main reason of preference of product's taste. The other parameters are also scored good (color, texture) indicating the attractive appearance of the product, aroma scored good proving that

product had acceptable and nice smell but slightly lower than other elements (7.8), that need to be improve more in future. According to the results the overall acceptability of the product was excellent (8.4), indicating that the sensory characteristics of the product satisfied consumer expectations and an advantage for market stability of the product by fulfilling the consumers expecatations in terms of taste and flavor along with functional properities.

Shelf life Study

The shelf life assessment of Aquanut Delight for 4 months obseverstions at different storage conditions, ambient temperature (25C) and refrigerate temperature (4C) to determine the stability of product and to predict the best storage conditions for better shelf life.

The sample of product that stored at room temperature observed, in its texture changes occurred, started melting. Shortly after being stored at room temperature, the chocolate started to lose its hardness, a sign of structural instability. The texture continued to deteriorate with time, becoming less uniform and softer. The product's quality gradually declined, especially in terms of mouthfeel and structural integrity, even though it was still usable for up to a month. The substance significantly deteriorated after a month, making it less suitable for ingestion (Hřivna, 2021).

Table 4 shelf life of Aquanut delight (4 months)

Storage Condition	Duration	Texture Stability	Taste & Aroma	Overall Quality
Ambient (25°C)	Immediate	Texture starts altering	No significant change	Acceptable initially
Ambient (25°C)	Up to 1 month	Softening and instability	Slight changes	Reduced quality
Ambient (25°C)	> 1 month	Significant degradation	Noticeable variation	Not acceptable
Refrigerated (4°C)	0–4 months	Stable, firm texture maintained	No noticeable change	Highly acceptable

Taste and the smell were comparatively consistent over the first storage period, with very minor alterations noted over time, despite the quick textural changes. The temperature sensitivity of fat components, which causes disruption in the chocolate matrix, may be the cause of the early commencement of texture alteration under ambient settings another reason might be not using any artificial binder or emulsifier in order to kept this product completely organic and natural blend.

On the other hand, samples kept in a refrigerator at 4°C did not exhibit any notable alterations over the course of four months. The texture, hardness, flavor, color, and general acceptability of the chocolate were all preserved. There were no or insufficient changes observed in the taste and texture of refrigerated sample till 4th month with no spoilage, mold growth or unpleasant aroma, indicating that the product is cold storage

product and predicted the best quality and stability of the product at refrigerate temperature .

Conclusion

This research of development a nutraceutical chocolate that providing both benefits; sensorial and nutritional for all age group, but particularly for the female gender, women that are suffering from menstrual pain and discomfort. The carefully selected ingredients such as water chestnut powder, coconut powder and other natural ingredients help to get relief from dysmenorrhea. All the quality tests such as proximate analysis, physiological analysis, phytochemical analysis, structural properties, sensory and shelf life analysis proved the product's stability, enhanced and improved shelf life and consumer preferences. The results claims that the product is highly stable, with low moisture content, acceptable and controlled water activity that is considered as an essential factor for inhibiting microbial activity and prolong shelf stability. The phytochemical analysis confirmed the presences of essential bioactive compounds such as flavonoids, phenols, tannins and saponins that are relieving the menstrual discomfort, improving the antioxidant and anti-inflammatory activity of the product and make the product more beneficial and unique. Sensory analysis of the product through hedonic scale indicates the high acceptability of the product on the basis of its organoleptic properties such as taste, aroma, color, mouthfeel, texture, making it consumer preferable and market stable product. The shelf life studies indicate that the product is more stable under refrigerated temperature, maintaining its quality for almost 4 months, insufficient or neglectable texture changes occur while no or minimal alter taste and aroma. The all quality analysis represents Aquanut Delight as a nutraceutical chocolate with highly considerable

nutritional and sensory qualities. The development of Aquanut Delight provides the convenient, delicious, enjoyable and ideal approach for relieving dysmenorrhea with proper storage and the possibility of future modification, Aquanut Delight holds great potential for commercialization in the nutraceutical and functional food markets.

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