IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Formulation and Development of a Natural, pH-Balancing Facial Toner Using Common Household Ingredients.

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ABSTRACT - The formulation of a natural pH-balancing facial toner aims to create a skin-friendly, cost-effective, and sustainable skincare solution using readily available household ingredients such as apple cider vinegar, green tea, and aloe vera. This toner is designed to restore the skin's natural pH (4.5–5.5), preventing common issues like dryness, irritation, and acne caused by pH imbalances. The formulation undergoes comprehensive physicochemical, stability, microbial, and skin compatibility testing to ensure safety and efficacy. Key evaluation parameters include pH measurement, stability testing, antioxidant activity (DPPH assay), viscosity, and microbial contamination assessment. A skin irritation test is also conducted to confirm its suitability for all skin types. The study further compares the effectiveness of the formulation with commercially available toners. The results highlight the potential of natural ingredients in skincare, promoting eco-friendly and chemical-free cosmetic formulations. This research supports the growing demand for sustainable and gentle skincare products.

KEYWORDS - Apple Cider Vinegar, Green Tea, Aloe Vera, Household Ingredients, pH-Balancing Facial Toner, Lavender Oil, Sodium Benzoate, Potassium Sorbate.

1. INTODUCTION -

The skin acts as the body's main defense barrier, protecting against environmental threats. Maintaining healthy skin involves hydration, vitamins, mild sun exposure, a balanced microbiome, and the use of safe skincare products. Post-COVID, the focus has shifted from makeup to skincare due to lifestyle changes like remote work, increasing awareness of skin health. Rising demand for skincare has led to concerns over harmful ingredients like heavy metals, prompting a move toward safer, health-focused formulations. Antioxidants such as niacinamide and botanical extracts like green tea are widely used for their protective and stabilizing properties. [1]

The anti-inflammatory, therapeutic, and moisturizing properties of aloe vera (Aloe barbadensis) make it a valuable plant. It may boost blood flow, stimulate fibroblast activity, and support collagen production, aided by components like mannose-6-phosphate, hyaluronic acid, and dermatan sulfate.

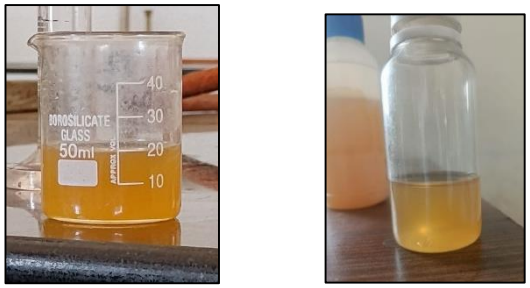

Fig. 1. Product Sample of 20ml for Testing

Apples are rich in antioxidants and nutrients that support overall health. Apple cider vinegar (ACV), made through acetous fermentation of apples, contains acetic acid, minerals, and beneficial compounds.
It's commonly used in natural skincare to balance skin pH. Creating a DIY facial toner using household ingredients like raw ACV and distilled water offers a gentle, natural alternative. Adding essential oils or herbal infusions such as chamomile or green tea enhances the toner's soothing and antioxidant effects, making it suitable for diverse skin types. [2-4]

2. MAIN INGREDIENTS -

The pH-balancing facial toner uses apple cider vinegar to restore pH and exfoliate, lavender oil for soothing and antibacterial action, aloe vera to hydrate and calm the skin, and green tea extract to protect with antioxidants. These ingredients support oil control and promote a fresh, healthy complexion.

2.1. Green Tea -

Green tea, extracted from Camellia sinensis, is valued in cosmetics for its strong antioxidant and anti-inflammatory properties. It helps protect the skin from free radical damage, soothes irritation, and supports clearer skin by targeting acne-causing bacteria. Its antimicrobial action also contributes to healthier, more balanced skin. [5,6]

Fig. 2. Green Tea [5,6]

2.1.1. Green Tea Composition -

Green tea is rich in catechins, especially EGCG, which makes up about 59% of its polyphenols. These antioxidants are preserved through steaming, which prevents their breakdown. Catechin content varies with plant parts, processing, and conditions. Their skin-related benefits depend on bioavailability, with absorption peaking a few hours after intake. [7]

2.1.2. Antimicrobial Properties -

Catechins support antimicrobial action not only by targeting microbes but also by reducing inflammation. They lower oxidative stress, boost nitric oxide production, and inhibit inflammatory markers like IL-6, IL-8, and C-reactive protein, helping to maintain skin health. [8]

2.1.3. Damage To the Bacterial Cell Membrane -

Tea catechins combat bacteria by damaging their cell membranes, reducing their ability to adhere, form biofilms, and release toxins. They also disrupt bacterial fatty acid synthesis, weakening overall function. Gram-negative bacteria are less affected due to their protective outer layer. [9]

2.1.4. Inhibition of Fatty Acid Synthesis -

EGCG in green tea disrupts bacterial growth by inhibiting enzymes involved in fatty acid synthesis, such as FabG and FabI, thereby reducing harmful metabolite production essential for membrane formation and energy. [10]

2.1.5. Inhibition of Other Enzyme Activity -

Green tea catechins hinder bacterial growth by blocking enzymes like protein tyrosine phosphatase, cysteine proteinases, and DNA gyrase. They also disrupt folate synthesis and inhibit ATP synthase, reducing bacterial energy production. [11]

2.2. Apple Cider Vinegar (ACV) -

Apples contain antioxidants, phenolics, and essential nutrients that support skin health. Apple cider vinegar, made from unfiltered apple juice through fermentation, contains acetic acid, flavonoids, and organic acids, making it beneficial for skincare use. [12]

Fig. 3. Apple Cider Vinegar (ACV) [12]

2.2.1. ACV as Anti-inflammatory - Studies show that apple cider vinegar, rich in flavonoids and polyphenols, reduces inflammation and oxidative stress. It also helps regulate lipid levels, supporting its antioxidant and protective role in skincare. Additionally, its bioactive compounds help calm irritated skin and may improve overall skin texture and tone. [13]

2.2.2. ACV as Antioxidant, Antimicrobial and Antifungal - Apple cider vinegar boosts antioxidant enzymes like SOD and glutathione peroxidase and shows strong free radical-scavenging activity due to its polyphenols. It also demonstrates antimicrobial and antifungal effects against E. coli, Staphylococcus aureus, Candida albicans, and other Candida species, supporting its role in skin protection and hygiene. [14,15]

2.3. Aloe Vera - Aloe vera, rich in nutrients and phytochemicals, offers anti-inflammatory, antimicrobial, and healing effects. Commonly used in cosmetics, it supports skin hydration, collagen production, and soothing of burns, making it effective for skincare and anti-aging. [16]

Fig. 4. Aloe Vera (Gel) [16]

2.3.1. Aloe Vera Composition - Aloe vera leaves are made up of three parts: the outer layer, internal transport tissues, and the inner gel. The gel, which is about 99% water and slightly acidic, contains glucomannan- a hydrating compound often used in skincare products for its moisturizing effect. [17]

2.3.2. Pharmacological/Wound Healing Properties - Aloe vera supports wound healing with active compounds like tannic acid and mannose-6-phosphate, promoting collagen formation and fibroblast activity. It speeds up recovery in burns and wounds while reducing inflammation and infection more effectively than standard treatments. [18]

2.3.3. Moisturizing and Anti-aging Properties - Aloe vera is a common ingredient in skincare due to its deep hydrating ability. It supports skin firmness by encouraging collagen and elastin formation, helps clear dead skin cells, and softens the skin through its amino acids, contributing to a smoother, youthful appearance. [19]

2.3.4. Anti-acne Effect - Aloe vera, packed with nutrients and hormones, helps manage acne and inflammation, particularly for oily skin. Its emulgel blend with natural oils cleanses, hydrates, and calms the skin while preventing dryness. [20]

3. HEALTH BENEFITS –

3.1.Aloe Vera - Aloe vera is a widely used natural ingredient in facial toners, valued for its multiple skin-enhancing properties and overall skincare benefits.

3.1.1. Hydration: Aloe vera gel is predominantly composed of water, which provides deep hydration to the skin without leaving a greasy residue.

3.1.2. Soothing Properties: The anti-inflammatory components in aloe vera, such as aloin and emodin, help to calm irritated skin, reducing redness and discomfort.

3.1.3. Antimicrobial Effects: Aloe vera contains compounds with antimicrobial properties, aiding in the prevention and treatment of acne by inhibiting the growth of bacteria.

3.1.4. pH Balancing: Using aloe vera in facial toners helps maintain the skin's optimal pH balance, which is crucial for overall skin health.

3.1.5. Enhanced Skin Healing: The polysaccharides in aloe vera promote skin repair and regeneration, facilitating faster healing of minor cuts and abrasions. [3]

3.2. Apple Cider Vinegar - Apple cider vinegar (ACV) is a natural ingredient celebrated for its various skin benefits, making it a valuable addition to facial toners. Incorporating ACV into your skincare routine can offer the following advantages.

3.2.1. pH Balancing: ACV helps restore the skin's natural pH balance, promoting a healthier complexion.

3.2.2. Antimicrobial Properties: The acetic acid in ACV possesses antimicrobial qualities, aiding in the prevention of acne by reducing bacteria on the skin.

3.2.3. Anti-Inflammatory Properties: ACV's anti-inflammatory effects can help reduce redness and irritation, soothing the skin.

3.2.4. Reduction of Age Spots: Regular use of ACV may help lighten age spots and improve skin tone due to its exfoliating properties.

3.2.5. Exfoliation: ACV contains malic acid, an alpha-hydroxy acid (AHA) that gently exfoliates the skin, removing dead cells and promoting cell turnover. [4]

3.3.Green Tea - Green tea is a potent ingredient widely used in natural facial toners due to its numerous skin benefits. Incorporating green tea into your skincare routine can offer the following advantages.

3.3.1. Antioxidant Protection: Green tea is rich in catechins, particularly epigallocatechin gallate (EGCG), which are powerful antioxidants that help combat free radicals, reducing signs of aging and protecting the skin from environmental damage.

3.3.2. Acne Reduction: Green tea possesses antimicrobial properties that can help fight bacteria responsible for acne, while its anti-inflammatory effects reduce the severity of breakouts.

3.3.3. Anti-Inflammatory Properties: The polyphenols in green tea exhibit anti-inflammatory effects, soothing irritated skin and reducing redness and swelling. [2]

4. MATERIALS AND METHODS –

4.1. Ingredients –

4.1.1. Green Tea - Green tea, rich in EGCG, is a powerful addition to facial toners, helping to calm inflammation, regulate oil, fight acne-causing bacteria, and shield the skin from oxidative damage. [21]

4.1.2. Apple Cider Vinegar - Apple cider vinegar supports skin pH balance, minimizes acne, and inhibits bacterial growth due to its antimicrobial effects.[22]

4.1.3. Aloe Vera - Aloe vera soothes irritation, reduces redness, and hydrates the skin by locking in moisture. It also supports skin repair and helps maintain a smooth, healthy complexion. [23]

4.1.4. Lavender Oil - Lavender oil adds a gentle, floral scent to skincare products, offering a calming effect that helps ease stress and enhances the overall sensory experience. [24]

4.1.5. Preservatives (Sodium benzoate and potassium) - Sodium benzoate and potassium sorbate are commonly used preservatives in cosmetics that prevent bacterial and mold growth, helping maintain product safety and shelf life. [25]

Fig. 5. Ingredients and Apparatus used in the Formulation

4.2. Apparatus –

a. Transparent Container
b. Beaker (20ml, 50ml, 100ml)
c. Measuring Cylinder (10ml, 25ml, 50ml, 100ml)
d. Glass Stirrer
e. Tong
f. Graduated Pipette

g. Ring Stand
h. Petri Dish

4.3. Equipment –

a. Ostwald Viscometer
b. Heating Mental
c. Stalagmometer
d. Incubator

4.4. Method –

4.4.1. Formula –

Table No. 1. Facial Toner Formula for 100ml Formulation

Ingredients	Function	Percentage (%)	Quantity for 100 ml	References
Green Tea Extract (Brewed)	Antioxidant, anti-inflammatory	50%	50 ml	53
Aloe Vera Gel	Hydration, soothing agent	20%	20 ml	54
Apple Cider Vinegar (ACV)	pH Balance, antimicrobial	10%	10 ml	52
Distilled Water	Diluent, maintain formulation	18%	18 ml	55
Preservative (Sodium Benzoate + Potassium Sorbate)	Prevents microbial growth	0.5%	0.5 gm	56
Essential Oil (Lavender/Tea Tree) (optional)	Antibacterial, soothing	0.5%	2-3 drops	57

Table No. 2. Facial Toner Formula for 20ml Formulation

Ingredients	Function	Percentage (%)	Quantity for 100 ml	References
Green Tea Extract (Brewed)	Antioxidant, anti-inflammatory	50%	10 ml	53
Aloe Vera Gel	Hydration, soothing agent	20%	4 ml	54
Apple Cider Vinegar (ACV)	pH Balance, antimicrobial	10%	2 ml	52
Distilled Water	Diluent, maintain formulation	18%	3.6 ml	55
Preservative (Sodium Benzoate + Potassium Sorbate)	Prevents microbial growth	0.5%	0.1 gm	56
Essential Oil (Lavender/Tea Tree) (optional)	Antibacterial, soothing	0.5%	1-2 drops	57

4.4.2. Standard Procedure and Experimental Work –

a. **Brew Green Tea Extract:** Heat 100 mL of distilled water to approximately 80°C (not boiling to prevent degradation of antioxidants).
Steep one green tea bag (or 1g of loose-leaf green tea) in the hot water for 10–15 minutes.
Allow the tea to cool completely to room temperature before use. [26]

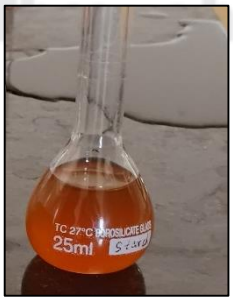

Fig. 6. Breweed Green Tea

b. **Prepare Aloe Vera Solution:** If using fresh aloe vera, extract 20 mL of aloe vera gel from the leaf.
Blend it with a small amount of distilled water to create a smooth liquid

If using store-bought aloe vera gel, ensure it is pure and free from added synthetic chemicals. [27]

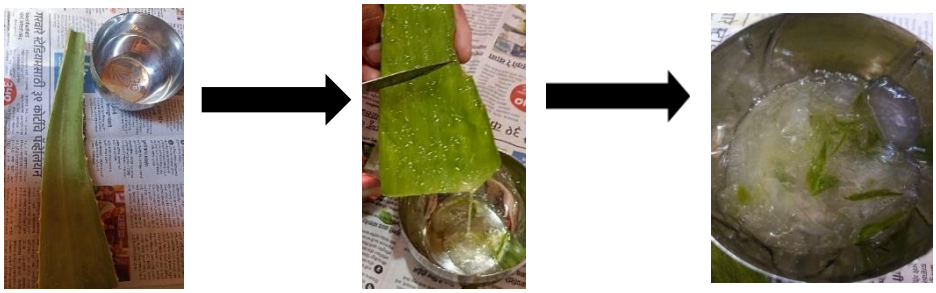

Fig. 7. Aloe Vera Solution Prepration

c. **Mix Apple Cider Vinegar and Green Tea Extract:** In a clean, sterilized glass or plastic mixing container, combine 10 mL of apple cider vinegar with the 50 mL of brewed green tea extract. Stir gently to ensure even mixing. [28]

Fig. 8. Apple Cider Vinegar into Green Tea Extract

d. **Incorporate Aloe Vera Gel:** Add 20 mL of prepared aloe vera solution to the ACV-green tea mixture. Stir slowly to prevent excessive foaming or aeration.

Fig. 9. Aloe Vera Gel Mixing

e. **Add Preservative & Optional Essential Oils:** If a preservative is needed for extended shelf life, dissolve 0.5g of sodium benzoate and 0.5g of potassium sorbate in a small amount of warm water, then add to the formulation.
If using essential oils, add 2–3 drops of lavender or tea tree oil for additional benefits.

f. **Final Mixing & pH Adjustment (If Necessary):** Use a pH meter or test strips to check the final pH of the formulation. The ideal pH range should be 4.5–5.5.
If the pH is too high, add a few drops of apple cider vinegar. If too low, add a bit more distilled water. [29,30]

Fig. 10. pH Adjustment

g. **Storage and Bottling:** Pour the final mixture into a sterilized glass spray bottle or a PET plastic bottle. Store in the refrigerator for up to 2–3 weeks to maintain freshness. [31]

Fig. 11. Finished Product

5. APPLICATION PROCESS –

5.1. Skin Preparation - Use a gentle cleanser that maintains the skin's pH to remove oil, debris, and impurities and then wipe your face with towel.

5.2. Applying the Toner - Pour a small amount (about a teaspoon) of the toner onto a cotton pad, then gently apply it to your face. This helps remove residual dirt, balance the skin's pH, and prepare it for moisturizer.

5.3. Follow-Up Care - Apply a hydrating, non-comedogenic moisturizer to lock in humidity. Sunscreen (Morning Routine) If you are using the color in the morning, follow it up with a sunscreen (SPF 30 or advanced) to cover your skin.

5.4. Frequency of Use - Normal/Oily Skin: Use twice daily (morning & night). Dry/Sensitive Skin: Use once daily or every other day to prevent over-drying. [32]

6. EVALUATION TESTS OF FORMULATION –

To ensure the quality, stability, and effectiveness of our natural pH-balancing facial toner, we conducted a series of evaluation tests. The results confirm that our toner meets all necessary parameters for safety, stability, and user experience.

6.1. pH Measurement – The toner retained a skin-friendly pH between 4.5 and 5.5, aligning with the skin's natural balance. Only minor adjustments were made using apple cider vinegar and distilled water. [33]

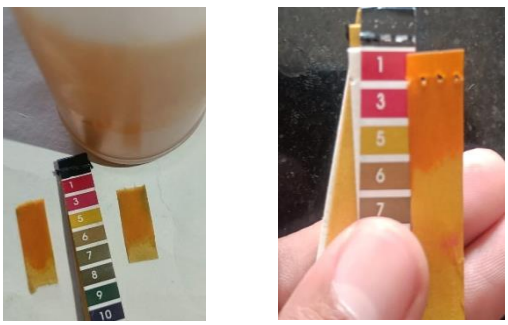

Fig. 12. pH Measurement Test

6.2. Organoleptic Evaluation (Appearance, Color, Odor & Feel) - The toner showed a clear and consistent look with a subtle rose oil fragrance. Sensory evaluation revealed a light, non-greasy texture that felt comfortable on the skin. [34]

6.3. Stability Testing (Short-Term & Long-Term) - The toner remained physically stable for four weeks at 25°C without any signs of phase separation, microbial contamination, or pH variation. Accelerated stability tests at 4°C, 25°C, and 40°C over two months showed no notable changes in color, scent, or texture. [35]

Fig. 13. Stability Test After 4 Weeks

6.4. Viscosity Test - Viscosity analysis using an Ostwald Viscometer indicated that the toner fell within the suitable range for liquid formulations. Flow test results demonstrated good spreadability, ensuring smooth and easy application on the skin. [36]

Fig. 14. Viscosity Test by Ostwald Viscometer

6.5. Skin Irritation Test (Patch Test) - Patch tests conducted on the hand and behind the ear of volunteers showed no redness, itching, or irritation within a few hours, indicating that the toner is safe for external use. [37]

Fig. 15. Skin Irritation Test

6.6. Foam Test (Surfactant-Free Test) - After shaking the toner for 30 seconds, only slight foam was noted, indicating it is a non-foaming formulation without added foaming agents. [38]

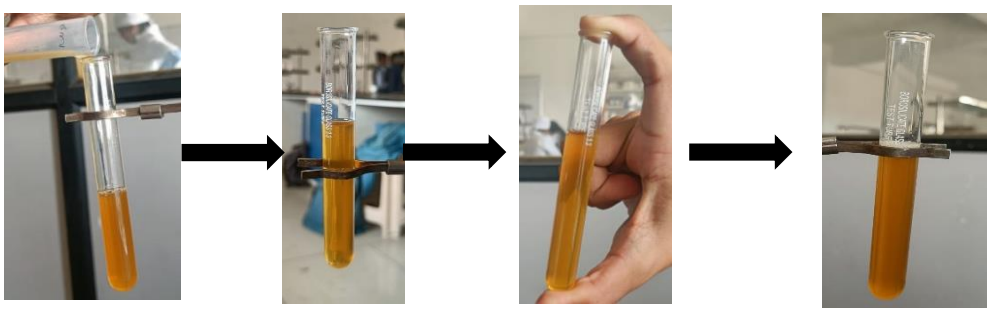

Fig. 16. Foam Test

6.7. Spreadability Test - The toner showed good spreadability, covering an average area of 4.5 cm within 30 seconds, allowing for smooth application and quick skin absorption. [39]

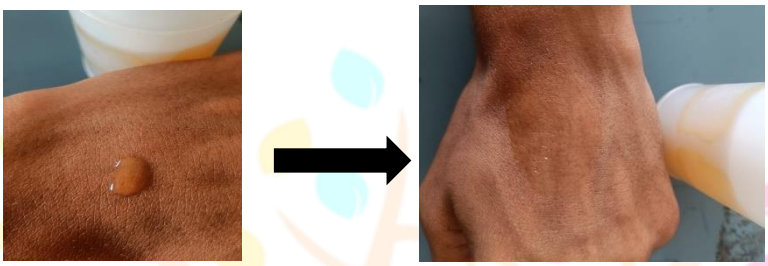

Fig. 17. Spreadability Test

6.8. Evaporation Rate Test - The toner dried within 1–2 minutes, providing an ideal evaporation rate that minimizes moisture loss without leaving any residue. [40]

7. CONCLUSION -

This natural facial toner showcases the effectiveness of household ingredients in providing a sustainable, affordable skincare solution. With the combined benefits of green tea, aloe vera, and apple cider vinegar, the formulation is safe, stable, and skin-friendly. The results support the use of natural alternatives in promoting healthy skin and align with the growing shift toward eco-friendly, chemical-free beauty products.

8. DISCUSSION -

The toner, made from green tea, aloe vera, and apple cider vinegar, effectively balances skin pH and supports healthy skin. Green tea offers antioxidant and antimicrobial benefits, aloe vera soothes and hydrates, and ACV helps regulate pH. Essential oils and preservatives enhance safety and appeal. Overall, the study supports natural, affordable, and eco-friendly skincare as a sustainable alternative to chemical-based products.

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