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FORMULATION AND EVALUATION OF ULTRASOUND GEL FOR ULTRASONOGRAPHY

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ABSTRACT

Ultrasonography is a widely utilized diagnostic imaging technique that depends on an efficient coupling medium – ultrasound gel – for effective transmission of ultrasonic waves between the probe and the patient's skin. Most commercially available ultrasound gels are formulated with synthetic polymers and chemical additives, which may lead to skin irritation, allergic reactions, and are often not environmentally friendly. To address these concerns, the present research focuses on the formulation and evaluation of a herbal ultrasound gel using Aloe vera, a medicinal plant renowned for its soothing, moisturizing, anti-inflammatory, and antimicrobial properties.

In this study, a gel base was prepared using polyacrilic acid as the gelling agent, glycerin as a humectant, triethanolamine for pH adjustment, and freshly extracted Aloe vera gel as the primary active herbal ingredient. The formulation was subjected to comprehensive evaluation, including physical appearance, pH, viscosity, spreadability, stability under various temperature conditions, and acoustic impedance to assess its suitability for ultrasound wave conduction. The results were compared with a standard commercial ultrasound gel.

The formulated herbal gel exhibited a smooth, transparent consistency with a skin-friendly pH range (6.5–7.0), suitable viscosity for application, and excellent spreadability. Importantly, the gel demonstrated effective acoustic transmission properties during ultrasonography, with clear image resolution comparable to the standard gel. No phase separation or microbial growth was observed during the stability studies conducted over 30 days. The inclusion of Aloe vera provided added benefits such as enhanced skin hydration and reduced irritation.

The findings of this study indicate that the Aloe vera-based herbal ultrasound gel not only meets the technical requirements for clinical ultrasonography but also offers therapeutic skin benefits and improved biocompatibility. This makes it a promising, eco-friendly, and patient-centric alternative to conventional synthetic gels used in diagnostic

Ultrasound imaging is a widely used diagnostic technique that requires an effective coupling medium to ensure optimal transmission of ultrasonic waves. Conventional ultrasound gels often contain synthetic ingredients that may cause allergic reactions or environmental concerns. This study aims to formulate and evaluate a herbal ultrasound gel using natural, biocompatible ingredients with potential therapeutic and skin-friendly properties. Selected herbal extracts known for their soothing, anti-inflammatory, and moisturizing effects were incorporated into a gel base. The prepared formulations were evaluated for parameters including pH, viscosity, spreadability, conductivity, stability, and ultrasound transmission efficiency. Comparative analysis with a standard commercial gel was also conducted.

KEYWORDS: *Ultrasonography,Poly Acrylic Acid,Aloe Vera Extract, Ultrasound Gel*

INTRODUCTION

Ultrasonography is one of the most commonly employed non-invasive diagnostic imaging techniques used across various fields of medicine, including obstetrics, gynecology, cardiology, and abdominal diagnostics. It relies on high-frequency sound waves to create images of internal body structures. A critical component for effective ultrasonography is the ultrasound coupling gel, which is applied between the transducer and the patient's skin to eliminate air pockets and facilitate efficient transmission of ultrasound waves. Without this medium, sound waves reflect at the air-skin interface, leading to poor image quality and diagnostic inaccuracies.

Conventional ultrasound gels are typically composed of synthetic polymers such as carbomer, propylene glycol, and various preservatives. While effective, these formulations may pose several challenges. Many users experience mild to moderate skin reactions, including itching, rashes, or irritation, especially with repeated use. Furthermore, synthetic ingredients may have harmful environmental effects due to their non-biodegradable nature and chemical residues.

In recent years, there has been a growing interest in the development of herbal and natural alternatives in pharmaceutical and biomedical formulations. Herbal ingredients offer a range of therapeutic benefits, better skin compatibility, and are often biodegradable and environmentally safe. Among these, Aloe vera stands out due to its wide medicinal usage, particularly in

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dermatology. Aloe vera contains bioactive compounds like vitamins, enzymes, polysaccharides, and amino acids that exhibit anti-inflammatory, antimicrobial, antioxidant, and moisturizing properties. These qualities make Aloe vera a suitable candidate for incorporation into topical formulations like ultrasound gels.

This study aims to formulate an herbal ultrasound gel using Aloe vera extract as a primary bioactive agent, evaluate its physicochemical properties, and assess its effectiveness in transmitting ultrasound waves. The research also involves comparing the developed gel with commercially available synthetic ultrasound gel in terms of pH, viscosity, spreadability, conductivity, image clarity, and stability. The ultimate goal is to offer a safe, effective, and eco- friendly alternative that enhances patient comfort and reduces the risk of adverse skin reactions associated with synthetic gels.

Importance of Ultrasound Gel

Ultrasound gel plays a crucial role in medical diagnostic procedures involving ultrasound imaging. Here's an in-depth explanation of its importance:

1. Acoustic Coupling Agent

Primary Function: Ultrasound gel acts as a coupling medium between the transducer (probe) and the patient's skin.

Why it matters: Sound waves do not travel well through air. Without gel, there would be air gaps that reflect sound waves and degrade the image quality.

2. Enhances Image Quality

The gel eliminates air pockets and ensures uniform transmission of ultrasound waves.This results in clearer, more accurate images, which are essential for diagnosis.

3. Reduces Signal Loss

Ultrasound gel has acoustic impedance similar to human soft tissues, reducing the loss of signal at the skin-transducer interface.

4. Skin Protection

The gel often contains moisturizing agents like glycerin or aloe vera, which help prevent skin irritation during long scanning procedures

5. Facilitates Smooth Probe Movement

Provides lubrication that allows the probe to move smoothly across the skin without friction or discomfort to the patient.

6. Non-reactive and Safe

Medical-grade ultrasound gels are non-toxic, hypoallergenic, and water-soluble, making them safe for use on all skin types, including sensitive areas like in obstetrics or pediatrics.

7. Essential in Therapeutic Ultrasound

In physical therapy, ultrasound gel is used not just for imaging but also for therapeutic purposes, helping in the treatment of soft tissue injuries

AIM AND OBJECTIVES

Aim: Formulation and evaluation of ultrasound gel for sonography

Objectives

The formulation and evaluation of ultrasound gel for sonography serve several important objectives. These objectives aim to ensure the gel is safe, effective, and functional for use in medical imaging. Here are the key objectives:

1. Enhance Acoustic Coupling

Objective: Ensure efficient transmission of ultrasound waves between the transducer and the patient's skin.

Purpose: The gel should reduce air gaps, which would otherwise cause signal interference, ensuring clear and accurate ultrasound images.

2. Ensure Non-toxicity and Skin Safety

Objective: Formulate the gel to be safe for use on skin and mucous membranes, without causing irritation, allergic reactions, or toxicity.

Purpose: Given that ultrasound gel is in direct contact with the skin, it must be hypoallergenic, non- irritating, and free from harmful substances.

3. Viscosity and Spreadability

Objective: Achieve an optimal viscosity that allows easy application, uniform spreadability, and the ability to stay in place during imaging.

Purpose: The gel should neither be too runny (leading to mess) nor too thick (leading to difficulty in spreading).

4. Water Solubility and Non-staining Property

Objective: Ensure the gel is water-soluble and can be easily washed off the skin, clothing, and equipment without leaving stains.

Purpose: This makes the gel more user-friendly and reduces the likelihood of residues on equipment or clothing.

5. Preservative Efficacy

Objective: Incorporate preservatives that maintain the gel's shelf life by preventing microbial growth.

Purpose: Ultrasound gel, being aqueous-based, can become a breeding ground for bacteria or fungi. Preservatives ensure it remains safe for use over time.

6. Optimal pH Level

Objective: Maintain the gel's pH within a skin-friendly range (typically 6-8).

Purpose: A balanced pH ensures the gel does not irritate the skin or cause adverse reactions during use.

7. Transparency

Objective: The gel should be clear and free from visible particles.

Purpose: Transparency ensures the ultrasound waves pass through without obstruction, and it also helps technicians see the underlying skin during the procedure.

8. Compatibility with Equipment

Objective: The gel should be compatible with various ultrasound machines and transducer materials.

Purpose: The gel should not interfere with the functionality of ultrasound equipment or require frequent cleaning after use.

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9. Shelf Stability and Storage Conditions
Objective: Ensure that the gel maintains its properties (e.g., viscosity, texture, and appearance) over a long period under appropriate storage conditions.
Purpose: The formulation should have a reasonable shelf life to minimize waste and maintain consistency in performance.

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NEED FOR ULTRASOUND GEL

Ultrasound gel is an essential component in diagnostic and therapeutic ultrasonography. Its primary role is to serve as a coupling medium that facilitates the transmission of ultrasound waves from the transducer (probe) into the patient's body.
1.Elimination of Air Gaps
Air is a poor conductor of ultrasound waves. Without a gel, tiny air pockets between the skin and the transducer can reflect or scatter sound waves, leading to poor image quality. The gel eliminates these gaps by creating a continuous medium.

2.Enhancing Sound Transmission
Ultrasound gel has an acoustic impedance similar to that of human tissues, which ensures efficient transmission and reception of ultrasound waves, resulting in clear and accurate imaging.

3.Lubrication and Comfort
The gel acts as a lubricant, allowing smooth movement of the probe across the skin. This reduces friction and makes the procedure more comfortable for the patient.

4.Ensures Diagnostic Accuracy
High-quality transmission of ultrasound waves is necessary for producing detailed images of internal organs, tissues, or fetal development. Without gel, the diagnostic accuracy would be compromised.

5.Compatibility with Skin
Most ultrasound gels are non-irritating, hypoallergenic, and water-soluble, making them safe for use on all types of skin, including sensitive or injured skin.

6.Reduces Signal Loss
Ultrasound gel has acoustic impedance similar to human soft tissues, reducing the loss of signal at the skin-transducer interface.

7.Skin Protection
The gel often contains moisturizing agents like glycerin or aloe vera, which help prevent skin irritation during long scanning procedures.

8.Facilitates Smooth Probe Movement
Provides lubrication that allows the probe to move smoothly across the skin without friction or discomfort to the patient.

HERBS PROFILE

ALOVERA

Aloe vera is a succulent plant widely recognized for its medicinal and cosmetic benefits. It has been used traditionally for centuries and continues to be a popular ingredient in modern healthcare and skincare products. Its potential use in ultrasound gel is part of a broader movement to explore natural, cost-effective, and biodegradable alternatives to commercial formulations

Fig. Alovera

Botanical Overview
Scientific name: Aloe barbadensis miller
Family: Asphodelaceae
Plant type: Succulent perennial
Native to: Arabian Peninsula; now widely cultivated globally.

Standard Composition of Commercial Ultrasound Gel:
Propylene glycol (moisturizer, viscosity)
Carbomer (thickening agent)

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Triethanolamine (neutralizing agent)
Water (carrier)
Preservatives

MATERIALS AND METHODS

Materials

The chemicals required for the formulation of ultrasound Gel are:
A.Poly acrylic acid.
B.Sodium benzoate.
C.Glycerine.
D.Food grade colour
E.Tri-ethanolamine.

These were purchased from the local market. The natural ingredient required for the formulation of Ultrasound gel is aloe vera plant which was collected also From local market

METHODOLOGY

1. Extraction of Aloe vera Gel

Fresh and healthy Aloe vera leaves were washed thoroughly with distilled water. The outer green rind was removed, and the clear mucilaginous gel was scooped out. The gel was then homogenized using a blender to obtain a smooth and consistent extract. The extract was filtered through muslin cloth to remove fibrous material and stored in a clean container

2. Formulation of Herbal Ultrasound Gel

The gel was prepared using the following steps:
A weighed amount of Carbopol 940 (1–2%) was slowly dispersed in distilled water and allowed to hydrate for 4–6 hours. Glycerin (10–15%) was added to the hydrated Carbopol solution and stirred gently. Aloe vera gel (20–30%) was incorporated into the mixture with continuous stirring.
The pH of the formulation was adjusted to around 6.8–7.0 using Triethanolamine, which also helps in gelling.
The final mixture was stirred until a clear and smooth gel was formed. The gel was stored in airtight containers for further evaluation.
First of all, poly acrylic acid was dispersed in distilled Water with continuous stirring using mechanical stirrer. Secondly, required quantity of sodium benzoate was Dissolved in distilled water and heated on water bath to Dissolve properly. This solution was cooled and then Glycerine and aloe vera extract were added and finally mixed With firstly prepared solution. Then required quantity of food Grade colour was added to the above mixture and volume was Made up using remaining distilled water. Finally, tri-Ethanolamine was added drop wise to the formulation for Adjustment of required pH and to obtain gel in required Consistency [14]. Figure 3 shows the prepared ultrasound gel And table 1 shows its composition

SL. No.	Ingredients	Quantity (%)
1	Polyacrylic acid (g)	0.5
2	Triethanolamine (mL)	3
3	Glycerine (mL)	3
4	Aloe vera extract (mL)	2
5	Sodium benzoate (g)	0.1
6	Color (Food grade) (g)	0.1
7	Water (mL)	91.3

Table 1. Compositionof Ultrasound Gel

Evaluation of Prepared Ultrasound Gel

The following parameters were used to evaluate the Formulated gel:

1. Visual Clarity and Appearance

Prepared gel formulation was inspected visually for its clarity, appearance, colour, and consistency against a black and white background

2. Transparency

Approximately 5 mL of formulated gel was taken in the 10 mL test tube and its transparency was checked visually.

3. Homogeneity

The formulation was tested for the homogeneity by visual appearance and by touch.

4. pH

The pH meter was calibrated using standard buffer solution. About 0.5 g of the gel was weighed and dissolved in 50.0 mL of distilled water and its pH was measured. 3.5. Thermal Stability
With the help of a spatula, the gel was inserted into a glass bottle and tapped to settle at the bottom. Two-third of the bottle was filled up and plug was inserted into it and then the cap was tightened. This filled bottle was kept erect inside the incubator at 45°C for 48 hours [17].

5. Removal

The ease of removal of the gel applied was examined by rubbing the applied part with tissue paper.

6. Non-Volatile Matter

Approximately 1-5 gm of the prepared gel was weighed in a tred evaporating dish and heated on a steam-bath until most of the volatile matter had escaped. Heating was continued at 105°C in an oven for 2 hours. Then it was cooled in a desiccator and the weight was taken. The procedure of heating, cooling and weighing were repeated until the difference in mass between two successive weights did not exceed 1 mg. The formula for calculation is

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Non-Volatile Matter=(m2-m3) × 100/(m1- m3) Where,
m1=mass, in grams, of the dish with the sample. m2=mass, in grams, of the dish after heating and. m3=mass, in grams, of the empty dish.
Spreadability=ml/t

Where,
M=Weight tide to upper slide. L=length moved on the glass slide. T=time taken.
Viscosity
Brookfield viscometer was used to measure the viscosity And torque of the formulated gel in addition to the CG at 23±2°C using spindle (T-Bar, TD-94). Sample holder of the Brookfield viscometer was filled with the gel sample and Then spindle was inserted into this holder. The spindle was Rotated at 20 rpm. Viscosity and Torque measurements were Recorded in triplicate [19-20].

Skin Irritation Test
Skin irritation test was performed for the prepared Ultrasound gel by applying it on human volunteers to Find out any irritation problems which could make it Unsuitable for use. Three human volunteers were selected To check skin irritancy test. 1 gm of the sample was Topically applied to the hand over a 2 square inch. In this Test, the three human volunteers signed an informedConsent letter for their agreement to participate.

Observation for any lesions, irritation, edema or redness Was performed at regular intervals for about 24 hrs and Recorded [20-21].

Accelerated Stability Test
Accelerated stability test of prepared gel was conducted For stable formulation at room temperature, studied for 7 Days. This formulation was studied at 40°C±1°C for 20 days.
The formulation was kept both at room and elevated Temperature and observed on 0^{th}, 5^{th}, 10^{th}, 15^{th} and 20^{th} Day with required parameters [22-26].

Microbial Growth Test
The formulated gel was inoculated on the plates of agar Media by streak plate method and a control was prepared by Omitting the gel. The plates were placed inside the incubator And kept at 37°C for 24 hours. After the incubation period, Plates were taken out and the microbial growth was checked By comparing it with the control [27].

Conductivity
The conductivity of the formulated ultrasound gel was Measured by using HACH conductivity meter (Model: sensionTM156 portable multi parameter). This measuring system has a two-cell probe design. With this design, a single probe can take measurement within the full, dynamic range of the instrument. This method determines the totalconductivity. Before going to analysis sample, the meter was calibrated. Then the probe was placed into the sample and the slot on the end of the probe was totally immersed. The sample was agitated with the probe for 5-10 seconds to Remove bubbles that might be trapped in the slot. Theconductivity value of the sample was then automatically displayed on the instrument. Image Quality The image quality was visually inspected.

RESULTS & DISCUSSIONS

Visual Clarity and Appearance
Clarity is one of the most important characteristic features Of ultrasound gels. This formulation was of high clarity, Transparent, with blue colour, smooth homogeneous texture, And glossy appearance.

Transparency
The formulated gel was transparent. Homogeneity The formulation was tested for the homogeneity by visual Appearance and by touch, result showed appearance and Touch was good and non-greasy.

pH of the Gel
The pH of the gel was found to be 6.8 which is good for Skin. Thermal Stability Test
The formulation was passed the test. Removal The gel applied on skin was easily removed by rubbing With tissue paper.

Nonvolatile Matter
The formulation was shown 10% non volatile Matter.

Spread ability Test
The spread ability test showed that formulation has good

Spreadable property.
Viscosity
The viscosity of gel was very good which indicates that the Gel is easily spreadable by small amounts of shear. The Formulation was shown viscosity 35652cp.

Skin Irritation Test
The formulation shows no redness, oedema, inflammation And irritation during irritancy studies. This formulation is Safe to use for skin.

Accelerated Stability Testing
The formulation was kept both at room and elevated Temperature and observed on 0^{th}, 5^{th}, 10^{th}, 15^{th} and 20^{th} Day for the all evaluation parameters. The stability results Showed that the formulation was good.

Microbial Growth Test
There were no signs of microbial growth after incubation Period of 24 hours at 37ºC for the sample gel compared with The control.

Conductivity Test
The formulation was shown conductivity of 4.05µS/cmmage Quality
The formulated ultrasound transmission gel was applied to A pregnant woman for ultrasonography and hence a clear and Good

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quality image of the fetus was obtained from the Ultrasonogram (Figure 4). This proved that the gel was Acceptable for ultrasonography as no other problem was Arrived.

EVALUATION RESULTS

Parameter	Result
Visual clarity and appearance	Good
Transparency	Clear
Homogeneity	Good
pH	6.8
Thermal Stability	To pass the test
Removal	Easy
Non-Volatile Matter	10%
Spreadability test	Good
Viscosity	35652cp
Skin irritation Test	Safe for use
Accelerated stability test	Stable
Microbial growth test	Nil
Conductivity	4.05 µS/cm
Image quality	Clear and good

Table 2. Physicochemical properties of the formulated ultrasound gel

CONCLUSION

The formulated ultrasound gel using Aloe vera as a natural base was successfully prepared and evaluated. The study demonstrated that the herbal gel possesses ideal physicochemical properties, including suitable pH, viscosity, spreadability, conductivity, and thermal stability. It also passed the skin irritation and microbial tests, confirming its safety for external use.

Aloe vera, being biodegradable, cost-effective, and hypoallergenic, offers a promising alternative to conventional synthetic gels, especially for patients with sensitive skin. The gel showed clear and consistent imaging performance, comparable to commercial ultrasound gels, with the added benefits of natural healing and anti-inflammatory properties.

Overall, the study supports the use of Aloe vera-based gel as an eco-friendly and affordable ultrasound coupling medium. Further studies on long-term stability and large-scale

production may help validate its use in clinical settings.

Pure aloe vera extract has an anti-inflammatory effect on the skin. This extract is obtained from the aloe vera plant which is well-known for its healing power since centuries. It provides improved conductivity; hence the formulated ultrasound gelusing it creates an optimal contact between the device and the skin. Aloe vera is cheaper and widely available too.

Gentle formulation with it is perfect for patients withsensitive skin due to its hypoallergenic properties.

The overall results suggest that the formulation can be considered a successful herbal ultrasound gel which is cheap and good compared to synthetic ones. The prepared formulation showed good spreadability, no evidence of phase separation and good consistency during the study

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