RESEARCH PAPER

HERBAL ROLL-ON FORMULATIONS FOR THE TOPICAL MANAGEMENT OF DYSMENORRHEA: FORMULATION STRATEGIES, SKIN PERMEATION AND THERAPEUTIC POTENTIAL: A REVIEW

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ABSTRACT
Dysmenorrhea commonly referred to as menstrual cramps, is a prevalent condition characterized by painful uterine contractions that can affect the daily life functionality and general well-being of individuals. The increased production of prostaglandins that is witnessed during menstruation, leads to increased uterine contractions and hence pain. Although standard analgesic treatment has been effective in managing this condition, the frequent use of analgesics has adverse effects which makes the development of convenient topical herbal medication desirable.
This project deals with developing a herbal roll-on for the topical management of dysmenorrhea. This treatment uses herbal and natural ingredients including lavender, eucalyptus oil, chamomile, rosemary, camphor, menthol, and appropriate carriers with proven pain-relieving, anti-inflammatory, antispasmodic, cooling and counter-irritant properties. The roll-on formulation offers a controlled and even dose of medication directly onto the affected part hence providing a targeted and effective therapy. The product was made using appropriate oil phase incorporation techniques and was placed into appropriate roll-on containers.
The formulation was subjected to tests including physical appearance, pH, viscosity and spreadability, drug content, in-vitro drug release, skin irritation, microbial examination, stability, rolling performance, leakage test and skin permeation. Proper packaging was also considered for the product to ensure stability of the formulation and protection of the active herbal ingredients. It was concluded that a roll-on herbal medication offers a convenient and patient-friendly method for the topical management of dysmenorrhea. However, further studies including clinical trials and scale up of the formulation into commercial production need to be considered for this new herbal formulation to be successful.

KEY WORDS:
Herbal roll-on, Topical formulation, Essential oils, Pain relieve, Skin permeation, Analgesic activity, Anti-inflammatory activity, Herbal medicine.
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Introduction

Dysmenorrhea:- Dysmenorrhea refers to pain or discomfort associated with menstruation and is one of the most common gynecological conditions affecting women of reproductive age. The pain is usually felt in the lower abdomen and may radiate to the lower back and thighs. It can range from mild discomfort to severe cramping that interferes with daily activities. The major cause of menstrual pain is the increased production of prostaglandins in the uterus during menstruation. [1,3]

Types Of Dysmenorrhea

Dysmenorrhea is classified in to two types :-

Primary dysmenorrhea is menstrual pain without any underlying physical abnormality and usually begins 6 months to 2 years after menarche with ovulatory cycles. The pain commonly starts 1–2 days before menstruation, peaks on the first day, and may radiate to the lower back and thighs. [2]

Secondary dysmenorrhea is caused by underlying conditions such as endometriosis, fibroids, adenomyosis, pelvic adhesions, IUDs, or PID. The pain may begin earlier in the cycle, persist after menstruation, and treatment mainly focuses on managing the underlying cause. [2]

Anatomy and Physiology of Menstruation

1. Anatomy of Uterus -

Fundus: The uppermost and widest part of your uterus. It connects to fallopian tubes .

Corpus: The main part of uterus is Corpus, where a fertilized egg implants during pregnancy.

Isthmus: The part of uterus between corpus and cervix. This is the site where uterus starts to narrow or thin.

Cervix: The lowest part of your uterus. Cervix opens to vagina. The endometrial lining of uterus.

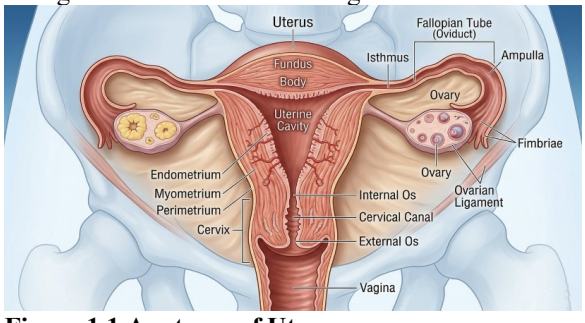


Figure 1.1 Anatomy of Uterus

Location -

Uterus is located between bladder and rectum. It's supported by pelvic floor muscles and perineal body . Ligaments in pelvis, lower back and hips also helps to hold uterus in their place.

Layers of Uterus –

Uterus consists of three layers.

- PERIMETRIUM :-The outermost, protective layer.
- MYOMETRIUM :-The highly muscular middle layer. This is what expand during pregnancy and contracts to push your baby out.
- ENDOMETRIUM **:-**The inner layer or lining of uterus. This layer of uterus is shed during menstruation.[2,3]

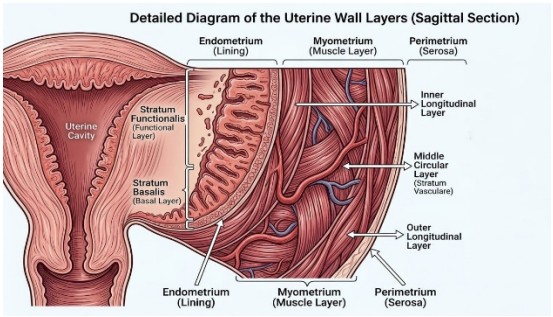


Figure 1.2 Layers of Uterus

2. **Menstrual Cycle:-** The menstrual cycle is the term used to describe sequence of events that occur in body as it prepares for the possibility of pregnancy each month . Every person's cycle is slightly different. The average length of a menstrual cycle is 28 days . However a cycle can range in length from 21 days to about 35 days and still be normal.

Phases of Menstrual Cycle :

The specific events that occur during menstrual cycle are,

1. The menses phase
2. The follicular phase
3. Ovulation
4. The luteal phase

The Menses Phase :- This phase begins on the first day of period. It's occurs when the lining of uterus sheds through vagina if pregnancy hasn't occurred. Most of the people's bleed for 3-5 days, but a period lasting only 3 days to many 7days is usually not a cause for worry.

The Follicular Phase :- This phase begins on the day get your period and ends at ovulation. During this time, the level of hormone estrogen rises, which causes the lining of uterus to grow and thicken. In addition another hormone FSH causes follicles in ovaries to grow. During days 10 to 14, one of the developing follicles will form a fully mature ovum.

Ovulation :-This phase occurs roughly at about day 14 in a 28 days of menstrual cycle. A sudden increase in another hormone LH causes ovary to release egg. This event is called ovulation.

The Luteal Phase :-This phase lasts from about days 15 to day 28 .Egg leaves ovary and begins to travel through your fallopian tubes to your uterus. The level of hormone progesterone rises to help prepare your uterine lining for pregnancy [2,3]

3. **Hormones Involved in Menstrual Cycle –**

Hormones are chemical messengers produced by endocrine gland. They travel through bloodstream and regulate body functions like growth, metabolism, mood and reproduction. Major hormones involved are

Gonadotropin Releasing Hormones (GnRH)	GnRH travels to the pituitary gland via blood stream and binds to the receptors that signal the gland to make other hormones that play critical roles in the menstrual cycle.
Follicle Stimulating Hormone (FSH)	The pituitary gland releases FSH to stimulate the follicles in ovaries to mature.
Luteinizing Hormone (LH)	LH is responsible for causing the dominant follicle to release an egg from the ovary during ovulation.
Estrogen	At the beginning of a cycle estrogen levels are low, but they continue to rise and send messages for uterus to grow a new lining to replace that was shed in previous menstrual cycle.
Progesterone	Prepares the uterus for pregnancy by thickening the endometrium and promoting vascularization.
Testosterone	Regulate sex drive and overall regulation of menstrual cycle, but it also helps to preserve muscle mass in women.

Table No : 1

Pathophysiology:- The pathophysiology of dysmenorrhea mainly involves excessive production

of prostaglandins in the endometrium during menstruation. Decline of progesterone levels before menstruation triggers release of arachidonic acid which is converted into prostaglandins through the cyclooxygenase pathway. These prostaglandins cause strong uterine contractions and vasoconstriction which reduce uterine blood flow and produce ischemic pain. Inflammatory mediators such as leukotrienes and vasopressin further increase uterine contractility leading to severe menstrual cramps. [2, 3]

CAUSES	SYMPTOMS
Primary Dysmenorrhe :	**Primary Dysmenorrhe :**
Reduced blood flow t uterine muscles.	Cramping pain in lowe abdomen.
Stress and Anxiety.	Pain before or durin menstruation.
Early age at menarche.	Pain radiating to lowe back and thighs.
Heavy menstrua bleeding.	Nausea and Vomiting.
Lack of exercise.	Dizziness and Sweating.
Secondary Dysmenorrhea :	**Secondary Dysmenorrhea :**
Endometriosis.	Severe pain increasin with age.
Adenomyosis.	Pain lasting longer tha menstruation.
Uterine Fibroids.	Heavy or irregula bleeding.
Ovarian Cysts.	Pain intercourse.
Pelvic inflammator disease.	Pelvic pain even betwee periods. [2, 3]

Table No : 2

Roll-On:- A roll on is a type of topical formulation designed for easy and controlled application of liquid or semi liquid preparation on skin. It consists of **a small container** fitted with **a rolling ball applicator** at the top. When the ball is moved across the skin surface, it rotates and dispenses a thin layer of formulation evenly. This system ensures smooth spreading of the product without the need for direct hand contact.

Roll-on products where initially developed for cosmetic purposes, particularly for deodorants and antiperspirants. Over time, the roll-on delivery system has been widely adopted in pharmaceutical and therapeutic applications because of its **convenience, hygienic use, and ability to provide localized drug delivery.** The applicator allows a controlled amount of formulation to be released, reducing wastage and ensuring uniform distribution on skin.

In pharmaceutical preparations, roll-on formulations are commonly used for delivering **analgesic, anti-inflammatory, cooling and soothing agents** through skin. The active ingredients are usually dissolved or dispersed in suitable solvents or oils that facilitate absorption through skin. Because the medication is applied directly to the affected area, it can produce a **localized therapeutic effect** while minimizing systemic side effects. [4]

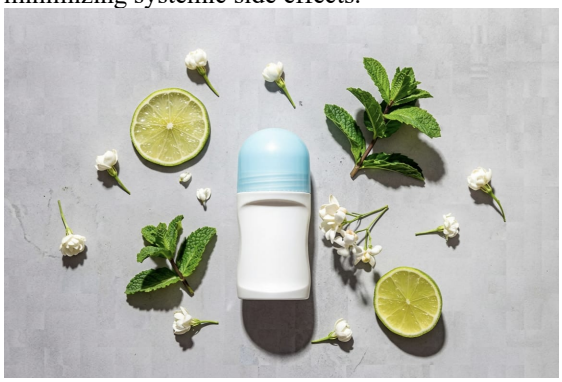


Figure 2.1 Roll On

History and Development:- The idea of roll-on applicator came from the ball point pen technology developed in 1930s. Scientist later released that the same rolling ball mechanism could be used to apply liquids evenly on skin .The concept of roll-on was given by Helen Diserens in late 1940s. In 1952, the first roll on deodorant was introduced, which become very popular because of its **ease of use and portability.** This success led to further development of roll-on containers for pharmaceutical preparation. Later the pharmaceutical industry started using this technology for topical drug delivery. Roll-ons began to be used for pain relief formulations, anti-fungal preparations, anti-inflammatory products and herbal medicines. This method help in delivering drugs directly to the affected area, reducing side effects and improving patient compliance.

In recent years roll-on formulations have further developed with the introduction of herbal ingredients, essential oils and improved packaging materials**. Modern roll-ons was designed to be leak proof, easy to carry and skin friendly.** They are now widely used for aroma therapy, head ache relief, muscular pain and even menstrual pain management.

Overall, the roll-on dosage form has developed from a simple cosmetic applicator into an important pharmaceutical drug delivery system because of its convenience, hygienic application and effectiveness.

Working Principle Of Roll-On:- The roll-on dosage form works on the principle of **" rolling motion and capillary action ".** It allows the liquid formulation to be delivered uniformly on the skin surface.

When the roller ball moves over the skin, it rotates within its housing. This rotation allows a small amount of liquid formation from the container to wet the surface of the ball. As the ball rolls, the formulation get transferred evenly onto the skin as a thin film. The flow of liquid is controlled by small clearance between the balls and its housing.

The effectiveness of roll-on formulations also depends on topical drug delivery principles, where the drug penetrates through the skin layers (mainly

the stratum corneum) to produce local therapeutic effect.

Components of Roll-On

A roll-on container consists of several important components that help in the safe storage and smooth application of the formulation. The main part is the **container body or bottle**, which holds the liquid formulation. It is commonly made of plastic materials such as HDPE, PET, or PP, and sometimes glass. The container should be lightweight, leak-proof, and compatible with the formulation to maintain product stability.

At the top of the container is the **roller ball or applicator ball**, which is a small spherical ball made of plastic, stainless steel, or glass. It rotates smoothly during application and helps in controlled dispensing of the liquid onto the skin.

The roller ball is supported by the **ball housing or ball seat,** which keeps the ball fixed in position while allowing free rotation. This component also helps prevent leakage and is usually made of plastic.

The **cap or closure** covers the roller assembly and protects it from dust, contamination, evaporation, and leakage. Caps are generally made of plastic and may be screw-type or snap-fit closures.

ADVANTAGES	DISADVANTAGES
➢ Easy to apply.	➢ Limited drug capacity.
➢ Controlled dose application.	➢ Clogging of roller ball.
➢ Less contamination.	➢ Uneven delivery sometimes
➢ Uniform spreading.	➢ Not suitable for all formulations
➢ Portable and convenient.	➢ Risk of leakage.

Permeation of Roll-On To Skin

The permeation of roll-on ingredients through the skin is a complex process primarily governed by the stratum corneum (SC), the outermost **"brick-and-mortar"** layer of the epidermis. While the skin is designed to be an effective barrier, roll-on formulations often use specific chemical strategies to bypass or temporarily disorganize this layer to deliver active ingredients.

Pathways of Permeation Molecules typically cross the stratum corneum through three main routes:-

Intercellular Route: This is the major pathway for most ingredients. Substances travel through the lipid-rich "cement" between skin cells (corneocytes). Lipophilic (oil-soluble) compounds pass through this hydrophobic matrix more easily than hydrophilic (water-soluble) ones.

Transcellular Route: Ingredients pass directly through the skin cells themselves. This route is generally more difficult due to the dense protein structure within the cells.

Transappendageal Route: Molecules enter through "shunts" like hair follicles and sweat glands. Although these occupy only about 0.1% to 1.0% of the skin's surface, they allow for faster entry of larger or charged molecules. [22,23]

Table No : 3

Previously used Ingredients For Relief of Dysmenorrhea:- Menstrual pain is commonly managed using herbal and natural ingredients that possess analgesic, anti-inflammatory, antispasmodic and warming properties**.** Many traditional medicine systems such as Ayurveda have used various plant based ingredients to relieve menstrual cramps and improve blood circulation.

- **FENNEL**



Scientific Name : *Foeniculum vulgare*

Chemical Constituents : Anethol, Fenchone, Estragole, Limonene, α-pinene and β-pinene.

Mechanism of Action : Fennel helps to relax smooth muscles including the uterine muscles. This property helps to reduce uterine cramps associated with dysmenorrhea. [4]

Properties : Antispasmodic, Anti-inflammatory, Analgesic, Anti-oxidant and Uterine relaxant.

- **CHAMOMILE**



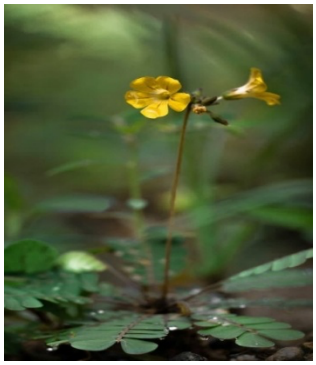
Scientific Name : *Matricaria recutita*

Chemical Constituents : Bisabolal, Apigenin, Rutin, Flavanoids and Terpenoids.

Mechanism of Action: Chamomile oil relaxes smooth muscles and helps to reduce spasms, especially uterine cramps during menstruation. [8]

Properties : Analgesic, Antispasmodic, Antimicrobial, Anti-inflammatory and skin soothing.

- **MUKKUTI**



Scientific Name : *Biophytum sensitivum*
Chemical Constituents : Biflavones, Isoorientin, Cupressuflavone, Amentoflavone and Phenolic acids.
Mechanism of Action: Mukkuti helps to reduce inflammation and swellings by inhibiting inflammatory mediators and reduce spasm. [8]
Properties : Anti-inflammatory, Antimicrobial, Uterine support and Antispasmodic.

- **COCONUT OIL**



Scientific Name : *Cocos nucifera*
Chemical Constituents : Capric acid, Caprylic acid, Myristic acid, Oliec acid and Palmitic acid.
Mechanism of Action : Coconut oil contains medium-chain fatty acid such as lauric acid and caprylic acid which helps to reduce inflammation in tissues. By lowering inflammation around the uterine and abdominal muscles, it can helps to decrease menstrual pain. [17]
Properties: Anti-inflammatory, improved skin absorption, muscle relaxation, moisturizing and soothing action.

- **THAZHUTHAMA**



Scientific Name : *Boerhavia diffusa*
Chemical Constituents : Alkaloids, Flavanoids, Steroids, Lignans, Glycosides.
Mechanism of Action: The anti-inflammatory and analgesic constituents present in the plant help reduce inflammation and relax uterine muscles, thereby decreasing menstrual pain. [8]
Properties : Analgesic, Anti-inflammatory.

- **ASAFOEITIDA**



Scientific Name : *Ferula foeitida*
Chemical Constituents : Ferulic acid, Umbelliferon, Sulphur containing compounds, Resin and volatile oils.
Mechanism of Action : Asafoetida relaxes smooth muscles and reduces uterine spasms, helping relieve dysmenorrhea. [8]
Properties : Antispasmodic, relaxes smooth muscles and uterine spasms.

- **BEESWAX**



Scientific Name: *Apis mellifera*
Chemical Constituents : Esters of fatty acids, Long-chain alcohols, Hydrocarbons.
Mechanism of Action : Beeswax acts mainly as a base and stabilizing agent that improves the texture and skin adherence of the formulation.
Properties : As thickening agent in topical formulations, helps to maintain consistency of roll ons, provide a protective layer on skin.

- **CLOVE OIL**



Scientific Name : *Syzgicun aromaticum*
Chemical Constituents : Eugenol, Caryophyllene, Eugenyl acetate.
Mechanism of Action: Eugenol present in clove oil inhibits inflammatory mediators and produces a mild anesthetic effect, thereby reducing pain. [17]
Properties: Carminative, Stimulant, Aromatic, Flavouring agent, Antiseptic, Dental analgesic.

- **PEPPERMINT OIL**



Scientific Name : *Mentha piperita*
Chemical constituents : Menthol, Menthone, Methyl acetate and flavonoids.
Mechanism of Action : Menthol activates TRPM8 receptors producing a cooling sensation and reduces pain perception. It also act as a smooth muscle relaxant, helping reduce uterine spasms responsible for menstrual cramps. [5, 17, 18]
Properties: Anti-inflammatory, analgesic, antioxidant.

- **TURMERIC**



Scientific Name: *Curcuma longa*
Chemical constituents: Curcuminoids, Curcumin, Demethoxycurcumin, Zingiberene, Bisdemethoxycurcumin, Turmerone. [27]
Mechanism of Action: Curcuma longa (turmeric) and its active compound curcumin reduce dysmenorrhea by inhibiting COX-2 and prostaglandin synthesis, thereby decreasing inflammation and pain. Its antioxidant properties protect against oxidative stress and lipid peroxidation, helping maintain hormonal balance.
Properties: Anti-inflammatory, Analgesic, Antioxidant, Antimicrobial and Antiseptic.

- **GINGER**



Scientific Name: *Zingiber officinale*
Chemical Constituents: Gingerol (especially 6-gingerol), Shogaol – formed when ginger is dried, Zingerone, Volatile oils (zingiberene, bisabolene),Resins and oleoresins [8]
Mechanism of Action: Ginger helps to reduce menstrual pain (dysmenorrhea) mainly by inhibiting Prostaglandin Synthesis. Gingerol block enzymes like COX and LOX. This reduces prostaglandins reducing Uterine Muscle Contraction, Uterine smooth muscles, decreases inflammation in uterine tissues, leads to reduced pain and discomfort, Improving Blood Circulation, Enhances local blood flow. [16]
Properties: Analgesic, Anti-inflammatory, Antispasmodic, Antioxidant and Carminative. [18]

- **LAVENDER OIL**



Scientific Name: *Lavandula angustifolia*
Chemical Constituents: Linalool (major component), Linalyl acetate, Camphor, Terpinen-4-ol, Lavandulol,Cineole (Eucalyptol),Linalool and linalyl acetate
Mechanism of Action : Linalool affects the nervous system by Inhibiting pain signal transmission by acting on GABA receptors causes less perception of pain relaxes Uterine Muscles. It reduces involuntary contractions of uterine muscles by directly decreases cramping. It reduces production of prostaglandins causing less pain. It enhances local blood flow when applied topically and reduce ischemic pain in uterine tissues. [17]
Properties: Analgesic, Antispasmodic, Anti-inflammatory, Sedative, Anxiolytic, Mild antimicrobial, Aromatherapeutic agent.

- **CAMPHOR**



Scientific Name : *Cinnamomum camphora*
Chemical Constituents: Safrole, Eugenol, Terpineol, Cineole, Linalol, Borneol, Camphene, Limonene.
Mechanism of Action: Camphor acts primarily as a topical counterirritant and analgesic by stimulate nerve endings sensitive to heat and cold (TRPV1, TRPV3, TRPM8) and inhibiting others (TRPA1), creating a cooling / warming sensation that mask pain. It increases local blood flow (rubefacient) and provides anti- inflammatory effects by inhibiting pro inflammatory cytokines. [19]
Properties: Counterirritant, Analgesic, Antiseptic, Decongestant, Rubefacient

COMPARATIVE STUDY WITH MARKETED FORMULATIONS

Parameters	**Previously marketed Herbal roll-ons**	**Newly formulated Herbal roll-on**
Examples	Nua, Pee safe, Sirona	Newly developed Herbal menstrual pain relief roll-on
Primary Action	Cooling and temporary pain relief	Therapeutic menstrual cramp management
Mechanism of Action	Counter- irritant and Cooling effect	Anti-inflammatory, Antispasmodic, Improved transdermal absorption
Pain Relief Type	Short-term symptomatic relief	Faster and long lasting relief
User Feedback	Moderate relief	Better comfort and faster soothing effect
Safety Profile	May contain synthetic preservatives or fragrances	100% natural ingredients and preservative-free
Skin Compatibility	Possible irritation in sensitive skin	Skin-compatible pH with lower irritation risk
Aroma	Medicinal/cooling aroma	Pleasant natural aroma
Storage Stability	Standard commercial stability	Stable with amber glass packaging and proper storage [5,27]

Table No : 4
FORMULATION OF ROLL-ON

Table No: 5

SL. No	Ingredients	Quantity required
1	Lavender oil	7.5 %
2	Rosemary oil	7.5 %
3	Chamomile oil	7.5 %
4	Eucalyptus oil	17.5 %
5	Camphor oil	10 %
6	Menthol	5 %
7	Thyme oil	4 %
8	White mineral oil	q. s upto 100 ml

Method of Preparation

The formulation of a herbal menstrual cramp relief roll-on begins with the extraction of botanical actives such as terpenes and flavonoids from plants like ginger, lavender, and peppermint using methods like CO_2 extraction or steam distillation to obtain concentrated therapeutic compounds. These extracts are then incorporated into a prepared oil phase containing carrier oils such as almond oil or fractionated coconut oil, which are heated to an optimal temperature to ensure proper blending and stability. During incorporation, the active constituents are carefully mixed into the oil base under controlled temperatures to maintain their potency and achieve a uniform formulation with effective skin absorption. Finally, the finished product is cooled and transferred to the filling stage, where automated systems accurately dispense the formulation into roll-on bottles, followed by sealing and applicator placement to preserve product quality, freshness, and consistent dosage. [4]

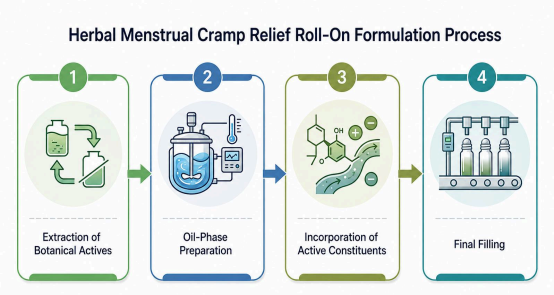


Figure 4.1

Evaluation of Roll-On

Physical Evaluation-

Apparatus: Transparent glass container, White/black background

Principle: Visual inspection helps assess uniformity and detect instability (phase separation, turbidity).

Procedure: Take the formulation in a clear container. Observe against white and black backgrounds. Note color, odor, clarity, and consistency.

pH Determination-

Apparatus: Digital pH meter, Beaker

Principle: Measures hydrogen ion concentration to ensure skin compatibility.

Procedure: Calibrate pH meter. Dip electrode into sample. Record pH.

Viscosity Measurement-

Apparatus: Brookfield viscometer

Principle: Measures resistance to flow under applied shear.

Procedure: Fill sample in viscometer cup. Select spindle and speed. Record viscosity reading.

Spreadability Test-

Apparatus: Glass slides, Weights, Stopwatch

Principle: Measures ease of spreading under applied force.

Procedure: Place sample between two slides. Apply weight. Measure time taken to spread. Calculate spreadability.

Drug Content Uniformity-

Apparatus: UV Spectrophotometer / HPLC, Volumetric flask.

Principle: Quantifies drug concentration based on absorbance.

Procedure: Dilute sample appropriately. Measure absorbance. Calculate drug content using calibration curve.

In-Vitro Drug Release Study-

Apparatus: Franz diffusion cell, Magnetic stirrer

Principle: Drug diffuses across membrane from donor to receptor compartment.

Procedure: Place sample in donor compartment. Fill receptor with buffer. Maintain temperature (~37°C). Withdraw samples at intervals. Analyze drug release.

Skin Irritation Test-

Apparatus: Patch/adhesive tape

Principle: Evaluates irritation caused by formulation on skin.

Procedure: Apply formulation on small skin area. Leave for 24 hours. Observe for redness, itching and swelling.

Microbial Limit Test-

Apparatus: Petri plates, Incubator

Principle: Detects microbial contamination by culturing organisms.

Procedure: Inoculate sample on culture media. Incubate. Count microbial colonies.

Stability Studies-

Apparatus: Stability chamber

Principle: Evaluates product stability under different environmental conditions.

Procedure: Store samples at different temperatures. Observe periodically for changes

Guidelines: Follow ICH stability protocols

Rolling Performance Test-

Apparatus: Roll-on container

Principle: Ensures proper functioning of roller ball.

Procedure: Apply roll-on on skin. Check smooth movement and uniform dispensing.

Leakage Test-

Apparatus: Filled roll-on bottles

Principle: Evaluates container sealing efficiency.

Procedure: Store bottles in inverted position. Observe for leakage

Permeation Study-

Apparatus: Franz diffusion cell

Principle: Measures drug penetration through skin membrane.

Procedure: Place skin/membrane between compartments. Apply formulation. Analyze drug permeated over time. [6, 7,19,28]

Packaging of Roll-On

Selection of Packaging Material

Selection of packaging material is a critical decision because it directly determines the stability, safety, and usability of the roll-on formulation. The primary components include the container (glass or plastic such as HDPE/PET), roller ball (stainless steel or plastic), ball housing, and closure cap. The material must be chemically compatible with the formulation, especially in the case of essential oils which can react with certain plastics or cause swelling and leaching. It should be non-reactive, non-absorptive, and non-leaching to maintain product purity. For light-sensitive formulations, amber-colored containers are preferred to prevent photo-degradation. The packaging must also ensure a tight seal to prevent leakage and evaporation of volatile components. Mechanical properties such as durability, resistance to breakage, and ease of use should also be considered. In most cases, amber glass bottles with stainless steel roller balls are considered ideal for essential oil-based formulations due to their inert nature and protective properties.

Cleaning of Containers

Cleaning of containers is an essential pre-processing step aimed at removing physical, chemical, and microbial contaminants that may compromise product quality. The process begins with washing the containers using a suitable detergent solution to eliminate dirt, grease, and residues. This is followed by thorough rinsing with purified or distilled water to remove detergent traces. In sensitive formulations, a final rinse with sterile water or 70% isopropyl alcohol may be performed to enhance microbial cleanliness. The cleaned containers are then dried using a hot air oven or under laminar airflow (LAF) conditions to prevent airborne contamination. Proper cleaning ensures product safety, prevents cross-contamination, and improves stability, making it a fundamental requirement under Good Manufacturing Practices (GMP) and protective properties.

Sterilization / Sanitization

Sterilization or sanitization is carried out to reduce or eliminate microbial load depending on the formulation requirements. Dry heat sterilization is commonly used for glass containers, typically performed at high temperatures for a specified duration to ensure complete destruction of microorganisms. Alternatively, UV radiation may be used for surface sterilization, and 70% isopropyl alcohol (IPA) is widely employed for rapid disinfection of containers and equipment. For herbal and essential oil-based roll-ons, sanitization is usually sufficient rather than full sterilization, as these formulations are less prone to microbial growth due to the presence of volatile oils. However, maintaining a controlled microbial level is still crucial to ensure product safety and shelf life.

Preparation of Filling Area

The filling area must be prepared to provide a controlled and contamination-free environment. Ideally, the process should be conducted in a clean room or under a laminar airflow (LAF) cabinet, which ensures a continuous flow of filtered air to minimize particulate and microbial contamination. Environmental parameters such as temperature, humidity, and air quality must be maintained within acceptable limits. Personnel involved in the process should follow hygiene protocols, including wearing gloves, masks, and lab coats. This step is essential to maintain the integrity and sterility (or cleanliness) of the formulation during handling and filling, especially in pharmaceutical and cosmetic preparations.

Filling of Formulation

Filling is the process of transferring the prepared formulation into the cleaned and dried containers. This can be done using manual methods such as syringes or measuring cylinders in laboratory-scale production, or semi-automatic filling machines for larger batches. It is important to ensure uniformity in fill volume across all containers to maintain dosage consistency. Care must be taken to avoid air entrapment, as air bubbles can affect the accuracy of application and may lead to oxidation of the formulation. Spillage and wastage should be minimized through careful handling. This step is critical as it directly influences dose accuracy, product consistency, and overall quality.

Insertion of Roller Ball Assembly

After filling, the roller ball assembly is inserted into the bottle. The roller ball is placed into its housing, which is then fixed securely onto the neck of the container. This step requires precision to ensure proper alignment and fitting. The roller ball should allow smooth and uniform rolling for effective application of the formulation on the skin. At the same time, it must be tight enough to prevent leakage. If the assembly is too loose, it may cause leakage; if too tight, it may hinder the rolling action and affect usability.

Sealing and Capping

Sealing and capping are performed immediately after the roller assembly is fixed to prevent contamination and loss of volatile components. The container is closed using either a screw cap or snap-fit cap, depending on the design. Proper sealing ensures that the product remains leak-proof, protected from external contaminants, and stable during storage and transportation. Inadequate sealing can lead to evaporation, contamination, and reduced shelf life, making this a crucial step in the packaging process.

Leak Testing

Leak testing is an essential quality control procedure used to verify the integrity of the packaging system. The filled and sealed container is inverted and subjected to slight pressure to check for any leakage from the roller ball or cap. The product is considered acceptable only if no leakage is observed. This test ensures that the packaging can withstand handling, transportation, and regular use without product loss or contamination.

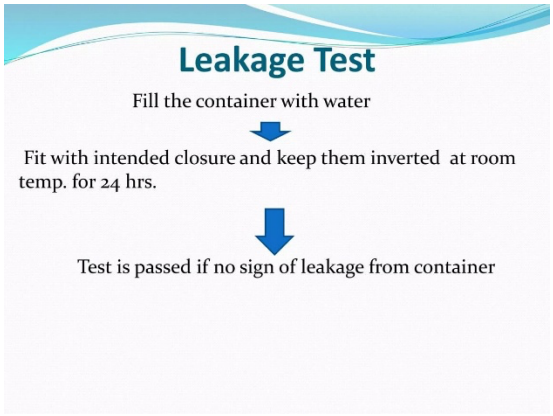


Figure 4. 2

Labeling

Labeling is a regulatory and informational requirement that provides essential details about the product. Each container must include information such as product name, list of ingredients, directions for use, batch number, manufacturing and expiry dates, and storage conditions. Warning statements like "For external use only" must be clearly mentioned. Proper labeling ensures consumer safety, product identification, and traceability, and is an important aspect of compliance with pharmaceutical and cosmetic regulations.

Secondary Packaging

Secondary packaging involves placing the primary container into an outer package such as a carton box, along with an instruction leaflet if necessary. This step provides additional protection against physical damage, environmental exposure, and contamination during transportation and storage. It also enhances the visual appeal and branding of the product, making it more marketable. Proper secondary packaging ensures safe delivery and better consumer experience.

Storage

The final packaged product must be stored under appropriate conditions to maintain its quality and effectiveness throughout its shelf life. Roll-on formulations should be kept in a cool and dry place, away from direct sunlight and heat sources, as exposure can lead to degradation of active ingredients, especially in essential oil-based products. Proper storage conditions help in preserving stability, potency, and safety, ensuring that the product remains effective until its expiry date. [4, 26]

Conclusion:- The present study on the formulation and evaluation of a menstrual pain relieving roll-on highlights a practical, patient-friendly, and effective approach for managing dysmenorrhea through topical drug delivery. Dysmenorrhea, primarily caused by increased prostaglandin production leading to uterine contractions and ischemic pain, significantly affects the quality of life in many women. While conventional treatments such as NSAIDs provide relief, their long-term use is often associated with undesirable side effects, which creates a need for safer alternatives.

In this project, a roll-on formulation incorporating essential oils such as lavender, eucalyptus, chamomile, rosemary, and camphor, along with menthol and suitable base oils, was successfully developed. These ingredients possess well-documented analgesic, anti-inflammatory, antispasmodic, and counterirritant properties, making them suitable for relieving menstrual discomfort. The roll-on delivery system ensures controlled application, improved patient compliance, localized action, and minimal systemic exposure, thereby reducing the risk of adverse effects.

The formulation was subjected to various evaluation parameters including physical appearance, pH, viscosity, spreadability, drug content uniformity, in-vitro drug release, skin irritation, and stability studies. The results indicated that the formulation was stable, safe for topical application, and capable of providing effective drug release and permeation. Packaging and proper handling further ensured product integrity, usability, and shelf life.

Overall, this study demonstrates that a herbal-based menstrual pain relieving roll-on is a promising alternative to conventional therapies. It combines the benefits of traditional medicinal ingredients with modern pharmaceutical technology, offering a convenient, non-invasive, and effective solution for the management of menstrual pain. Future improvements can focus on clinical validation, optimization of formulation, and large-scale production to enhance its commercial viability and therapeutic acceptance.

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