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IPL in treatment of acne Vugaris

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Abstract
The objective of this study was to assess the efficacy of various packaging materials in extending the shelf life and maintaining the quality of sapota (Manilkara achras) fruits during ambient storage. Sapota is a climacteric fruit with high perishability, and improving its post-harvest shelf life can significantly reduce economic losses and ensure better availability for consumers. The experiment was conducted using a completely randomized design (CRD) with seven treatments replicated thrice. The treatments included sapota fruits packed in different materials: brown paper bag, butter paper, LDPE (low-density polyethylene) bag with 1% ventilation, LDPE bag without ventilation, perforated polybag, newspaper wrapping, and an unpacked control group.
The fruits were stored at ambient room temperature, and various parameters such as physiological loss in weight (PLW), spoilage percentage, marketability, firmness, and total soluble solids (TSS) were recorded at regular intervals. The results indicated that packaging significantly influenced the post-harvest quality of sapota fruits. Among all treatments, LDPE bags with 1% ventilation exhibited the best results in reducing physiological loss in weight and spoilage, thereby enhancing the shelf life and maintaining better firmness and marketability of the fruits. On the contrary, the unpacked fruits showed the highest spoilage and weight loss, deteriorating quickly during the storage period.

Keywords: Sapota, packaging material, shelf life, LDPE bag, post-harvest quality, storage, spoilage

Introduction

Definition

Acne vulgaris is a common kind of pilosebaceous unit chronic inflammatory condition. It may cause a range of skin lesions, such as open and closed comedones, pustules, nodules, cysts, and inflammatory papules. Due to the existence of villous hair and large sebaceous glands, this ailment may present in several areas such as the face, cheeks, nose, forehead, chest, upper back, and upper arms [1]. Acne is a self-limiting disorder that has no major health risks, but it may lead to social isolation, sadness, poor self-esteem, deformity, and scarring, some of which can last a lifetime [2].

Epidemiology

The condition's onset coincides with the production of sex hormones during puberty and is most common in young adults and adolescents; nevertheless, its incidence gradually decreases as people age [3].
Adolescent acne, especially more severe types, disproportionately affects boys [4]. Contrarily, the illness affects more women than males when they reach maturity.
It is believed that among adolescents, the prevalence rates vary from 35% to more than 90% [5].
Acne vulgaris is more common among urban dwellers than to rural residents. There is some evidence that the incidence of acne vulgaris differs between racial and ethnic groups.Acne is more common among people of African American and Asian descent. Conversely, white people tend to have milder acne [6].

Predisposing factors

A 2021 meta-analysis of 53 studies found that fatty diets, dairy products, chocolate, and meals with a high glycemic index are among the variables that might lead to acne [7].
On the other side, eating enough of fruits, vegetables, and fatty acids may help keep acne at

bay. Studies have shown that whey protein supplements, low vitamin D levels, and excessive doses of vitamins B6 and B12 might all contribute to acne [8-9].

In addition to heredity (Which accounts for 80% of cases), there are several other factors that can increase the risk. These include being overweight, having oily or seborrheic skin, a higher skin surface pH, emotional stress, repetitive mechanical trauma, excessive sunlight exposure, pregnancy, surgical mask, headband, or pad wear, topical application of greasy products or occlusive preparations, medication use, congenital adrenal hyperplasia or tumors, polycystic ovarian syndrome, or body dysmorphic disorders [10].

Pathogenesis

There are four pathophysiological elements that contribute to the formation of AV: an imbalance in sebum production, comedone-causing alterations in follicular skin keratinization, Propionibacterium acnes colonization of the skin, and inflammatory processes involving innate and acquired immunity [11].

The androgen hormone sets off the first pathology. Patients of either sex may see a substantial increase in levels of sex hormone-binding globulins (SHBG), androstenedione, as well as DHEAS [12].

A number of factors associated with the immune response and C acnes have a role in acne development, such as:

- Recent research has shown that acne-causing C acnes strains are more prone to activating the pro-inflammatory cascade, which specifically includes TH17 cells. This kind of T cell is responsible for secreting inflammatory cytokines into the circulation, such as interleukin (IL)-17 and interferon (IFN)-gamma. On the flip side, research suggests that skin-healthy strains may encourage TH17 cells to produce the anti-inflammatory cytokine IL-10 [13].
- The acne-causing yeast Candida albicans has been linked to antibiotic resistance and biofilm development in hair follicles by some strains [14].
- C acnes triggers the NLRP3 inflammasome in human sebocytes and monocytes, leading to an innate immunological response and the induction of IL-1 production [15].
- It targets perifollicular macrophages and activates their Toll-like receptor-2, leading to an increase in the production of IL-8 and IL-12, two pro-inflammatory cytokines. When these cytokines attract neutrophils, they release lysosomal enzymes that help the follicle burst [15].
- The pathogenicity of certain strains of the acne bacteria and variations in the host's inflammatory response to the colonization of skin by these bacteria may account for the observed wide variation in acne frequency and severity [16].

Clinical picture: One of the earliest signs of acne vulgaris, which often manifests in areas of the body that produce sebum, is the pathognomonic comedo, which is a closed or open follicle [17]. In the absence of an obvious central pore and other clinical indicators of inflammation, a dome-shaped papule that is white or flesh-colored is called a closed comedo, or whitehead. The skin surface is attached to the narrowest part of its flask-shaped design [18]. The formation of an open comedo, also known as a blackhead, occurs when the follicular opening enlarges and finally opens due to the accumulation of keratin and sebum [19].

A typical open comedo looks as a black lesion that is either flat or slightly elevated. A black keratotic plug is contained inside a centrally dilated follicular orifice that typically measures one to three millimeters in diameter. Rather than oxidized fat or grime, the open comedo's black surface is oxidized melanin [20].

Reddening of the skin, pustules, papulopustules, nodules, and cysts can form as a result of an inflammatory reaction that starts when the blocked follicle bursts and releases free fatty acids into the surrounding tissue. The quantity of damaged tissue, its location, and the kind of tissue all have a role in how severe the response is.The appearance of cysts and nodules is a hallmark of severe nodulocystic acne [21].

Diagnosis

Lesions in particular locations (e.g., the face, neck, back, chest, shoulders, or upper arms) accompanied by specific symptoms (e.g., closed or open comedones, pustules, inflammatory papules, inflamed nodules, or inflamed nodulocystic lesions) constitute the primary clinical evidence for an AV diagnosis. A laboratory test is often not ordered by a doctor unless the patient actively requests it. It is possible to check the blood levels of DHEAS, which stands for dehydroepiandrosterone, androstenedione, as well as testosterone and androstenedione. These levels may also be measured in women who are fertile. A pelvic ultrasound may be performed to detect polycystic ovarian syndrome if hyperandrogenism signs are suspected, such as hirsutism, clitoromegaly, or the unusually fast development of pubic or axillary hair [22].

- **Histopathology:** In normal acne lesions, a keratin plug may be seen in the enlarged follicle. In more severe instances, an open comedo might develop as a result of the enlarged follicle.Rupture of a follicle's delicate wall may cause inflammation and the growth of germs in the affected region.The healing process may include the development of fibrosis and scarring in instances when trauma is applied to big acne lesions [23].
- **Grading of acne vulgaris: Investigator's Global Assessment (IGA) scale:** The FDA suggested the IGA scale as a static, qualitative way to measure the severity of acne in general. From 0 (Very clear), 1 (Almost clear), 2 (mild), 3 (Moderate), and 4 (Severe) grades, there are five levels to it. (Table 1) [24].

Table 1: Comprehensive explanation of the IGA scale [25]

Grade	Description
0	Skin free of any discoloration or other abnormalities
1	Nearly invisible; very unusual non-inflammatory lesions accompanied by a single tiny inflammatory lesion
2	Mild severity; higher than Grade 1; a small number of non-inflammatory lesions; a small number of inflammatory lesions (Limited to papules and pustules; no nodular lesions)
3	Moderate severity; class 2 or above; frequent non-inflammatory lesions; occasional inflammatory lesions; nodular lesions (Smaller than 1 cm)
4	Extremely severe; higher than Grade 3; inflammatory lesions present, but limited to a small number of nodular lesions; many non-inflammatory lesions

Differential diagnosis

Table 2: Acne vulgaris differential diagnoses [26-27]

Condition	Characteristics
Bacterial folliculitis	Comedones nonexistent; pustules and papules with a singular foci appear suddenly
Pityrosporum folliculitis	The scalp and upper back are infested with itchy, unilateral, folliculocentric papules and pustules that appear out of nowhere.
Acne keloidalis nuchae	Nodules or plaques resembling keloid tumors may develop on the scalp and nape of the neck as smooth, solid, distinct, dome-shaped follicular papules; comedones are usually nonexistent.
Milia	These papules often appear on the eyelids and are asymptomatic; they are tiny, hard, smooth, and may range in color from white to yellow.
Miliaria rubra	This condition manifests as red, itchy papules or papulovesicles that itch and sometimes bleed when exposed to heat or when you push yourself too much.
Syringomas	Symmetrically distributed, soft, skin-colored to slightly yellowish papules that usually manifest in the periorbital area; normally, they do not cause any symptoms.
Perioral dermatitis	There are often no flesh-colored to red papules, papulovesicles, or papulopustules in the perioral area, which are symmetrical and grouped on top of an erythematous and scaly base.
Sebaceous hyperplasia	The most prevalent locations for these asymptomatic, isolated, dome-shaped papules are the cheeks and forehead; a few of these lesions also have central umbilication. They may be yellow or flesh-colored.
Nevus comedonicus	The clustered or linear arrangement of comedones is accompanied by symptoms that manifest before the age of 10.
Papulopustular rosacea	In most cases, comedones are not present, but the patient does have telangiectasias, a central facial erythema that stays, inflammatory dome-shaped erythematous papules, and little surmounting pustules.
Keratosis pilaris	Facial lesions that resemble gooseflesh and have a rough texture are small, distinct keratotic follicular papules that may or may not have varying perifollicular erythema.
Molluscum contagiosum	Unique center umbilication characterizes these waxy papules, which are discrete, smooth, solid, and dome-shaped.
Facial angiofibromas in tuberous sclerosis	In the malar area, lesions that seem like dome-shaped papules and range in color from pink to red first emerge during preschool.
Eruptive vellus hair cysts	Typically seen on the chest, these papules are flesh-colored and asymptomatic.
Steatocystoma multiplex	Multiple painless spherical, soft, and movable nodules or papules that are inflammatory in nature; superficial lesions are often yellowish, whereas lesions deeper in the skin are skin-colored.
Verruca vulgaris	An unsymptomatic nodule or papule that seems healthy but has a hyperkeratotic and verrucous surface
Drug-induced acne or acneiform eruption	A history of drug use is one of the symptoms. Other signs include the development of papulopustules or monomorphic inflammatory papules at a very early age. Lesions may appear in strange locations other than seborrheic areas. When the offending medicine is stopped, the symptoms of the lesion disappear.
Skin lesions of Birt–Hogg–Dubé syndrome	Acromembranes, fibrofolliculomas, and trichodiscomas form a trio.
Skin lesions of Cowden syndrome	Tumors of the face; acral keratosis
Skin lesions of Muir–Torre syndrome	Squamous cell tumors of the face; sebaceous neoplasms

Complications

People with dark skin tones (skin phototypes IV–VI) are more likely to have post-inflammatory hyperpigmentation and, less often, hypopigmentation. People who are prone to scarring may be at increased risk, particularly for severe forms of acne like acne fulminans and acne conglobata. Typically, the likelihood of persistent acne lesions increases as the inflammatory process progresses deeper. Nevertheless, scarring may still occur with comedonal acne. Scarring from acne vulgaris may be lessened with prompt and efficient treatment [28]. Scars caused by acne often become less prominent over time and fall into one of three distinct types: boxcar, ice pick, or rolling scars. There are three types of scars: boxcar, ice pick, and rolling. Boxcar scars are angular and punched out in a U shape with sharply defined vertical edges; ice pick scars are small and deep; and rolling scars are wider and shallower than ice pick scars with rounded, sloping edges that give them a wavelike or undulating look. When multiple rolling scars arise in the same area, they make the skin look like it's been rolled. However, there are thicker varieties of acne scars, including hypertrophic scars (in which the scars remain within the boundaries of the initial incision) and keloid scars (in which the lesions extend beyond the boundaries of the initial wound, impacting the surrounding normal tissue and perhaps causing pain or itching) [29].

For numerous reasons, including but not limited to: anxiety, poor self-esteem, feelings of unattractiveness and worthlessness, despair, suicidal ideation and behavior, and acne itself (especially on the face in women), acne is a terrible and humiliating experience [30]. Acne-related feelings of inadequacy may negatively impact one's social life, sexual relationships, and overall self-esteem [31].

Treatment of Acne Vulgaris

Reducing scarring and psychological consequences while maximizing the patient's desired aesthetic outcome is the primary focus of therapy. The goals of treatment include reducing the number of cystic acne, eliminating comedones, and inhibiting the synthesis of fatty acids and sebum. Topical medications for acne vulgaris have a typically good safety profile. Therefore, topical therapies are recommended for mild to moderate acne, and they may be used in combination therapy for severe acne [32-33].

Topical therapy

- For mild to severe acne vulgaris, the prescribed medicine is a topical retinoid, a diverse family of vitamin A compounds that control gene expression. By lowering follicular blockage and microcomedone development, these medicines decrease keratinocyte growth. Furthermore, these substances have anti-inflammatory properties [34].

- Topical benzoyl peroxide (2.5, 5, or 10% concentration) is an effective antibacterial that kills bacteria quickly. Bactericidal action against Candida albicans is mediated by protein oxidation. It inhibits sebum triglyceride lipolysis and reduces inflammation in acne lesions simultaneously. The keratolytic and comedolytic effects of benzoyl peroxide are also somewhat mild [35].
- A topical antibiotic's anti-inflammatory and bactericidal or bacteriostatic capabilities are formulation dependent. Antibiotics used topically have less systemic adverse effects and less systemic toxicity than their oral counterparts. The use of topical antibiotics as a sole treatment strategy poses the risk of microorganisms developing resistance. Topical antibiotics such as erythromycin 2%, dapsone, minocycline, clindamycin 1%, and others have shown some success in the treatment of acne [36].
- A natural saturated straight-chained acid, anazelaic acid has several medicinal uses due to its antioxidant, anti-inflammatory, antikeratinizing, comedolytic, and tyrosinase-inhibiting properties, as well as its gel content of 15% or 20% [37].
- Salicylic acid, when used topically, has several uses as an antimicrobial and comedolytic [38].
- Nicotinamide, when applied topically, has an anti-inflammatory and sebostatic effect, making it an effective acne treatment [39]. Acne lesions produce interleukin 8 (IL-8) when Propionobacterium acnes colonizes them. Interleukin 8 (IL-8) is a chemokine that both aids in the movement of neutrophils and has the ability to cause keratinocyte divisions. Also, topical nicotinamide helps keep infections at bay by bolstering the skin's natural defenses and may even inhibit the growth of Propionibacterium acnes [40].

Systemic therapy

- The use of oral antibiotics is essential in the treatment of severe acne lesions and acne that does not improve with topical therapies. These compounds impede neutrophil chemotaxis and modify macrophage and cytokine production; they also have inherent anti-inflammatory characteristics; and they significantly reduce C. acnes. Due to their superior effectiveness and tolerability, tetracyclines (doxycycline and minocycline) are favored. When tetracyclines are not an option, the macrolides that are often used include azithromycin and erythromycin [41].
- Oral isotretinoin is efficient in treating acne by lowering sebum production, follicular keratinization, and intrafollicular concentration of Propionibacterium acnes. Another benefit of oral isotretinoin is its anti-inflammatory properties. Although it is most often used for severe instances of nodular acne vulgaris, it is sometimes used for mild cases when scarring is noticeable, there is considerable psychological distress associated with acne, or when other treatment methods have not been effective [42].
- Hormone replacement therapy is an alternative to consider for postmenopausal women (often those over the age of fifteen) if conventional methods of treating moderate to severe acne (pustulocystic or nodulocystic) do not work or are too painful. When used orally, oestrogen-containing contraceptives inhibit the androgens' stimulatory actions on pilosebaceous units, which decrease and improve the function of sebaceous glands, resulting in less sebum production and keratinous material accumulation [43].

Using Light and Lasers for Treatment

For certain individuals, including those who do not react to or comply with traditional acne treatments, as well as those who have developed a resistance to antibiotics, lasers and light-based devices may provide an alternative. The development of various light sources was driven by the need to treat or eliminate acne. This category of lights includes, but is not limited to, halogen, tungsten, fluorescent, and, more recently, laser lights. There are several methods for classifying acne treatment devices. Various technologies may target Propionibacterium acnes, either directly or indirectly. These include sunlight (UVA/UVB), blue light, and combinations of blue and red light. Contrarily, techniques such as pulse dye laser (PDL), infrared lasers, radiofrequency, photodynamic treatment (PDT), and aminolevulinic acid (ALA) may influence both the sebaceous gland structure and the acne-causing bacteria [44].

IPL in acne vulgaris

Some studies have looked into IPL for acne vulgaris as a treatment alone, while others have combined it with PDT for even more effective results [45]. Multiple hypotheses have been advanced on how IPL can influence acne. Blood arteries that feed sebaceous glands may undergo thermolysis. Both sebum production and gland size decrease in conjunction with this. Barakat *et al*. [46] found the same thing when they measured the surface area of sebaceous glands and did histological examinations both before and two weeks after six IPL treatments. The research found that after IPL treatment, the sebaceous gland's surface area was significantly reduced. Increasing transforming growth factor beta and reducing TNF-α are two ways in which IPL decreases inflammation [47].

The majority of studies that employed IPL on acne patients found that both inflammatory and non-inflammatory lesions were decreased. On average, patients reported a 40%-60% improvement after using IPL on acne lesions, with claimed effectiveness ranging from 34% to 88%. In those trials, the number of IPL sessions varied between four and eight [48-49].

IPL and PDT together are more successful than the two methods alone in treating acne vulgaris, according to the research. The percentage of persons who thought it worked ranged from 60% to 80%. Shaaban *et al*. found that PDT using intralesional 5-aminolevulinic acid (5-ALA) was safer and more effective than IPL or IPL alone in treating acne vulgaris. Researchers used an open-label split-back design in a prospective research that included 30 participants. Although all patients saw a decrease in acne lesions across the board, the side that got PDT in conjunction with IPL had a much more marked decline and a significantly lower rate of lesion recurrence compared to the side that underwent IPL alone [50].

Kumaresan and Srinivas (2010)(7) evaluated the techniques of intense pulse light (IPL) to compare burst-pulse and single-pulse modes for the treatment of facial acne. Ten participants were included in the study. The severity of acne significantly improved. The severity score of acne on both sides improved significantly after four IPL treatments. The side that received continuous pulses showed better control

than the side that received just single pulses. No major side effects were seen either during or after treatment [51].

Mechanism of action

Reflection, absorption, scattering, and transmission are the four potential ways in which a laser might interact with skin. In order for light to have a therapeutic impact, it must first penetrate the skin, which in turn releases photons containing heat energy. So, either an internal or external chromophore takes in the light, and the targets are heated to the point of thermocoagulation as a result of the photons' released thermal energy [52]. Despite not being a laser in and of itself, IPL uses the same principles: targeting particular chromophores inside the skin with polychromatic light causes thermotropy [53].

Wavelength

The flashlamp can produce polychromatic light with a wavelength range of about 420-1400 nm, which encompasses both the visible and infrared parts of the light spectrum (Figure 1) [54].

There are a lot of chromophores in the skin, and their ability to absorb and scatter light depends on the wavelength [56]. Some have hypothesized that the blue vein hue is due to dispersion. Chromophores and other structures with sizes smaller than the wavelength of the light they produce cause this kind of scattering to be most apparent at the blue end of the visible spectrum. Light can't reach deeper layers of skin because scattering reduces its absorption by targeted chromophores. This explains why blue light can only reach a depth of 1 millimeter under the skin, but red light may reach depths of 4 to 5 millimeters [55]. One of the most crucial aspects of administering an IPL treatment is the wavelength. When used as directed, it prevents the emission of light with shorter wavelengths [57].

It is important to think about competing chromophores in the same treatment region when choosing a wavelength. The targeted chromophores in the dermis, for example, may be protected by the melanin in the epidermis. This helps to clarify why some IPL equipment on the market could have difficulty when used on persons with darker skin types (Fitzpatrick type VI). Because melanin absorbs light at lower wavelengths, those with darker skin tones should be treated with longer ones. On the other hand, people with pigmented lesions are better off with shorter ones [56].

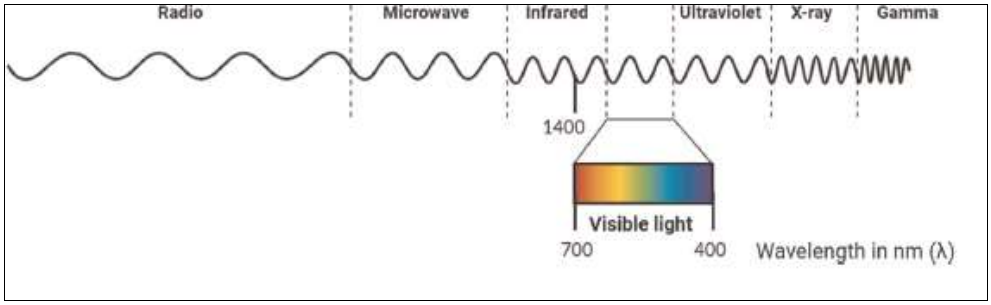

Fig 1: Range of wavelengths (λ) in the spectrum of visible light [56].

Duration of a pulse

The chromophore's tissue relaxation time guides the selection of pulse length; this is the amount of time required for 63% of the thermal energy to disperse after tissue has been heated [57]. Pulses of 10–12 ms, delivered in either a single or double pulse, are recommended for the treatment of the majority of lesions [58]. It takes more time for a chromophore to "cool down" if it is bigger. Exposure to the target for an amount of time greater than the tissue relaxation time increases the risk of damaging neighboring tissues, which in turn increases the risk of scarring and other undesirable clinical effects. When treating dark-skinned persons, this concept is useful for destroying big chromophores, such as hair follicles, without causing hypopigmentation [56]. Lesion size is also taken into consideration while adjusting thermal relaxation time (TRT). Generally speaking, bigger lesions often need longer TRTs in comparison to smaller ones [59]. Also, studies have shown that skin cooling down between pulses (5-100 ms) reduces damage [60].

Fluence

The quantity of heat energy transferred per square centimeter is called flux (J/cm2). A fluence of up to 40 J/cm2 may be delivered via IPL. However, while dealing with pigmented lesions, it is often recommended to use a fluence of 16-20. Fluence must be increased for targets situated deep beneath the skin or for chromophores with low light absorption characteristics [61]. Tolerability and the occurrence of side effects during IPL exposure are significantly impacted by fluency, with darker-skinned people and greater fluency levels experiencing more frequent side effects. Thanks to advancements in cooling technology, a technique known as an epidermal bypass may now be used to send larger fluences of energy to deeper tissues while shielding the epidermis from harm [62].

Spot size

An essential component of skin condition therapy is the spot size, or the diameter of the light beam from the laser or flashlamp. Light may penetrate deeper into a target with an enlarged spot size due to the fact that scattering is reduced. Therefore, in order to heat dermal targets efficiently with a smaller spot size, larger fluences will be necessary [63].

Cooling systems

A cooling system is an essential component of an IPL or laser device because photons and energy are delivered to the skin surface. Depending on the equipment, they might be either inside or outside. Pulsed cryogen sprays, cooled glass chambers, or chilled tips are all part of an integrated cooling system. External cooling equipment includes devices such as ice packs, cold gels used topically to the skin before treatment, and forced air cooling [64].

Using a light spectrum spanning from 420 to 1400 nm, IPL may produce pulses of light that are polychromatic,

noncoherent, and noncollimated. There are a number of ways in which IPL treatment may be modified to address certain health issues. For example, you may plan single, double, or triple pulses of light with durations between 2 and 25 ms and interpulse delays between 10 and 500 ms. Using a longer pulse duration while treating deeper arteries may help lessen the likelihood of hyperpigmentation and purpura [65]

Side effects of IPL

The feeling of discomfort during treatment is a common side effect, but it's usually not a big deal. A topical anesthetic or cooling (during and/or after therapy) will usually alleviate the pain. Common adverse effects include redness and swelling, which might last for a few days. After using high fluences, blisters and scabs might develop. The danger of infection and scarring makes it imperative that patients in these situations refrain from scratching their skin. Dyspigmentation (lightening or darkening of the skin tone) and hypertrophic scarring (keloid formation) are two of the most long-lasting and problematic side effects [66].

Due to the significant risk of hyperpigmentation, patients who are tanned, have a high phototype, or are unable or unwilling to avoid sunlight after treatment should typically not undergo therapy [67]

Table 3: Advantages and Disadvantages of IPL [68]

Advantages	Disadvantages
	Differences in the emission spectrum and fluence
Highly versatile	Weight of handpiece
Reduced cost (with the exception of premium models)	Problems with focusing
Huge spot magnitude	Gel application device and cooling
High degree of skin coverage	A system that uses either cold air, cooling sprays, or both
Robust technology	Direct skin-to-skin contact

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