“Development and Evaluation of Cabbage Leaf Extract Loaded Sunscreen Cream”

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Abstract

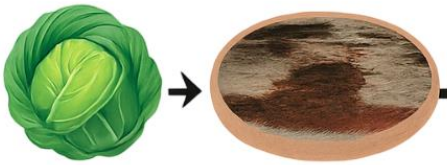
The current study focuses on creating and testing a sunscreen cream that employs leaf extract from green cabbage (*Brassica oleracea var. capitata*). Following the extraction of phytoconstituents from fresh cabbage leaves, UV spectroscopic examination was performed in the 200–400 nm range. With a maximum absorbance (λ_{max}) of 0.527 at 279 nm, the extract demonstrated it’s capacity to absorb damaging UV rays, thereby validating its anti-solar properties. The presence of flavonoids, which are recognised for their UV-protective qualities, was confirmed by additional characterisation by employing the use of infrared spectroscopy and chemical assays. The extract from cabbage leaves was then used to create a sunscreen cream.

According to compatibility studies, the extract and formulation excipients did not interact. Three formulations were compared in order to evaluate the finished product: a commercially available sunscreen, a placebo (without extract) and the cream with cabbage extract. Physical appearance, pH, viscosity, spreadability, washability, irritancy and stability were among the parameters evaluated; all of these had positive outcomes. The commercial product's in-vitro Sun Protection Factor (SPF) was 30.43, the placebo's was 5.22 and the formulation loaded with cabbage extract had an SPF of 10.62. These findings show that extract from cabbage leaves has promising anti-solar qualities and can be used successfully in the creation of natural sunscreens.

Keywords: Cabbage leaf extract, *Brassica oleracea var. capitata*, sunscreen cream, UV absorption, flavonoids, anti-solar activity, in-vitro SPF, herbal formulation, photoprotection, natural ingredients.

GRAPHICAL ABSTRACT

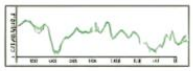
Extraction & Analysis



Phyto-constituent Extraction

λ_{max} = 279 nm
Absorbance = 0.527

IR Spectroscopy + Chemical Tests:



✔ Presence Flavonolds

Anti-Solar Activity

Brassica oleracea var. capitata extract has Anti-Solar activity.

Sunscreen Formulation Three Samples:

Marketed Sunscreen
Placebo (No Extract)
Cabbage Extract Cream
No interaction with excipients

Evaluation Parameters
Physical Properties:
Appearance, pH, Viscosity
Usability: Spredabiliity, Washability, Irritancy

In-vitro SPF Results

Sample Cream	SPF
Marketed	30.43
Placebo	5.22
Extract	10.62

Conclusion
Cabbage leaf extract shows **promising anti-solar activity, offering natural** and effective alternative for sunscreen formulations.

Introduction

The skin, a complex and dynamic organ, serves as the body's primary interface with the external environment, fulfilling a multitude of critical protective functions. These functions include shielding against microbial pathogens, environmental pollutants, mechanical damage, and thermal fluctuations [1]. Crucially, the skin acts as a barrier against the deleterious effects of ultraviolet (UV) radiation, which is a major contributor to a spectrum of dermatological concerns [2]. Prolonged and unprotected exposure to UV light—comprising UVA (320–400 nm), UVB (280–320 nm) and UVC (100–280 nm) wavelengths is unequivocally linked to a cascade of adverse skin conditions, ranging from acute sunburn and photosensitivity reactions to chronic issues such as accelerated photo aging, hyperpigmentation disorders and most critically, an increased risk of various skin cancers, including basal cell carcinoma, squamous cell carcinoma and malignant melanoma [3,4]. While UVC radiation is largely absorbed by the Earth's ozone layer, both UVA and UVB rays effectively penetrate the atmosphere and reach the skin underscoring the indispensable need for comprehensive photoprotection strategies [5,6]. In response to the pervasive threat of UV-induced skin damage, the development and widespread adoption of sunscreens have become cornerstones of public health initiatives aimed at mitigating these risks [7]. Sunscreens function primarily by either reflecting or absorbing UV radiation before it can inflict cellular damage [8]. Historically, the market has been dominated by formulations containing synthetic UV filters, which while effective, often raise concerns regarding their potential for skin irritation, systemic absorption, endocrine disruption and environmental impact, particularly on aquatic ecosystems [9,10] .These growing apprehensions among consumers and regulatory bodies have spurred a significant shift towards exploring and developing safer, more biocompatible and environmentally sustainable alternatives for photoprotection [11,12]. The demand for natural, plant-derived ingredients in cosmetic and dermatological formulations is rapidly expanding, driven by a preference for products perceived as inherently safer, less allergenic and more aligned with eco-conscious values [13,14]. This paradigm shift underscores a critical unmet need for innovative, plant-based solutions that can deliver robust photoprotective benefits without compromising human health or ecological integrity [15]. Against this backdrop, the exploration of botanical sources for novel photo protective compounds has gained substantial momentum. Numerous plant extracts have demonstrated inherent UV-absorbing, antioxidant and anti-inflammatory properties, making them attractive candidates for incorporation into advanced sunscreen formulations [16,17]. Among these, *Brassica oleracea var. capitata*, commonly known as green cabbage, stands out as a particularly promising candidate. Cabbage is a widely cultivated cruciferous vegetable globally recognized not only for its nutritional value but also for its rich phytochemical profile [18]. It is replete with a diverse array of bioactive compounds, including an abundance of vitamins (A, C, K, B6), carotenoids, minerals (selenium, potassium, manganese) and potent nitrogen-sulfur derivatives such as glucosinolates and isothiocyanates [19, 20,21]. Crucially,

green cabbage is an exceptional source of polyphenols and flavonoids, compounds renowned for their robust antioxidant and anti-inflammatory activities [22,23]. Flavonoids, in particular, possess a chromophoric structure that enables them to absorb UV radiation across a broad spectrum, thereby acting as natural photoprotectants [24]. Specific flavonoids identified in cabbage, such as quercetin, apigenin, kaempferol and flavones, exhibit significant UV absorption capabilities, suggesting their direct utility in sun-protective applications [25]. The antioxidant capacity of these compounds is further enhanced by their ability to scavenge reactive oxygen species (ROS) generated by UV exposure, thus preventing oxidative damage to skin cells and mitigating the cascade of events leading to photo-aging and skin cancer [26,27]. The objective of the current research is to harness the inherent photo-protective properties of green cabbage leaf extract for the development of a novel, natural sunscreen cream. This study will systematically investigate the extraction, characterization, formulation and evaluation of a sunscreen cream enriched with *Brassica oleracea var. capitata* extract. The specific aims include preparing and authenticating the green cabbage leaf extract; performing comprehensive phytochemical profiling to identify key bioactive compounds; assessing the extract's in-vitro anti-solar activity, particularly its UV absorption spectrum and potential for SPF enhancement; formulating a stable and aesthetically acceptable sunscreen cream incorporating the optimized green cabbage extract and conducting a thorough evaluation of the final product's physicochemical properties, including pH, viscosity, spreadability, homogeneity, washability and irritancy as well as its in-vitro Sun Protection Factor (SPF) and stability over time. By rigorously validating the efficacy and safety of a green cabbage extract-loaded sunscreen, this research endeavors to contribute to the growing body of knowledge on plant-based photo-protection and to offer a promising, natural and sustainable alternative for effective sun care in the cosmetic and pharmaceutical industries.

Materials and Methods

Material & Chemicals

The freshly harvested Green Cabbage leaves was procured from Sangola, located in the Solapur District of Maharashtra and verified by Dr. Tembhurne R. R. from Dept. of Botany, Sangola Mahavidyalaya, Sangola with Flora of Solapur District, Maharashtra, India. We properly cleaned the Green Cabbage leaves two to three times under running water and once with distilled water. After that, Green Cabbage leaves was air dried in the shade. After that it dried, a grinder was utilised to powder the Green Cabbage leaves. The powder was kept in an air tight container. The chemicals like Stearic acid, Cetyl alcohol, Liquid Paraffin, Glycerine, Propylene Glycol, Triethanolamine, Propyl paraben, Ethanol, Zinc oxide, Titanium dioxide supplied by Research-Lab Fine Chem. Pvt, Ltd. Mumbai, India.

Extraction method

The dried powder of *Brassica oleracea var. capitata* leaves was extracted by Soxhlet Apparatus using ethanol as a solvent. A permeable bag or muslin fabric bag containing the finely ground Green Cabbage leaves powder was put into a Soxhlet device. The ethanol extraction solvent was heated in a flask and the evaporated vapours condensed in a condenser. When the liquid level in the chamber reaches the top of the syphon tube, the liquid condenses from the chamber syphon into the flask. Until the last drop of solvent in the syphon tube entirely evaporated and left no trace, this process was repeated [28].

Characterization of *Brassica oleracea var. capitata* Leaves Extract

Identifying organic components through chemical techniques in which the extract was subjected to general flavonoid identification testing utilizing conventional chemical techniques. The Shinoda test involved dissolving the dried extract in 5 milliliters of 95% ethanol, treating it with strong hydrochloric acid and adding 0.5 grams of magnesium turnings. The result was a pink due to that indicated the presence of flavonoids. A little amount of extract was mixed with lead acetate solution for the lead acetate test, which resulted in a yellow precipitate that further demonstrated the presence of flavonoid components in the sample. *Brassica oleracea var. capitata*'s λ_{max} and calibration curve were determined. 10 mg of *Brassica oleracea var. capitata* extract was mixed in 10 mL of ethanol to create a 1 mg/mL stock solution, which was then diluted to 100 μg/mL in order to determine the wavelength. To find the analytical wavelength, the filtered solution was exposed to UV spectrophotometric examination in the 200–400 nm wavelength range. Standard solutions of 20, 40, 60, 80, and 100 μg/mL were made from the stock solution and subjected to spectrophotometric analysis at 279 nm in order to construct the calibration curve. To determine the analytical procedure, a standard curve was created using the absorbance data and the values of the slope, intercept and correlation coefficient were computed. *Brassica oleracea var. capitata* Extract FT-IR Analysis in which a Bruker Alpha-II FT-IR spectrometer with an ATR attachment was used to acquire the infrared spectra of the green cabbage leaf extract. The functional groups contained in the extract sample were identified by spectral analysis conducted across the scanning range of 650–4000 cm^{-1}.

Pharmacological evaluation of Extract of *Brassica oleracea var. capitata* leaves

Anti-Solar Activity

The sample preparations were carried out by 10 mg% w/v concentration dissolving into the 100 ml of distilled water (10 mg/100ml). The UV absorption spectrum for the extract was obtained in ranges of 200-400 nm using UV-Vis Spectrophotometer model Shimadzu-1900i [29,30,31].

Formulation of *Brassica oleracea var. capitata* leaves Extract Sunscreen Cream

A three-step emulsification procedure was used to create the sunscreen product. Brassica oleracea extract, zinc oxide, titanium dioxide, vitamin E, propylene glycol, propyl paraben and glycerin were

dissolved in deionized water and heated to 80°C in order to create the aqueous phase in the first stage. Concurrently, cetyl alcohol, liquid paraffin and stearic acid were combined to create the oil phase, which was then heated to 80°C. The oil phase was progressively added to the aqueous phase at 80°C during the last mixing stage, stirring constantly for ten to fifteen minutes. After adjusting the pH with triethanolamine, the liquid was homogenized to produce a homogenous emulsion. To ensure product stability, the finished mixture was moved to wide-mouth containers and kept at temperatures no higher than 37°C.

Table No.1 Sunscreen Cream formulation composition.

Sr.No.	Ingredients	Quantity Taken
1	Green Cabbage Extract	0.6 gm
2	Zinc Oxide	0.6 gm
3	Vitamin E capsule	0.6 gm
4	Titanium dioxide	0.6 gm
5	Stearic acid	3.6 gm
6	Liquid paraffin	0.6 ml
7	Cetyl alcohol	0.8 gm
8	Propyl paraben	0.008 gm
9	Triethanolamine	0.4 gm
10	Propylene glycol	2 gm
11	Glycerine	4 gm
12	Water	1 ml
13	Rose water	0.192 gm

Retention of Functional Groups During Incorporation of Cabbage Extract into Sunscreen Cream (FTIR Spectroscopic Study)

Investigating the retention of important functional groups found in cabbage extract following its incorporation into a sunscreen cream formulation and guaranteeing the preservation of active phyto-constituents primarily flavonoids that provide anti-solar activity were the goals of this study. In order to find any significant chemical changes or interactions that might happen during formulation, a comparative FTIR study was conducted between pure cabbage extract and extract-loaded sunscreen. FTIR spectra of the pure cabbage extract and the sunscreen formulation containing cabbage extract were obtained as part of the approach. The stability and effectiveness of the finished product were confirmed by this spectroscopic comparison, which made it possible to determine if the bioactive compounds retained their structural integrity and functional qualities after being added to the sunscreen matrix.

Compatibility studies

In order to determine compatibility and spot any possible chemical interactions between the extract and other formulation ingredients, compatibility experiments were carried out to analyze and contrast the infrared spectra of sunscreen formulations containing and lacking cabbage extract (Placebo). FTIR spectra of the sunscreen formulation including cabbage extract and the placebo formulation without it were obtained as part of the approach. To directly compare the two formulations, an overlay infrared spectrum was made. This allowed for the detection of any spectral shifts, peak formations or spectral changes that might point to chemical interactions or incompatibilities between the base ingredients of the sunscreen and the cabbage extract. The inclusion of the extract did not negatively impact the final formulation's chemical stability thanks to this comparison investigation.

Evaluation of *Brassica oleracea var. capitata* leaves Extract Sunscreen Cream

The formulation's physical properties were systematically assessed using a variety of evaluation techniques. In order to evaluate the formulation's overall chromatic properties, the colour was ascertained by visual inspection and manual observation. In order to feel and examine the aroma profile and olfactory characteristics of the prepared product, the preparation was applied directly onto the hand surface. In order to ascertain the formulation's overall aesthetic and morphological qualities, the appearance characteristics were carefully investigated using visual inspection techniques, guaranteeing thorough documentation of all perceptible physical elements [32].To find the pH of each cream formulation, 0.5 g of the cream was continually weighed out of the container, dissolved in 50.0 ml of distilled water and the pH of the resulting solution was measured and recorded for each formulation [32]. The sunscreen lotion's washability was assessed by repeatedly putting it on the skin and then washing it off with water to see how easily the formulation came off [33]. In order to guarantee consistency throughout the product, the homogeneity of the formulation was assessed by regularly analyzing its visual appearance and evaluating its texture by touch [33]. The irritancy test was carried out by continuously marking a one-square-centimeter area on the left hand's dorsal surface, applying the lotion there, recording the time it was applied and then monitoring the area for any indications of edema, erythema or irritancy over the course of a day. All observations were documented [33]. For the purpose of testing the prepared formulation's stability, it was continuously stored at room temperature for seven days, then at a higher temperature of $45 \pm 1°C$ for twenty days. The formulation was observed at both conditions on the 0th, 5th, 10th, 15th, and 20th day for all evaluation parameters in order to determine whether stability changed over time [12]. In order to measure the viscosity of the cream formulation, the gel sample was continuously placed in a sample holder, a specific spindle was inserted into the gel, the Brookfield viscometer model (LV DV-I Prime) was attached to the spindle, allowed to rotate at a specific speed for two minutes and the viscosity of the formulation was then recorded [34]. In order to assess the sunscreen formulation's therapeutic efficacy, a suitable quantity of the sunscreen was continuously applied between two slides, a specific

load was placed on top and the slides were allowed to move under pressure. The time in seconds it took for the slides to separate was recorded; spreadability is the ability of the slides to separate in less time [14]. A 0.10% (w/v) solution of each lotion was continuously prepared by dissolving 0.050 g of the herbal sunscreen in 50 ml of ethanol. Then, using a UV-Visible spectrophotometer, the aliquots were scanned between 290 and 320 nm at 5 nm intervals to evaluate the in-vitro efficacy. The SPF was then calculated using a standard equation, with each sample being analyzed three times to ensure accuracy [35].

Result and Discussion

Extract of *Brassica oleracea var. capitata* leaves

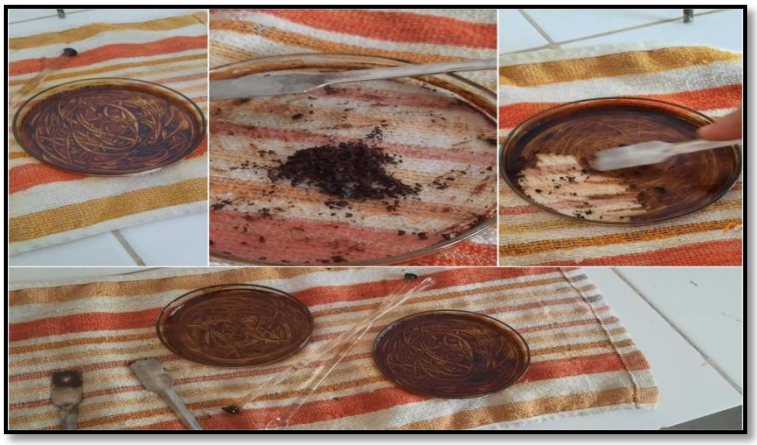


Fig.No.1 Extract of *Brassica oleracea var. capitata* leaves

Green Cabbage Leaves was dried and form fine powder. Green Cabbage Leaves was subjected for extraction in the presence of appropriate solvent and resultant extract was collected.

Characterization of *Brassica oleracea var. capitata* Leaves Extract

Determination of λ_{max}

Fig.No.2 UV Spectra of *Brassica oleracea var. capitata*.

The λ_{max} for *Brassica oleracea var. capitata* (cabbage) from the ethanol extract, the absorbance spectrum of the extract is typically scanned between 200 nm and 400 nm.The λ_{max} of extract *Brassica oleracea var capitata* was noted to be at 279 nm.

Calibration Curve of *Brassica oleracea var. capitata* Leaves Extract

Table No.2 Concentration and Absorbance

Concentration (µg/ml)	Absorbance
20	0.116
40	0.201
60	0.353
80	0.45
100	0.538

To make a 1 mg/mL stock solution, 10 mg of *Brassica oleracea var. capitata* extract was combined with 10 mL of ethanol. This solution was further diluted to 100 µg/mL. To create the calibration curve, standard solutions of 20, 40, 60, 80 and 100 µg/mL were prepared from the stock solution and then analyzed spectrophotometrically at 279 nm.

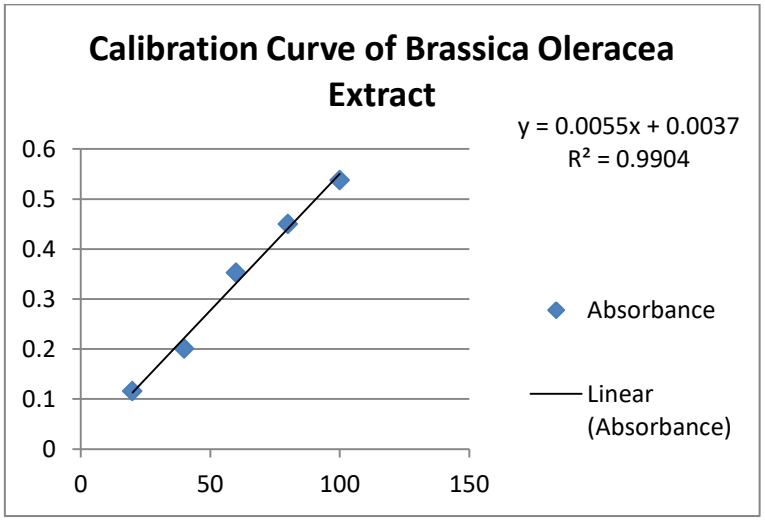


Fig.No.3 Calibration Curve of *Brassica oleracea var. capitata* Leaves Extract.

From the calibration curve equation obtained was,

$y = 0.0055x + 0.0037$

The value of slope (m) = 0.0055

The value of intercept (c) = 0.0037

The value of regression coefficient (R^2) = 0.9904

Fourier Transform Infrared Spectroscopy (FTIR) of *Brassica oleracea var. capitata* Leaves Extract

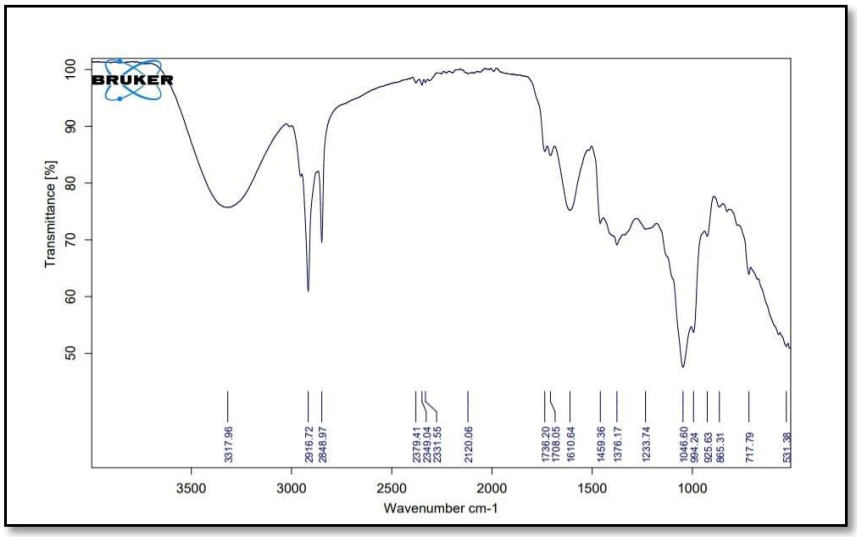


Fig.No.4 Fourier Transform Infrared Spectroscopy (FTIR) of *Brassica oleracea var. capitata* Leaves Extract.

The FTIR spectrum of the cabbage leaf extract revealed several characteristic absorption bands corresponding to different functional groups. A broad band at 3371.96 cm^{-1} was assigned to O–H stretching vibrations, indicative of phenolic hydroxyl groups commonly present in flavonoids and polyphenols. Peaks observed at 2848.97 and 2916.17 cm^{-1} corresponded to aliphatic C–H stretching of sp^3 hybridized carbons. A minor band at 2016.17 cm^{-1} suggested the possible presence of –C≡C– or –C≡N groups, which could be due to trace compounds or background interference. A strong absorption at 1738.20 cm^{-1} was attributed to C=O stretching vibrations, consistent with esters, ketones or carbonyl groups from flavonoids. Prominent peaks at 1610.04 and 1505.36 cm^{-1} were associated with aromatic C=C stretching, a core feature of flavonoid and polyphenolic structures. The band at 1376.17 cm^{-1} corresponded to C–H bending vibrations, typically from methyl groups. Additional peaks at 1223.74 and 1046.00 cm^{-1} indicated C–O stretching, confirming the presence of phenols, ethers or glycosides, which are also characteristic of flavonoid structures. Bands at 994.24 and 925.63 cm^{-1} were assigned to =C–H out-of-plane bending, representing substituted aromatic rings. Further absorptions at 865.31 and 717.79 cm^{-1} indicated aromatic C–H bending vibrations, while the band at 531.38 cm^{-1} fell within the fingerprint region, representing complex bending modes not easily assigned to a single functional group. FTIR analysis of cabbage leaf extract revealed phenolic O–H, aromatic C=C, carbonyl (C=O) and C–O groups, confirming the presence of flavonoids and related polyphenols responsible for UV-protective and anti-solar activity.

Pharmacognostical evaluation of Extract of *Brassica oleracea var. capitata* leaves

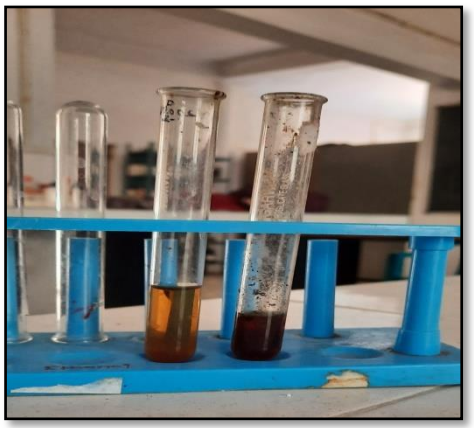


Fig.No.5 Pharmacognostical evaluation of Extract of *Brassica oleracea var. capitata* leaves.

The phytochemical screening of the extract confirmed the presence of flavonoids. In the Shinoda test, the appearance of a pink colour indicated a positive result for flavonoids. Similarly, the lead acetate test showed the formation of a yellow precipitate, further confirming the presence of flavonoids in the extract.

Pharmacological evaluation of Extract of *Brassica oleracea var. capitata* leaves

Anti-Solar Activity

Fig.No.6 Anti-Solar Activity of Extract of *Brassica oleracea var. capitata* leaves.

The UV scanning absorption spectra of the extract showed very strong absorption 0.850 A with λ_{max} at 279 nm. The graph extract also showed a plateau in range of 350-400 nm with moderate absorbance of ~0.5-0.3. This confirms *Brassica oleracea var. capitata* extract has Anti-Solar activity.

Formulation of *Brassica oleracea var. capitata* leaves Extract Sunscreen Cream

Two sunscreen formulations were prepared for the study one incorporating cabbage leaf extract as the active ingredient and a placebo formulation without the extract. Both were developed under identical

conditions to ensure uniformity in texture, colour and application properties, thereby allowing a reliable comparison of their characteristics and performance.

Fig.No.7 Formulation of Extract of *Brassica oleracea var. capitata* leaves.

Retention of Functional Groups During Incorporation of Cabbage Extract into Sunscreen Cream (FTIR Spectroscopic Study)

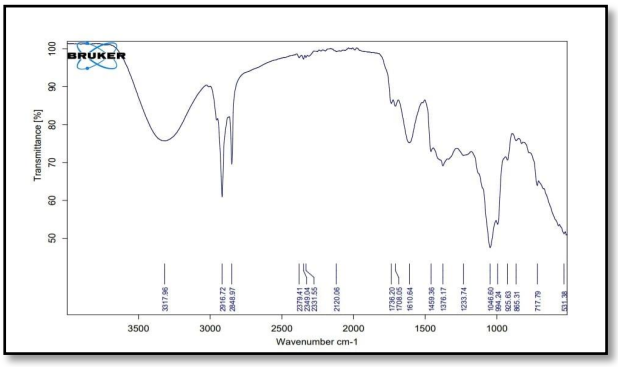


Fig.a) FTIR of *Brassica Oleracea var. captita* extract

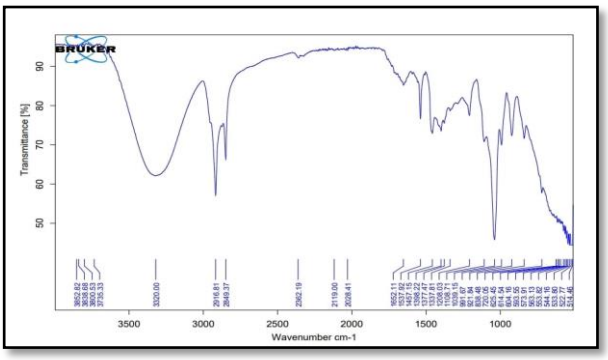


Fig.b) FTIR of Extract loaded sunscreen Cream.

Fig.No.8 Retention of Functional Groups During Incorporation of Cabbage Extract into Sunscreen Cream (FTIR Spectroscopic Study)

The main functional groups in charge of the anti-solar action were preserved during formulation, according to FTIR analysis of the cabbage extract and the sunscreen formulation including the extract. While distinctive C=O stretching vibrations in the range of ~1738–1652 cm^{-1} demonstrated the stability of the conjugated carbonyl system, a broad O–H stretch seen about ~3320 cm^{-1} verified the existence of phenolic hydroxyl groups. The C–O stretching bands (~1233–1046 cm^{-1}) showed the retention of ether and ester connections, while the C=C aromatic stretch near ~1610 cm^{-1} further verified that the flavonoid aromatic structure remained intact. Furthermore, aliphatic C–H stretching vibrations (~2916 and 2849 cm^{-1}) reinforced the compounds structural soundness. These findings

imply that the crucial functional groups (O–H, C=O, C=C and C–O) associated with anti-solar activity were not broken down during formulation, as flavonoids are known to be present in cabbage extract.

Compatibility studies

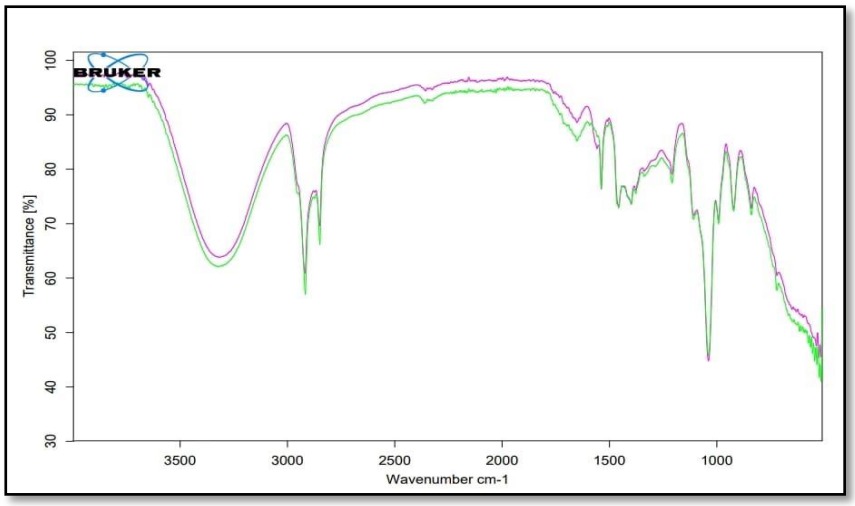


Fig.No.9 FTIR Overlay of *Brassica Oleracea var. captita* extract Sunscreen Cream and Placebo Sunscreen Cream.

The infrared spectra of the sunscreen formulations containing cabbage extract and a placebo were captured and superimposed. The overlay showed that the distinctive peaks of the key functional groups in both formulations stayed the same indicating that the chemical stability of the sunscreen base is unaffected by the addition of cabbage extract. Chemical compatibility between the extract and the formulation matrix was demonstrated by the absence of any notable new peaks or the elimination of pre-existing peaks. The integrity of the base formulation and the efficient inclusion of cabbage phytochemicals without unfavourable interactions were confirmed by the common peaks in both spectra that corresponded to O–H stretching, C=O stretching and C–H bending. Overall, the IR spectral properties of the sunscreen containing cabbage extract were similar to those of the placebo, indicating the extract's stability and chemical compatibility within the sunscreen base and bolstering its safe integration into the finished product.

Evaluation of *Brassica oleracea var. capitata* leaves Extract Sunscreen Cream

Physical parameters

The marketed sunscreen, placebo sunscreen and cabbage extract sunscreen were all semisolid in state with good overall appearance. Both the marketed and placebo formulations were white in colour while the cabbage extract sunscreen was brown. All three formulations had a rose-like odour and a smooth texture.

Determining pH of the Cream

The pH values for the formulations are as follows the marketed sunscreen has a pH of 7.1, the placebo sunscreen has a pH of 7.3 and the cabbage extract sunscreen has a pH of 7.4.

Washability

Along with marketed Sunscreen, both Placebo (without extract) and Cabbage extract sunscreen creams are easily washable.

Homogeneity

Along with marketed Sunscreen, both Placebo (without extract) and Cabbage extract sunscreen creams are Homogenous in nature.

Irritancy Test

The marketed sunscreen, placebo sunscreen and cabbage extract sunscreen showed no irritant effects. No erythema or edema was observed in any of the formulations, indicating that all three were non-irritating and well-tolerated on the skin.

Stability Testing

The marketed sunscreen, placebo sunscreen and cabbage extract sunscreen showed no oil separation, indicating good physical stability of all formulations.

Spreadability

S=ml/t

m=25.40

l=7.5

t= 37 sec

Thus, spreadability of Extract loaded sunscreen cream was found to be 5.14.

Determination of Viscosity

Using a Brookfield viscometer with spindle number 64 and 100 rpm, the viscosity of Marketed, placebo, Cabbage Extract Sunscreen Cream was determined. The viscosity was measured and found to be 844 CPS, 1120 CPS, 1460 CPS respectively.

Sun Protection Factor (SPF) Calculation

$$\mathrm{SPF(Spectrometry)} = \mathrm{CF} \times \sum_{290}^{320} \mathrm{EE}(\lambda) \times \mathrm{I}(\lambda) \times \mathrm{abs}(\lambda)$$

Where, CF =10 (Correction Factor), EE (λ) = Erythemogenic effect of radiation at wavelength (λ), I (λ) = Intensity of solar light at wavelength (λ), abs (λ) = Absorbance of wavelength (λ).

Table No.3 Sun Protection Factor (SPF) Calculation.

		Marketed Sunscreen cream	
Wave length (λ)	**EE(λ)×I(λ)**	**Abs(λ)**	**EE(λ)×I(λ)×Abs(λ)**
290	0.015	3.052	0.04578
295	0.0817	3.02	0.246734
300	0.2874	3.023	0.8688102
305	0.3278	3.072	1.0070016

310	0.1864	3.015	0.561996
315	0.0839	3.053	0.2561467
320	0.018	3.154	0.056772
Total		3.0432375	
SPF		**30.432375**	

			Placebo Sunscreen cream
Wave length (λ)	**EE(λ)×I(λ)**	**Abs(λ)**	**EE(λ)×I(λ)×Abs(λ)**
290	0.015	0.493	0.007395
295	0.0817	0.457	0.0373369
300	0.2874	0.479	0.1376646
305	0.3278	0.547	0.1793066
310	0.1864	0.552	0.1028928
315	0.0839	0.575	0.0482425
320	0.018	0.532	0.009576
Total		0.5224144	
SPF		**5.224144**	

			***Brassica oleracea var. capitata* leaves Extract Sunscreen Cream**
Wave length (λ)	**EE(λ)×I(λ)**	**Abs(λ)**	**EE(λ)×I(λ)×Abs(λ)**
290	0.015	1.192	0.01788
295	0.0817	1.021	0.0834157
300	0.2874	0.989	0.2842386
305	0.3278	1.131	0.3707418
310	0.1864	1.068	0.1990752
315	0.0839	1.060	0.088934
320	0.018	1.016	0.018288
Total		1.0625733	
SPF		**10.625733**	

From the above observation and calculation it was found that the SPF of Marketed Sunscreen, Placebo (Without Extract) Sunscreen and *Brassica oleracea var. capitata* Extract Sunscreen Cream as 30.432375, 5.224144, 10.625733 respectively.

Summary

The project focuses on the formulation and evaluation of a sunscreen cream loaded with green cabbage (*Brassica oleracea var. capitata*) leaf extract. The extract was obtained through standard extraction methods and analyzed for its photo-protective potential.

UV spectroscopic analysis was performed in the range of 200-400 nm, where the cabbage leaf extract showed a maximum absorbance (λ_{max}) at 279 nm with an absorbance value of 0.527, confirming its

ability to absorb harmful UV radiation. Further characterization using Infrared (IR) spectroscopy revealed the presence of flavonoids, which was supported by positive results in chemical tests specific for flavonoids, highlighting the extract's potential for anti-solar activity.

A sunscreen cream was then formulated incorporating the cabbage leaf extract. Compatibility studies confirmed good compatibility between the extract and other cream ingredients. The prepared formulation was evaluated alongside a marketed sunscreen and a placebo (cream without extract).

The evaluation parameters included physical appearance, pH, viscosity, spreadability, washability, irritancy and stability all of which demonstrated positive and acceptable results for the Green cabbage Extract-loaded formulation.

Finally, in-vitro determination of the Sun Protection Factor (SPF) was carried out. The results showed that the marketed formulation had an SPF of 30.43, the placebo formulation had an SPF of 5.22 and the sunscreen loaded with cabbage extract exhibited an SPF of 10.62.

Conclusion

The study successfully demonstrated that green cabbage leaf extract possesses notable anti-solar activity, primarily attributed to the presence of flavonoids. The formulated sunscreen cream showed acceptable physical and chemical properties, good compatibility and stability.

Although the SPF of the cabbage-loaded sunscreen was lower than that of the marketed formulation, it significantly outperformed the placebo, proving its efficacy as a natural UV-protectant. This suggests that cabbage leaf extract can be a promising natural ingredient in the development of herbal sunscreen products, contributing to safer and more sustainable skincare alternatives.

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