T.R.
USKUDAR UNIVERSITY
INSTITUTEOF SCIENCE

DEPARTMENTOF CHEMICAL
ENGENEERING PROGRAM

MASTER THESIS

DESIGNING NATURAL SKIN CARE PRODUCT FORMULATIONS TO ACTIVATE VITAMIN D_3 IN THE BODY

MARWAH SABAH ABDUL HASAN AL-JAILAWI

Thesis Advisor
Asst. Prof. Mert Mehmet OYMAK

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ÖZET

Güneş insan vücudu için çok önemlidir. Güneşin önemli katkılarından biri de vücutta D vitamini üretimidir. D_3 vitamini üretiminin sağlanması için güneşin UVB ışınlarına ihtiyaç vardır.

Güneş ürünleri göl ve denizlerde kullanılmakta, deniz ortamına sızarak deniz yaşamına zarar vermekte ve su kirliliği oluşturmaktadır. Bu nedenle formülasyon hazırlarken amacımız mümkün olduğunca doğal bileşikler ve daha az kimyasal kullanmaktı. Doğal renge sahip homojen bir formül olarak en uygun olanlar; Formül 1 (%70 aloe vera jeli-%30 hindistan cevizi yağı), Formül 8 (%90 aloe vera jeli-%10 kahve mate'i) ve Formül 10 (%80 aloe vera jeli-%20 kahve mate'i) idi.

Yüksek spf faktörüne sahip güneş ürünleri esas olarak güneş yanığını önlemek için tasarlanmıştır ancak yüksek UV engelleme nedeniyle D vitamini üretimi için tasarlanmamıştır. Amacımız aynı zamanda kısmi güneş engelleme özelliğine sahip bir güneş ürünü tasarlamaktır. Bu nedenle tasarlanan formüller arasında (%20 kahve içeren) formül 9 iyi bir engelleme özelliği göstermiştir. Kahve çözeltisi yüzdesinin artmasıyla bloklama yeteneğinde bir artış gözlendi. Formül 9'un kullanılması UV İndeksini New York City için tüm yıl boyunca düşük ve orta seviyelere düşürdü.

Anahtar Kelimeler: D Vitamini, UVB, Güneş ürünü, UV Blok.

ABSTRACT

Sun is very important for the human body. One of the important contributions of the sun is vitamin D production in the body. To ensure vitamin D_3 production, UVB rays of the sun is needed.

Sun products are used in lakes and seas, leaks into marine environment, harming marine life and creating water pollution. For this reason, our aim was to use natural compounds and less chemicals as much as we can in formulations. Formula 1 (70% aloe vera gel-30% coconut oil), formula 8 (90% aloe vera gel-10% coffee mate) and formula 10 (80% aloe vera gel-20% coffee mate) were the most suitable as a homogeneous formula with natural color.

Sun products with high spf factors are mainly designed for sunburn preventing but not vitamin D production due to high UV blocking. Our aim is also to design a sun product with partial sun blocking properties. Among designed formulas for this reason, formula 9 (with 20% coffee) showed good blocking ability. An increase in blocking ability was observed with increasing coffee solution %. Using formula 9 decreased the UV Index to low and moderate levels for the whole year for New York City.

Keywords: Vitamin D, UVB, Sun product, UV Block.

DECLARATION

I hereby declare that this study is my own thesis study, that I have not engaged in any unethical behavior during the development or composing of the thesis, that I have complied with all legal and academic requirements for obtaining the information included in the thesis, and that I have consulted all relevant sources for any information or responses not included in the thesis.

Marwah Sabah

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1. INTRODUCTION

Human health is very important, and therefore most of the researches around the world in various sciences aims to enhance human health and study materials and their impact on both of health and environment. Among these materials are medicines, vitamins, nutritional supplements, manufactured foods, care products, sunscreens, and others. In this study we will shed light on D vitamin, because D vitamin is the most important vitamin in the body.

In general, Vitamins are organic compounds that body mainly needs, they are necessary for enzymes function and vital processes in the body, they are obtained from various animal and plant sources in daily meals, and although human's body may produce small quantities of some types of vitamins, many of them not produced by body and must be obtained from external sources, the body needs amounts of vitamins within a certain range, and any deficiency or excess beyond this normal range causes serious health problems. (Slominski AT, et al., 2017).

1.1. Types of Vitamins

There are 13 vitamins of two types

1- Fat-soluble vitamins

A vitamin, D vitamin, E vitamin and K vitamin.

2- Water-soluble vitamins

C vitamin and B vitamins (B_1, B_2, B_3, B_5, B_6, B_7, B_9 and B_{12}).

1.2. Vitamin D and Its Properties

D vitamin is one of the fat-soluble vitamins, it is a white crystalline substance (Figure 1) that resists heat and it is relatively stable in the oxidation (Figure 2). (Slominski AT, et al., 2017).

Figure 1: Cholecalciferol (Vitamin D3).

Chemical name: Cholecalciferol

Molecular formula: $C_{27}H_{44}O$

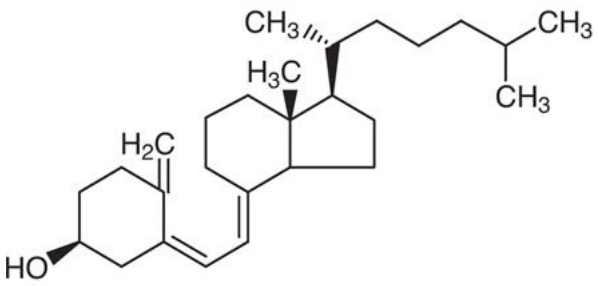


Figure 2: Chemical structure of Cholecalciferol (D3 vitamin).

1.3. How D Vitamin Produced in The Body

It is produced in the body naturally by converting (7dihydrocholesterol) present between skin layers into a form of vitamin D_3 called Cholecalciferol under the influence of one of solar rays through sunlight called UVB it's wavelength between (280-315) nm. Then it is transported through blood to the liver and there it turns into (25hydroxycholecalciferol) or (25-hydroxyD_3) called Calcifediol (Figure 3) then transported again through the blood to the kidney and there it turns into (1,25dihydroxycholesiferol) or (1,25$(OH)_2D_3$) called Calcitriol which is the final form of vitamin D or hormone D that can bind to vitamin D receptors in the cells membrane to inter the cell and then carry out the necessary activities in the body (Figures 3,4). (Slominski, et al., 2017)

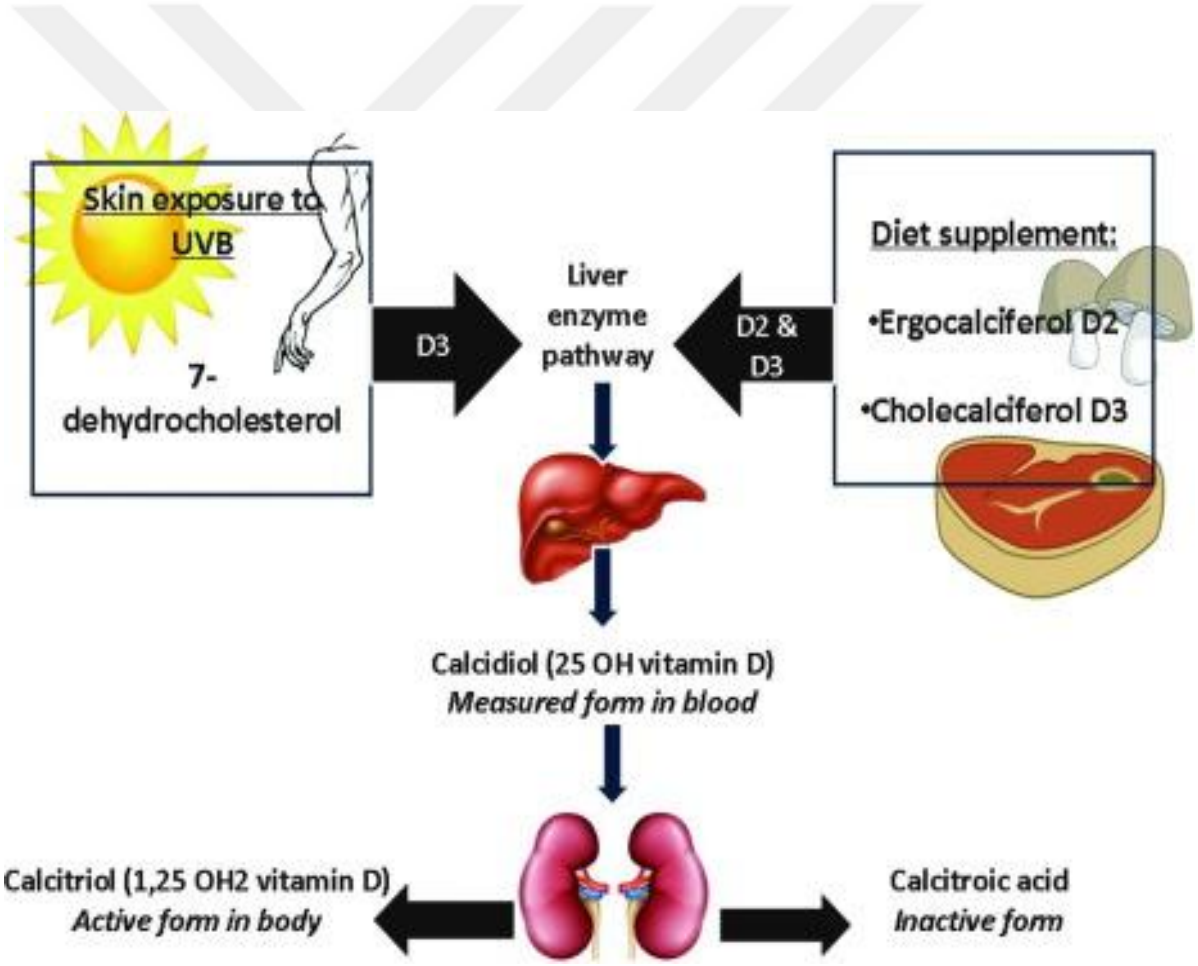


Figure 3: Active form of vitamin D production in human's body.

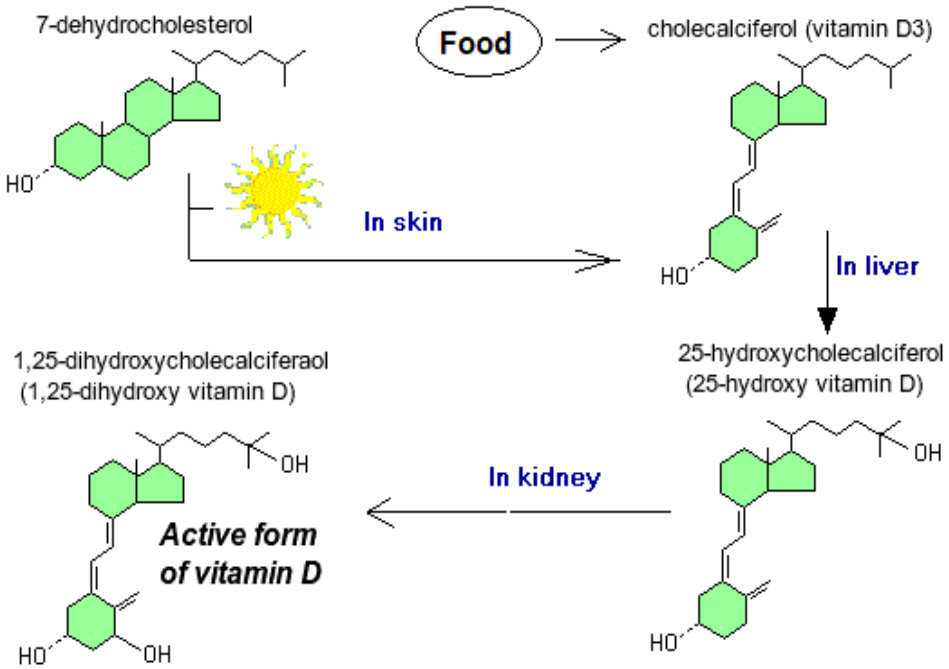


Figure 4: Activation of vitamin D in the body.

1.4. Types of Vitamin D

1.4.1. Vitamin D_1

Vitamin D1, which is the first type of vitamin D, the history of the discovery of vitamin D_1 comes from the German scientist Adolf Windaus, who was able to identify 3 types of vitamin D in the beginning, then he named them vitamin D_1, vitamin D_2, and vitamin D_3. then it was discovered that D_1 consists of a homogeneous mixture of two compounds Ergocalciferol and Lumisterol and because of being not pure compound of vitamin D, so it is no longer called vitamin D_1.

1.4.2. Vitamin D_2

It is a type of vitamin D, which consists mainly of the compound Ergocalciferol, chemical formula ($C_{28}H_{44}O$) which is formed in some plants when exposed to sunlight. Therefore, it is only found in plant sources such as mushrooms, vegetable oils, fortified foods, or manufactured nutritional supplements. one of the concerns facing science about vitamin D_2 is that supplements made from it are less stable chemically, as they are

considered more sensitive to humidity and temperature fluctuations than others, and decompose faster over time. therefore, it is recommended to store vitamin D_2 supplements in their own container, at room temperature away from moisture, heat, and direct sunlight.

1.4.3. Vitamin D_3

Vitamin D_3 consists of the compound (Cholecalciferol), which is produced naturally in the skin of human and animals after exposure to sunlight, chemical formula ($C_{27}H_{44}O$), therefor this type of vitamin D (D_3) is also can be extracted from animal sources, as it is available in large quantities in fish oil, liver, egg yolk, and ghee.

The body generally produces vitamin D_3 when only exposed to ultraviolet rays from sunlight wavelength (280-315) nm, but using sunscreen or not being exposed to enough sunlight hinders the process of producing vitamin D_3 in the skin.

1.4.4. Vitamin D_4

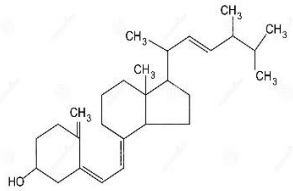
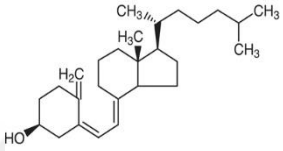
It is 22-Dihydroergocalciferol chemical formula ($C_{28}H_{46}O$) it is a form of vitamin D, known as vitamin D_4, found in certain mushrooms, being produced from Ergosta-5,7-dienol (22,23-dihydroergosterol) instead of Ergosterol, it has a role as a fungal metabolite. In fact, there isn't enough study about the role of vitamin D_4 in the body. (Slominski, et al.,2017).

Therefore, we can say that there are only two active types of vitamin D, which are D_2 and D_3.

1.5. The Difference Between D_2 and D_3

The difference between D_2 and D_3 shown in table 1 and explanations.

Table 1: The difference between D2 and D3.

D_2	**D_3**
$C_{28}H_{44}O$	$C_{27}H_{44}O$
Ergocalciferol	Cholecalciferol
	
Found only in mushroom and some vegetable oils or nutrition supplements.	Produced naturally in the body by exposure to sunlight and found in fish, egg yolk, liver and butter or ghee.
Less active in the body	More active in the body
Less stable	More stable
More toxic	Less toxic

The difference between vitamin D_2 and vitamin D_3 in terms of producing

Includes that vitamin D_3 can be produced through exposure to sunlight, where the compound 7-Dehydrocholesterol, which is found in the layers of the skin, is transformed into vitamin D_3 by ultraviolet rays (280-315) nm,

While a similar process occurs in plants when they are exposed to sunlight, in which vitamin D_2 is formed from the compound Ergosterol found in vegetable oils.

The difference between D_2 and D_3 in terms of activity in the body, vitamin D_3 produces much more amounts of Calcifediol compared to D_2. Calcitriol or (1,25-hydroxyD_3) the most active form of vitamin D which results from the conversion of Calcifediol

(25-hydroxyD_3) in the kidney. Most studies show that vitamin D_3 is more effective than vitamin D_2 in raising blood levels of Calcifediol.

A study in 32 elderly women found that a single dose of vitamin D_3 was almost twice as effective as vitamin D_2 at raising Calcifediol levels in the blood. vitamin D_2 can be obtained from its primary substance, which is sometimes called primary vitamins or provitamins, which is Ergosterol, which is abundant in plants and is not characterized by great nutritional benefit because it cannot be absorbed well through the intestine, when the provitamin Ergosterol is exposed to sunlight or ultraviolet rays, we can obtain vitamin D_2, when exposing the pre-vitamin 7-dihydro cholesterol, which can be obtained from the activated cholesterol compound, to sunlight or ultraviolet rays, we can obtain vitamin D_3,(Figure 5). (Slominski AT, et al.,2017).

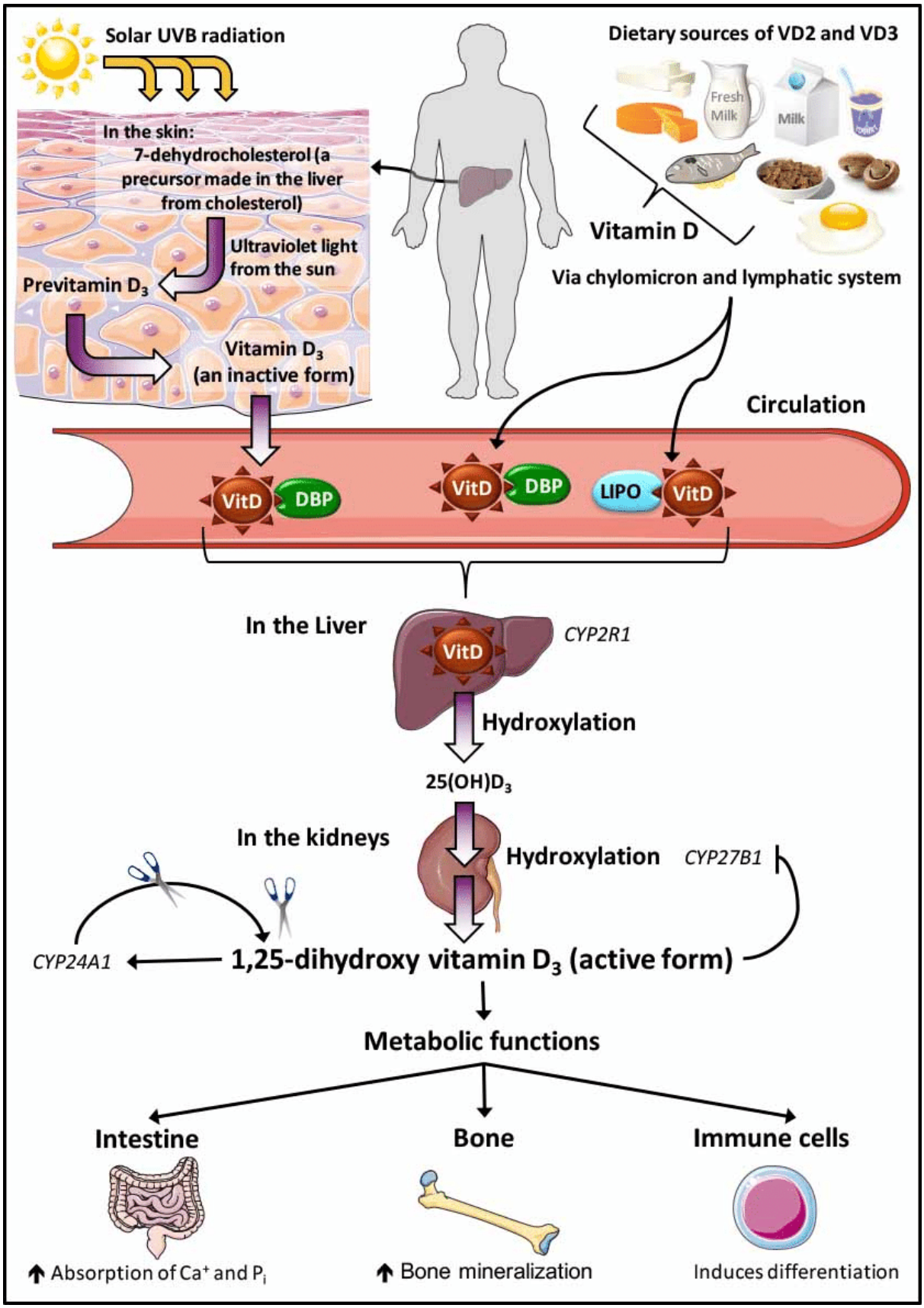


Figure 5: Metabolism of vitamin D in the body.

1.6. The Role of Vitamin D in The Body

The effect of vitamin D on various organs and tissues of the body. Vitamin D is often linked to bone health and the immune system, but the role of this vitamin includes various parts of the body, and it is truly amazing and wonderful. Vitamin D receptors are found in every cell of the body, and since it is hydrolyzed, it penetrates the cell membrane and reaches the center of the cell where the nucleus is. Therefore, it has a tremendous effect on the cell, the truth is that vitamin D is not considered a vitamin, but rather a hormone that is being studied.

In more detail, there are more than 64 thousand studies and reviews on vitamin D, which has been studied extensively and is the most important fat-soluble vitamin and affects 3-4% of the genome. Genome is the genetic material in the body, DNA, which is tightly packed side by side, 3-4% of this genetic material is subject to the influence of Vitamin D. (Eric Berg.,2022).

In the following the effect of vitamin D on some organs and parts of the body.

The Brain

Vitamin D deficiency prevents sleep at night, this vitamin enhances the circadian system and enhances the sleep centers in the brain called the superchiasmatic nucleus, whether you suffer from obstructive sleep apnea or insomnia, or you suffer from waking up at night at 2 a.m. due to high cortisol, vitamin D greatly affects the part responsible for cognitive skills in defense and the part responsible for memories, which helps focus, vitamin D deficiency is a common factor in Alzheimer's, Parkinson's, and dementia, and it also affects mood greatly in the winter months. What we notice is the occurrence of seasonal affective disorders and depression due to lack of exposure to the sun and the resulting vitamin D deficiency, which leads to depression and feelings of sadness, and this is an indication of the great importance of vitamin D for the health of the body, the body can convert sunlight into vitamin D through the skin through cholesterol present in the tissues, without obtaining it from food. Rather, all that is needed is exposure of the skin to sunlight. if you suffer from anxiety or depression in particular, you should take vitamin D, which inevitably contributes to Enhances mood and also enhances memory (Figures 6,7). (Eric Berg.,2022).

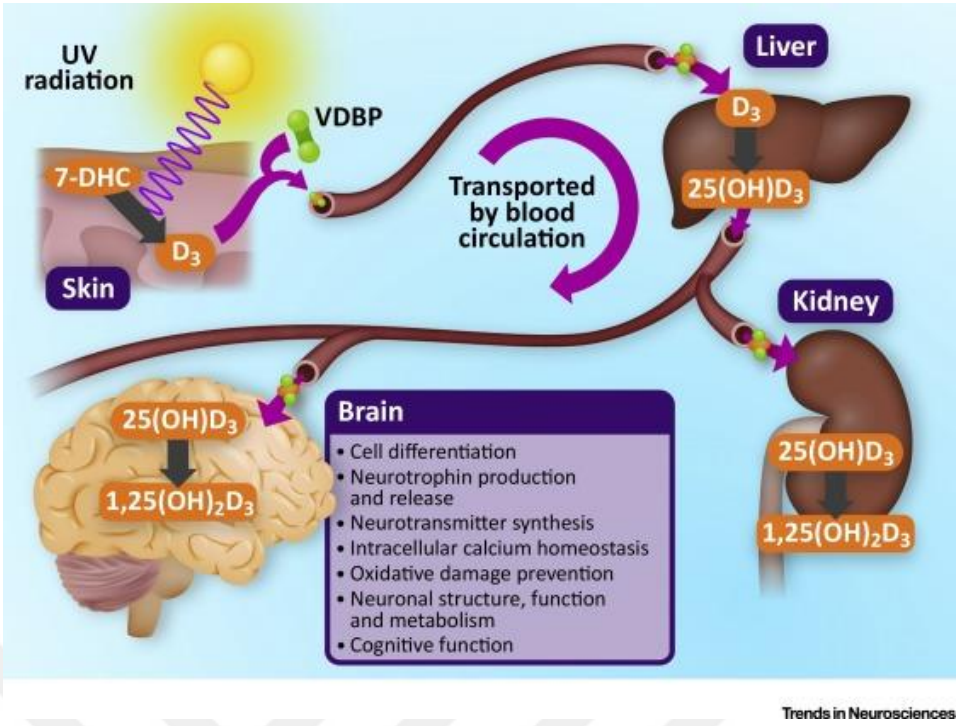


Figure 6: Vitamin D effect on the brain.

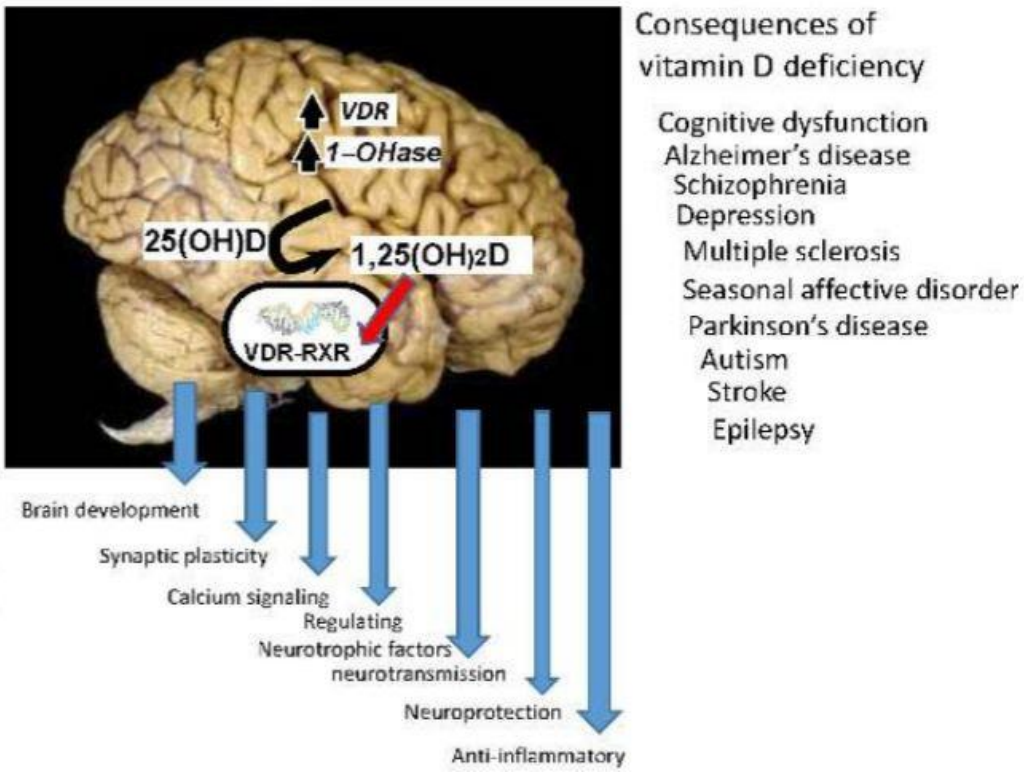


Figure 7: The rule of vitamin D in brains functions. (Natalie J. Groves.,2014).

Hair Health

Vitamin D deficiency leads to hair dryness and breakage and leads to decreased hair growth because hair growth depends on vitamin D and may lead to premature graying and hair loss resulting from stress (telogen effluvium) and hair loss at the age of menopause, or suffering from an autoimmune disease, such as alopecia areata, which leads to hair loss, so controlling inflammation helps control these diseases, and vitamin D is one of the best and most effective natural anti-inflammatories. (Eric Berg.,2022).

The Scalp

Vitamin D is also necessary for the scalp because its deficiency makes it vulnerable to psoriasis or even eczema in the skin. It is also necessary for skin health in general. People with acne suffer from vitamin D deficiency, usually vitamin D contributes to reducing inflammation in the skin and helps prevent acne. Vitiligo, which is the loss of the natural color of the skin or the appearance of white spots. People with vitiligo suffer from vitamin D deficiency. In all cases, vitamin D deficiency leads to a greatly increased risk of skin cancer (melanoma 9). (Eric Berg.,2022).

Sinuses

The sinuses contain vitamin D receptors, so vitamin D deficiency may lead to nasal congestion or sinusitis. The purpose of the presence of vitamin D in the nose is to combat viruses that attempt to enter the body through the nasal airways. (Eric Berg.,2022).

The Immune System

Vitamin D is required for its supportive role in all parts of the immune system. Every part of the immune system contains receptors for vitamin D, both B and T cells, and the innate immune system that we are born with, as well as the acquired immune system, also needs it to Vitamin D, vitamin D helps control the inflammatory storm (cytokine) and helps control the development of some immune diseases, it helps control the self-attack that occurs in autoimmune diseases, it is also an immunomodulatory, meaning it helps control immune reactions, which is why it helps in cases of allergies as well. It also contributes to controlling viruses and reduces the risk of contracting viral infections. (Eric Berg.,2022).

Therefore, vitamin D is the most important nutrients for a healthy immune system.

The Thymus Gland

The thymus gland (9th thymus) is located above the heart and serves as a training camp for T cells, but with age, this gland begins to shrink, as does the immune system. (Eric Berg.,2022).

Eye Health

Vitamin D contributes to delaying the development of cataracts in people most at risk of developing it. Vitamin D deficiency is linked to macular degeneration and glaucoma, especially dry eyes. (Eric Berg.,2022).

Thyroid Gland

The health of the thyroid gland, which is located at the base of the neck and measures 5cm, the most common disorder is Hashimoto's disease, as 90% of cases of hypothyroidism are attributed to Hashimoto's, an autoimmune disease. as mentioned, vitamin D is the best natural treatment for autoimmune diseases because of its role in reducing inflammation, the absence of inflammation when suffering from any of the autoimmune diseases greatly reduces any complications and side effects that result from the body's attack on itself, thus both Hashimoto's disease and Graves' disease are autoimmune diseases, one of which is hypothyroidism and the other is hyperthyroidism. (Figure 8). (Eric Berg.,2022).

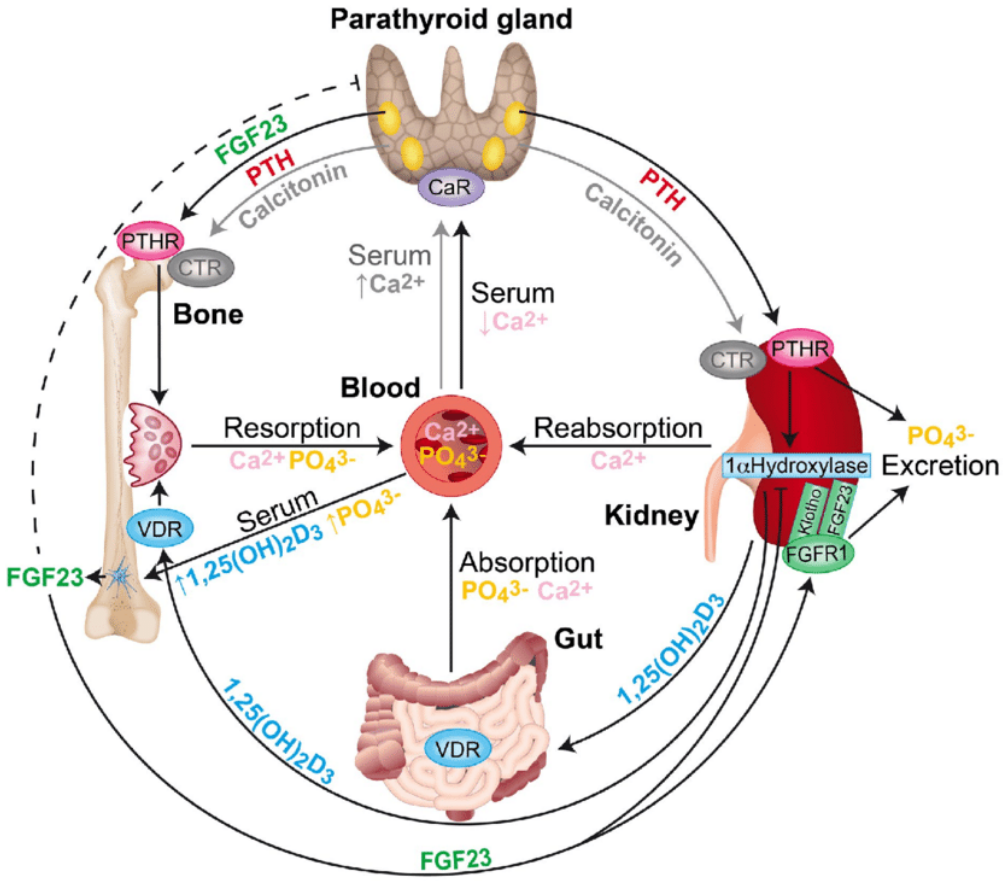


Figure 8: The role of vitamin D in Thyroid gland functions. (Verena Fischer,.2018).

Dental Health

Vitamin D deficiency affects the access of calcium to the bones and teeth, just as bones are calcium, vitamin D is necessary for regulating calcium (Figure 9), vitamin D deficiency at an early age or at the fetal stage in the mother's womb can lead to various bone deformities at various stages. Later in life, or even in childhood. there may be abnormalities in the upper jaw, such as the advancement of the upper or lower jaw, or the need for braces due to crooked teeth, or due to the loss of some teeth, therefore, the effect of vitamin D deficiency is not limited to the teeth, but rather to the entire skeleton, and increases the susceptibility to developing lateral scoliosis, which causes the spine to tilt in the shape of a letter (S), or kyphosis of the spine or a curved back (ischemia), which is a severe curvature of the back, flat feet, or bowed legs, which is rickets because vitamin D deficiency causes softening and deformation of the bones, which may be devastating to the child because it affects his appearance and thus his self-confidence, at later stages of his life, he may be forced to undergo jaw protrusion surgery, whether upper or lower,

which is a massive type of surgery, and it is really difficult, including making incisions in the bones and removing some parts of the face and then reattaching them in their correct place to restore the symmetrical shape of the face and correct the protrusion properly, which may require years of braces, which is something that can be avoided. Completely, as soon as the mother obtains a sufficient amount of vitamin D in the early stages during pregnancy and breastfeeding, this secures the child's need for vitamin D and other nutrients during the growth stage. The effect of vitamin D on the teeth is very enormous, as is the case with calcium. (Eric Berg.,2022).

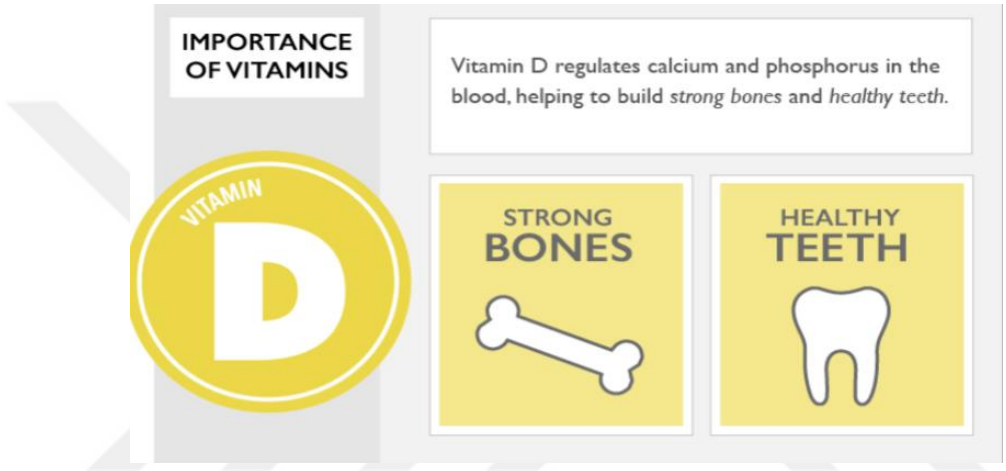


Figure 9: The importance of vitamin D in bones and teeth.

The Lungs

The lungs exposure to sunlight may alleviate the symptoms of asthma in children, as vitamin D helps open the airway in the lungs and improves the problem of asthma. It has a tremendous effect on lung infection, inflammation, and bronchitis, and it is also what helps most in all cases, it helps keep viruses at bay and has a tremendous effect on chronic obstructive pulmonary disease and lung cancer. (Eric Berg.,2022).

The Muscle

Vitamin D deficiency hinders the muscle recovery process after exercise and leads to muscle spasm because vitamin D helps control calcium. Calcium is responsible for the process of muscle contraction and relaxation, so it is not necessarily one of the electrolytes that is the cause. Spasticity, but rather the vitamin that helps absorb electrolytes,

Magnesium is also necessary when taking vitamin D because they work together because Magnesium is very necessary for muscle physiology, and that is why we need vitamin D for muscle pain, spasm, or weakness. (Eric Berg.,2022).

Adrenal Gland

The main hormone produced by the adrenal cortex is cortisol, which works similarly to vitamin D, both are effective anti-inflammatory agents and both enhance the strength of the immune system, high levels of cortisol require more vitamin D, this is why vitamin D is very necessary to enhance the function of the adrenal gland, adrenal gland High levels of cortisol cause a loss of vitamin D, which leads to a severe increase in the need for vitamin D. (Eric Berg.,2022).

The Pancreas

Especially its cells responsible for insulin production, called the islets of Langerhans, beta cells need vitamin D to produce insulin, but when suffering from an autoimmune disease such as type 1 diabetes, vitamin D deficiency may greatly increase the body's vulnerability to this infection, as for the infection the importance of vitamin D lies in reducing inflammation as much as possible. (Eric Berg.,2022).

The Heart

There is a close connection between coronary artery disease and vitamin D deficiency.

Vitamin D reduces inflammation within the coronary artery. Likewise, with regard to high blood pressure, vitamin D is one of the best things that contributes to reducing high blood pressure. People with high blood pressure suffer from a vitamin D deficiency, so one of the benefits of vitamin D is that it reduces high blood pressure, which contributes to reducing the risk of a stroke and reduces the risk of other kidney and heart diseases (Figure10). (Eric Berg.,2022).

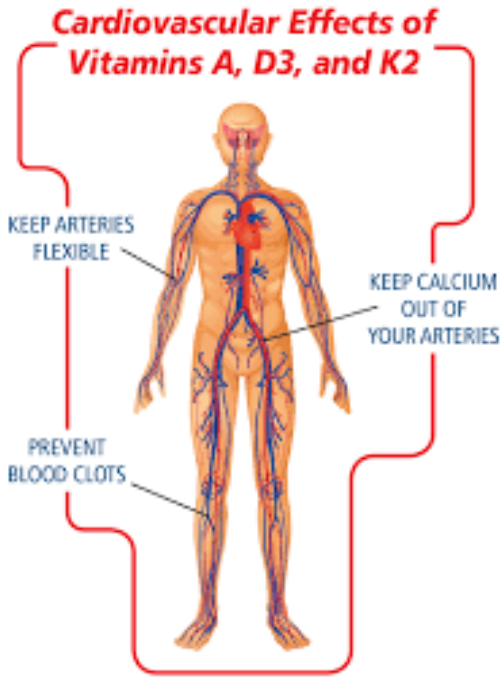


Figure 10: The role of vitamin D in heart function.

The Liver

The lack of vitamin D increases the risk of developing insulin resistance, which many people suffer from. Vitamin D helps in the absorption of insulin and other nutrients as well, especially calcium, as there is a close connection between D deficiency and fatty liver, and between vitamin D deficiency and hepatitis, so it is recommended to take vitamin D for all cases of inflammation in the body's organs, especially the liver (Figure 11). (Eric Berg.,2022).

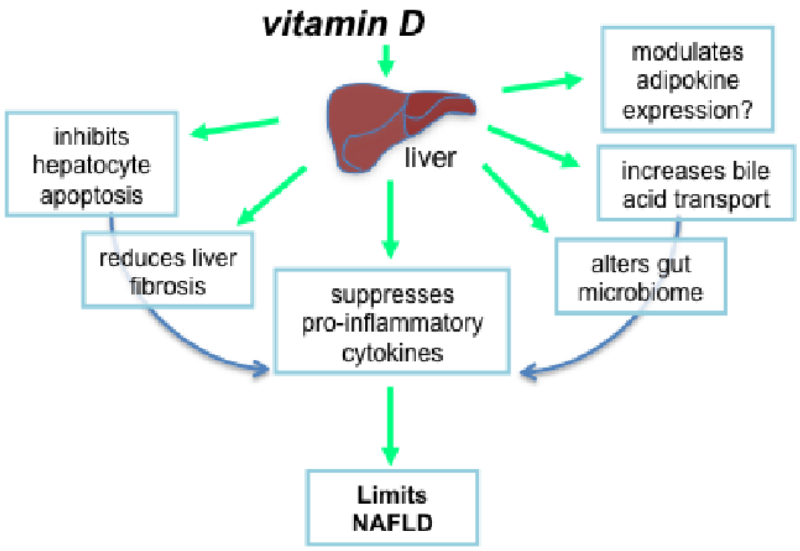


Figure 11: The role vitamin D in liver function. (Shelley Gorman2015).

The Kidney

Vitamin D deficiency increases the tendency to form kidney stones, the kidneys are among the last stations where vitamin D is converted to the active form, so the presence of any damage to the kidneys hinders the process of converting vitamin D, knowing that all cells also enjoy with the ability to convert vitamin D to its active form, but the largest role falls on the kidneys in the process of converting vitamin D from the inactive form to the active form, many suffer from irritable bowel syndrome, ulcerative colitis, Crohn's disease, and diverticulitis. (Eric Berg.,2022).

The Intestine

Vitamin D contributes to alleviating all types of inflammation in the intestine, but exacerbation of these infections leads to leakage of the intestine and the formation of gaps in the intestine, resulting in autoimmune diseases and allergies to various things, including both food and the environment. (Eric Berg.,2022).

The Prostate

Vitamin D deficiency leads to prostate enlargement.

The Ovaries

Vitamin D deficiency leads to problems in the ovaries and testicles.

Joint Health

One of its amazing benefits is to enhance joint health, as it helps in cases of joint stiffness, pain, and inflammation, because vitamin D is a natural and effective anti-inflammatory and gets rid of pain, especially in cases of inflammation such as rheumatoid and degenerative arthritis. (Eric Berg.,2022).

The Bones

The importance of vitamin D in bone health has been mentioned, vitamin D deficiency causes softening of the bones, which is the beginning of bone deformation, especially in the early stages of life, and a decrease in bone density, which is a precursor to osteoporosis, and finally osteoporosis, i.e., severe thinning and decrease in bone density. Indications of vitamin D deficiency include pressure on the sternum or shin bone, and if you feel pain, this means that you suffer from vitamin D deficiency, because its deficiency causes bone pain, especially lower back pain, this was to clarify the importance of vitamin D for the health of every organ of the body (Figures 12,13). (Eric Berg.,2022).

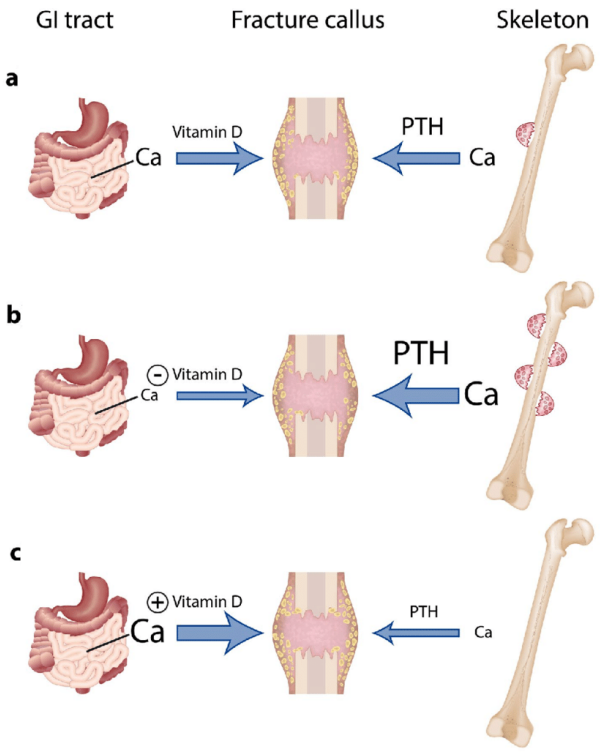


Figure 12: The role of vitamin D in bones. (Verena Fischer,.2018).

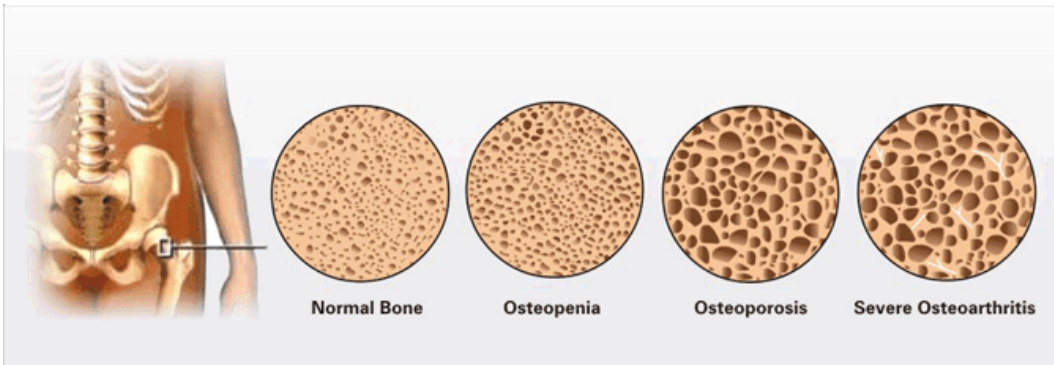


Figure 13: The diseases caused by deficiency of vitamin D.

1.7. Symptoms of Vitamin D Deficiency

Vitamin D is one of the most important and influential vitamins and has a major role in the body. It is the only vitamin that acts as a hormone, and its deficiency in the body causes a malfunction in many of the body's functions, and its deficiency may cause serious diseases (Figure 14).

1-Vitamin D deficiency means calcium and phosphorus deficiency.

2-weak teeth.

3-Osteoporosis.

4-Rickets in children.

5-Joint stiffness and pain in the bones and joints.

6-Determine movement and walking.

7-Lack of energy and lethargy.

8-Increased cholesterol level in the blood.

9-Fat accumulation and weight gain.

10-Increased risk of clots and blockages in the arteries.

11-Nerve stiffness.

12-Hormonal imbalance, especially thyroid and adrenal gland hormones.

13-Increased stress, anxiety, and nervous tension.

14-Hair loss and roughness of the hair and scalp.

15-Skin problems.

16-Low immunity.

17-Increased inflammation.

18-Problems with the sinuses and bronchial tubes, leading to asthma in some cases.

19-Imbalance in the body's metabolism and vital activities.

20- Vitamin D deficiency helps cancer cells grow due to immune deficiency and weak body organs. (Eric Berg.,2022).

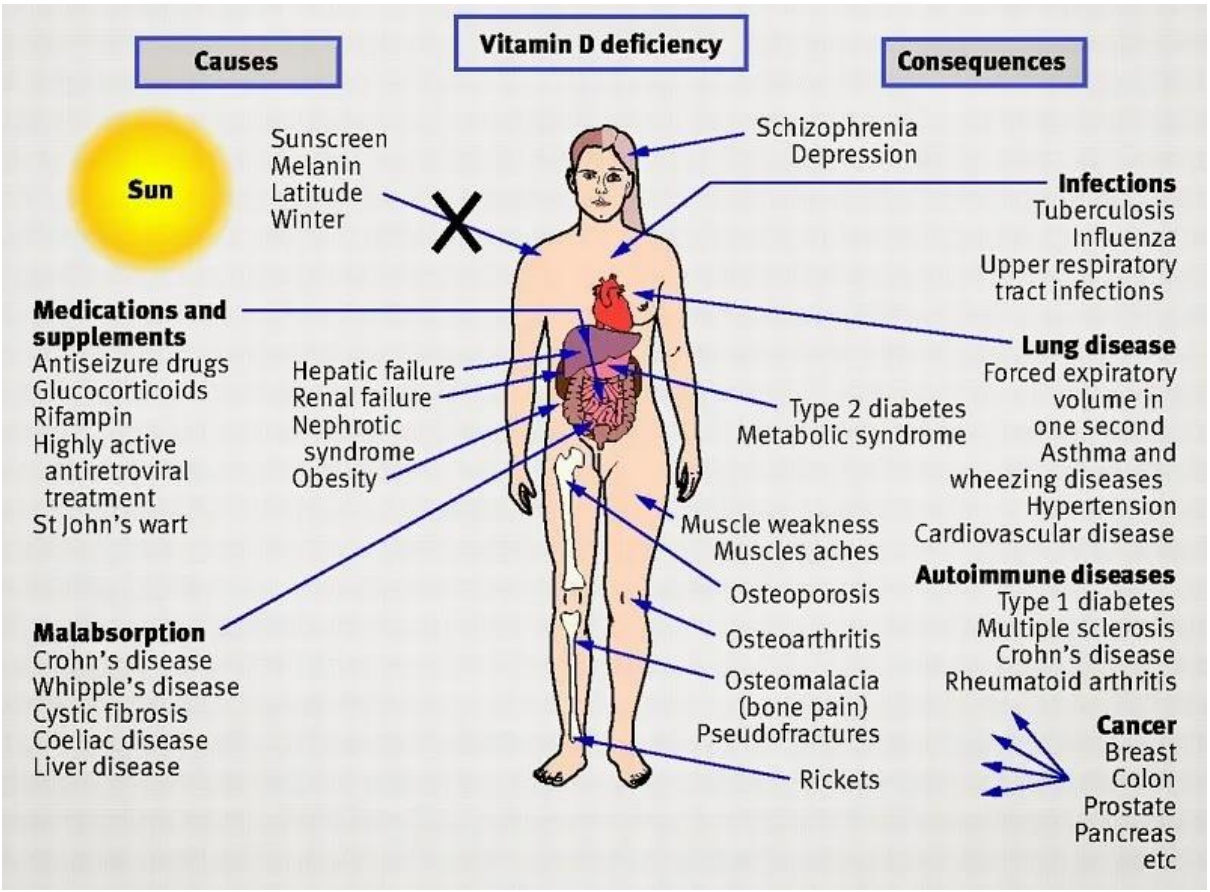


Figure 14: Vitamin D functions in the body.

1.8. Daily Need for Vitamin D

The level of vitamin D is measured in micrograms or international units (in English: International units IU), and one microgram is equivalent to 40 IU.

The following is an explanation of the daily need for types of vitamin D in general according to age group:

Newborns up to 12 months: 400 IU or 10 micrograms.

Children age 1-18 years: 600 IU, or 15 micrograms.

Adult age 18-70: 600 IU, or 15 micrograms.

Seniors over age 70: 800 IU, or 20 micrograms.

Pregnant or breastfeeding women: 600 IU, or 15 micrograms.

This measure is an approximate range because the amount that the body actually needs depends on the size of the body or body mass, that is, the number of cells that need the vitamin, as well as physical activity, that is, the amount of vitamin consumption, the amount of energy that the body needs to produce, and the speed of metabolism in the body, all of this determines vitamin's amount that body needs, so each human's body needs may differ from others. (Slominski, et al,.2017).

1.9. Sources of Vitamin D

1. Converting cholesterol in the skin into vitamin D_3 through direct exposure to ultraviolet rays with a wavelength of (280-315) nm through sunlight.

2. Vitamin D can be obtained from animals (because animals produce vitamin D by exposure to the sunlight too), from eating the meat, fish, chicken, liver, eggs, animal butter, and fresh cow's milk. However, this type of vitamin D, although it is D_3, but vitamin D, which is produced in the animal body, is less effective for humans than vitamin D, which is produced naturally in the human body itself. (Bikle DD.,2015).

3. Vitamin D can be obtained from eating some types of plants (because vitamin D produced by plants after exposure to sunlight) these plants such as mushrooms, vegetable oil, and some seeds, such as sunflower seeds. However, vitamin D in plants is of the D_2 type, which is less effective than D_3, and is also less able to combine with vitamin receptors. In the human body, although it turns into D_3 in the human body after exposure to sunlight.

4. Taking manufactured vitamin D in the form of nutritional supplements, and this type is more harmful than beneficial, because manufactured vitamin D molecules are large in size compared to the size of natural vitamin D molecules, and they are less likely to bind to receptors and are harmful and exhausting for the liver and kidneys, in addition to the harmful effects of the preservatives they contain and others of the chemicals that may be included in the product, such as artificial colors, flavorings, and others. (Bikle DD.,2015).

1.10. Tips to Improve the Level of Vitamin D in the Body

1- Exposing a good area of clean skin to direct sunlight without cloth, sunscreen, or any moisturizing products for at least 10 minutes a day or at least twice a week, preferably in the morning before 12:00 PM.

2- Having fish at least once or twice a week.

3- Having liver at least once or twice a week.

4- Having Mushroom at least once or twice a week.

5- Having egg, butter and fresh cow milk daily.

6- Having sunflower seeds and vegetable oils.

7- Reduce stress and try to stay relaxed, calm and positive (Because stress increases the production of stress hormone cortisol in the body which inhibits the activity of vitamin D).

8- Avoid drinking alcohol.

9- Avoid smoking.

10- Try to avoid using antibiotics (Because antibiotics decreases the absorbance of vitamin D in the intestine). (Bikle DD.,2015) (Eric Berg.,2022).

1.11. Comparison of Vitamin D Sources, The Best Source.

The possibility of dispense with sunlight and suffice with animal and plant food sources to get body's need for vitamin D is impossible to get enough D without sunlight because if a person relies solely on food to obtain vitamin D, he must eat huge amounts

of food that exceed several times the stomach's capacity to obtain enough of the body's need for effective vitamin D molecules that are able to combine with receptors and are qualified to enter the cell and perform its tasks, this is because food may contain a large amount of vitamin D, but not all of them are effective and able to enter the cell. In addition, sometimes vitamin D is not absorbed from food in the digestive system for pathological reasons or when taking certain medications such as antibiotics or cases of high levels of certain hormones such as Cortisol (stress hormone), which hinders the absorption of vitamin D from food so there is no benefit in eating it. (Rhiannon Lambert.,2021).

Therefore, it is necessary to exposure to the sun to get enough active vitamin D produced in the body itself from Transforming cholesterol accumulated under the skin into active vitamin D, while if you rely on taking vitamin D from other sources, amounts of cholesterol will accumulate under the skin, causing weight gain, high cholesterol levels, and other diseases.

That's why it's better to get vitamin D_3 from the body itself than to get it from other sources because vitamin D works on the principle of lock and key, it has a specific code that it combines with the receptor to enter the cell, as if it is the password that allows only the active vitamin D molecule to enter the cell. In order for the vitamin D molecule to be effective and able to combine with the receptor, it must be in a specific chemical formula. It is preferable that it be produced within the body itself to ensure that the codes match the vitamin molecule and the receptor, and thus a sufficient amount of vitamin D molecules enter the body's cells to carry out vital activities within the cell (Figure 15). (Chen ML, et al.,1996).

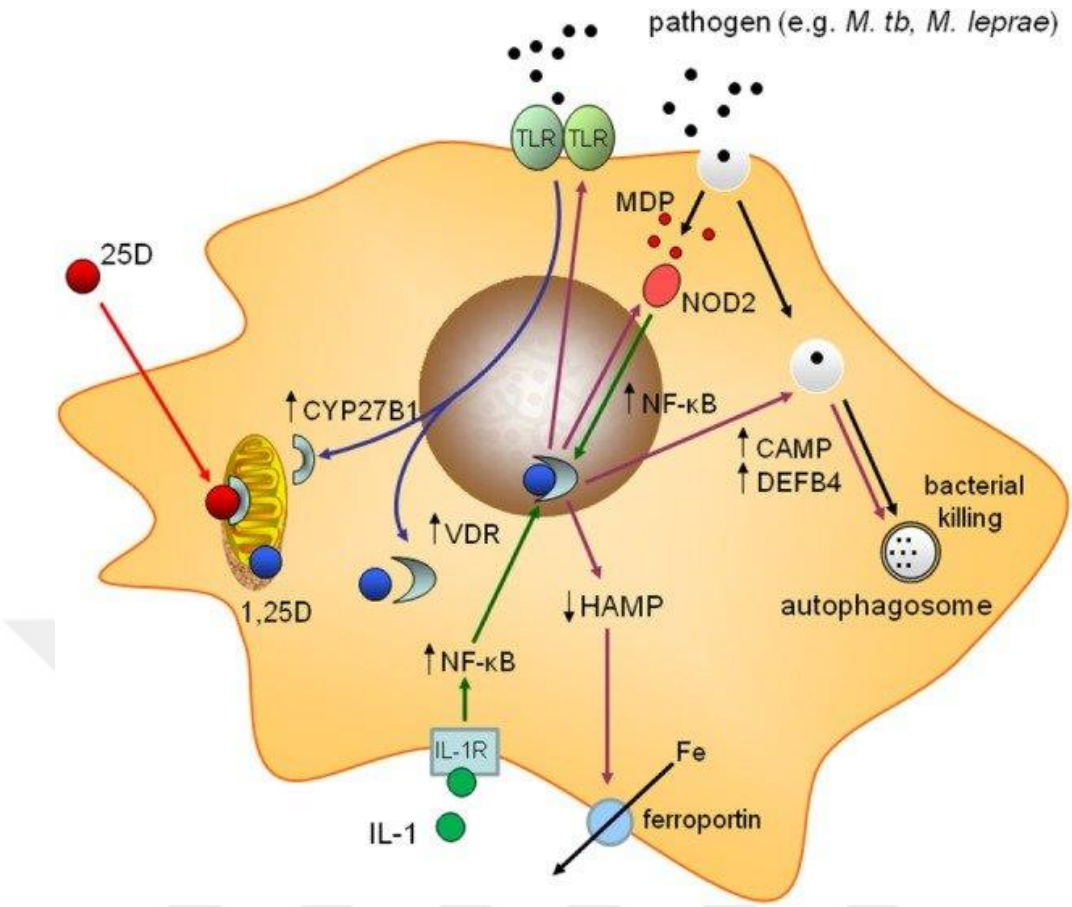


Figure 15: Vitamin D binds to its receptor in the cell.

The best source of vitamin D and its self-production in the body under the influence of ultraviolet rays in sunlight, as this is where cholesterol is converted into vitamin D, while having it from other sources causes an increase in the level of cholesterol in the blood and causes weight gain, also, vitamin D_3 resulting from the conversion Cholesterol is the best in quality and effectiveness, as the size of the self-produced vitamin D_3 molecules in the body carries the special code that matches the receptors in the cells, and all of them are able to combine with the receptors, enter the cells and perform their activity, while the type of vitamin D from animal sources is D_3, but it is less effective than D_3 from self-production by sun because it is produced in the body of animals, and the molecules may be slightly different, not all of them are able to bind to receptors, but they are better than the type of vitamin D from plant sources, because the type of vitamin D in plant sources is D_2, and this type of vitamin D_2 is less effective than the type of vitamin D_3 in the body, but despite that, plant D_2 is better than nutritional supplements

because nutritional supplements are manufactured vitamins that are an alternative to natural vitamins and are less effective in the body and need high doses of it because the binding rate of manufactured vitamin molecules to receptors is low, in addition, having these nutritional supplements has side effects that are harmful to the health of the body because of the chemicals they contain, therefore, natural sources of vitamins are generally better than manufactured sources. (Chen ML, et al.,1996).

Therefore, it's better to get vitamin D from sunlight effect than from animals and from animals than plants and from plants than nutritional supplements.

1.12. Manufactured Vitamins and Its Properties

Nutritional supplements and synthetic vitamins as pills, drops or injections do not contain natural vitamins, but rather manufactured vitamins, and the difference make it not able to meet body's need of vitamin D or other required vitamins and elements, up to the side effects of those manufactured supplements which can be observed from their Properties of Manufactured Vitamins as bellow.

Chemically

Synthetic vitamins are manufactured in a laboratory from chemical substances to produce vitamin-like substances or vitamin substitutes. These substances are very harmful to the body and organs more than their benefits, and they contain toxic substances, for example, the very toxic substance Cyanide, from which vitamin B_{12} is made in the laboratory.

In addition to the other harms from the other components of nutritional supplements, such as preservatives and others. (Rhiannon Lambert.,2021).

Physically

The molecules of manufactured vitamins are larger in size compared to the size of molecules of natural vitamins, and a large percentage of them cannot be recognized by the vitamin receptors in the cell because the code of the vitamin molecule does not match. Therefore, a high dose of manufactured vitamin D is recommended, because most of them do not actually enter the cells, and the large size of the particles harms the organs, especially the liver and kidneys, and causes gallstones, bladder and kidney stones.

In addition, large quantities of manufactured vitamins that are recommended to be taken in daily doses can cause poisoning or an increase in the level of the vitamin in the blood,

especially which leads to diseases, because an excess of the vitamin causes diseases as well as a deficiency. (Rhiannon Lambert.,2021).

Therefore, sun is the only safe source that provides the body with what needs to produce enough effective vitamin D naturally (Figure 16).

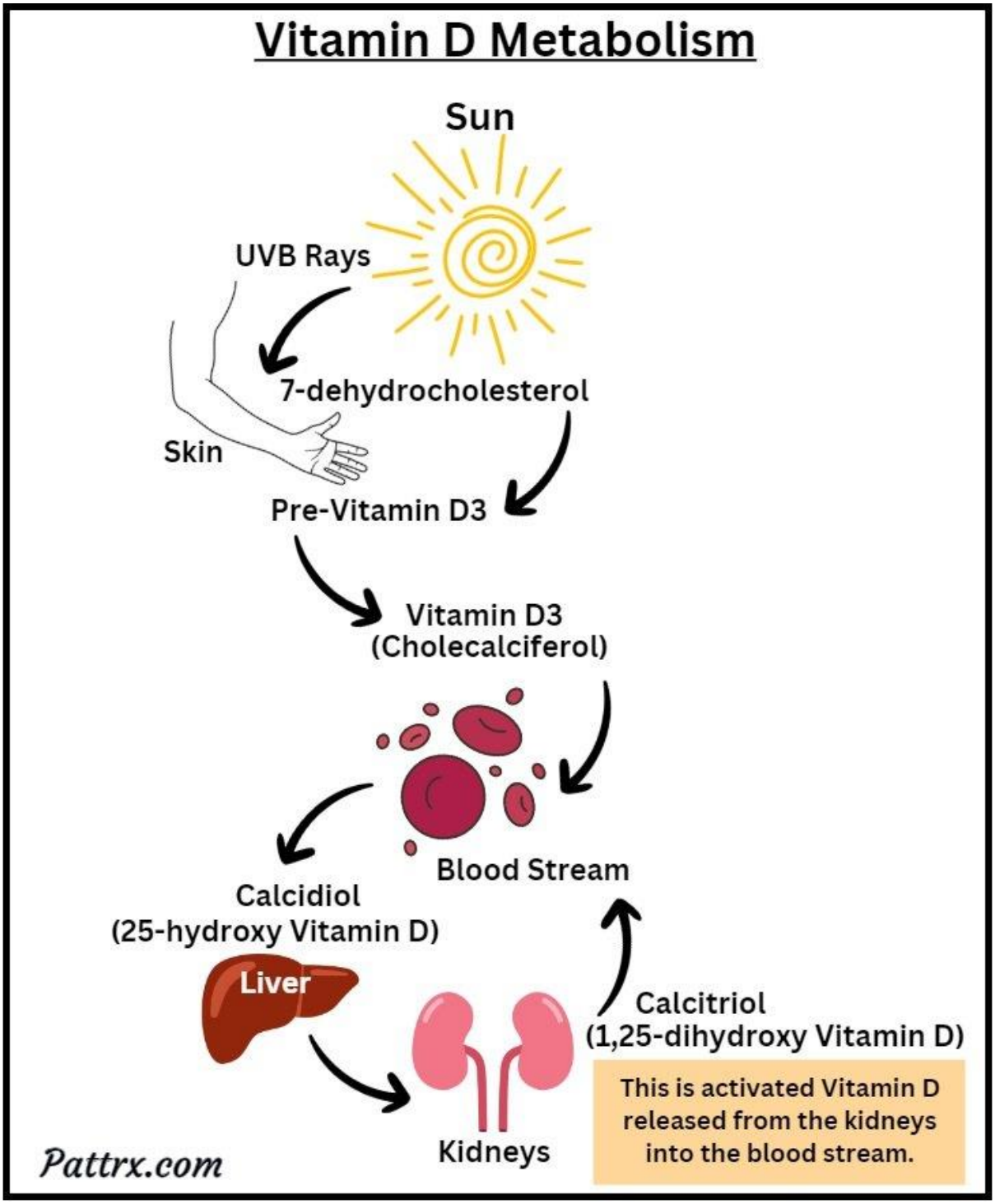


Figure 16: Vitamin D3 metabolism when its produced by effect of sunlight.

Unlike dietary vitamin D, excessive exposure to sunlight will not cause the formation of high amounts of vitamin D_3 in the skin, and will not contribute to vitamin D toxicity, because human skin is very smart, so it adjusts the amounts of vitamin D manufactured in it according to the body's need, however, a high percentage of people suffer from vitamin D deficiency as a result of their lack of exposure to the sun, as a result of the nature of their work that requires staying indoors, or because they live in countries where the winter season prevails throughout the year, therefore, these individuals are advised to eat foods rich in vitamin D_3, and to consult a specialist doctor or pharmacist to take vitamin D_3 supplements that compensate for their deficiency, when a person takes vitamin D_3 or food rich in it, the body converts it through the liver into the compound 25-Hydroxyvitamin D_3, which may increase the concentration of vitamin D in the body, and that's doesn't mean the body can get enough of active vitamin D without producing vitamin D naturally in the body from the sunlight affection.(Rhiannon Lambert.,2021).

1.13. Solar Rays and Its Types

The sunlight that we see and feel its warmth and energy is only one part of solar radiation, and it is the only visible part that falls within the visible spectrum, which has seven colors from red to violet, and its wavelength extends from (400-700) nanometers.

Wavelength is the distance from one crest to another, or from one trough to another (Figure 17), of a wave (which may be an electromagnetic wave, a sound waves, or any other wave), Symbolized by (λ), crest is the highest point of the wave whereas the trough is the lowest.

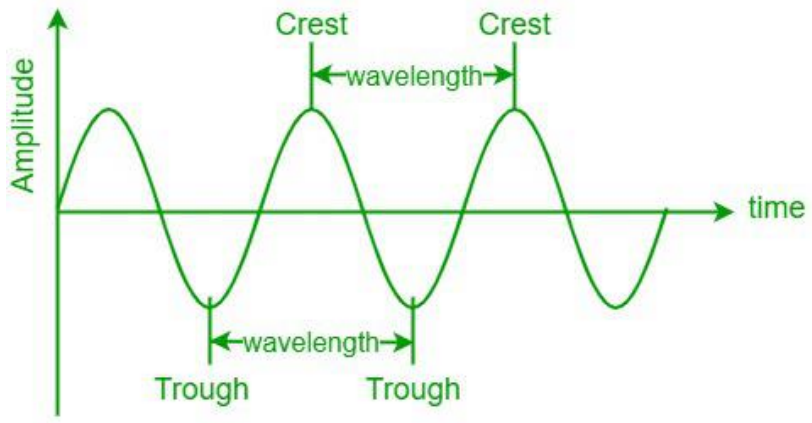


Figure 17: Wavelength crest and trough.

A nanometer is a unit of measurement for length in metric system, symbolized by (nm).

Nanometer a measure just like meter and centimetre, a nanometer is one billionth of a meter, 1 nm = 0.000000001 or 10^{-9} meters.

Solar rays are divided into three main categories (Figure 18).

1- Infrared rays. 2- Visible rays. 3- Ultraviolet rays.

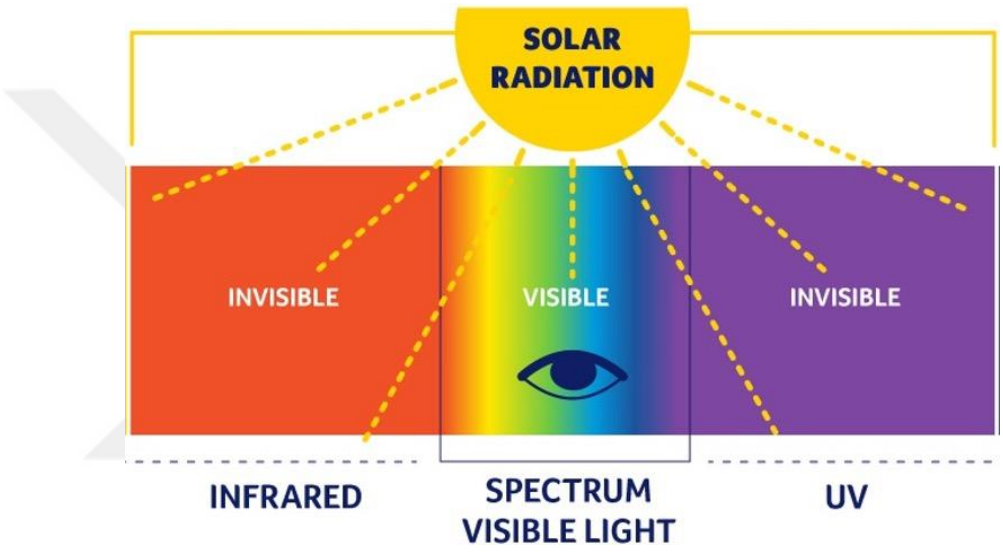


Figure 18: Solar rays.

Some details about these types of solar rays to know how to deal with these rays and take its benefits without its harm.

1.13.1. Infrared Rays

These rays are invisible and are above the red rays of the visible spectrum, since red rays has the longest wavelength of 700 nm in the visible spectrum, Infrared rays or radiation within the range of wavelengths (700 – 1000) nm.

1.13.2. Visible Rays

The visible light spectrum is the segment of the electromagnetic spectrum that the human eye can view (consist of 7 colors red, orange, yellow, green, blue, indigo and violet) (Figure 19).

More simply, this range of wavelengths is called visible light, typically, human's eye can detect wavelengths from 400 to 700 nanometers.

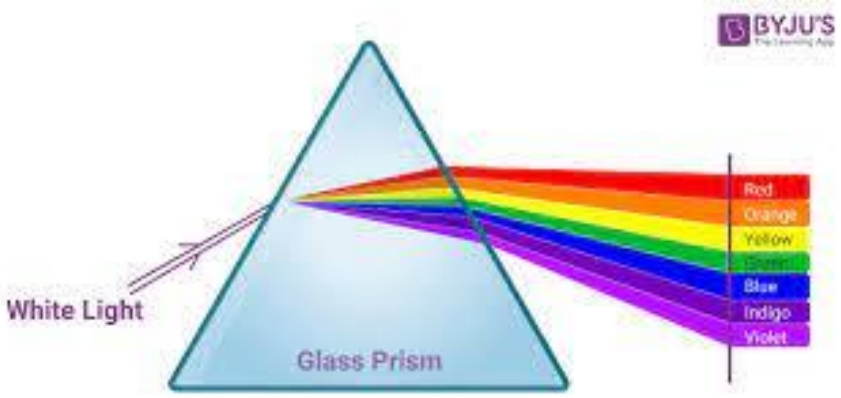


Figure 19: Visible light spectrum.

1.13.3. Ultraviolet Rays

It's invisible rays and starts after the violet rays of the visible spectrum, since violet rays have the shortest wavelength in the visible spectrum of 400 nm, ultraviolet rays within the wavelength range (400-100) nm, ultraviolet rays symbolized as UV and it's divided into 3 types: UVA, UVB and UVC, (Figures 20,21).

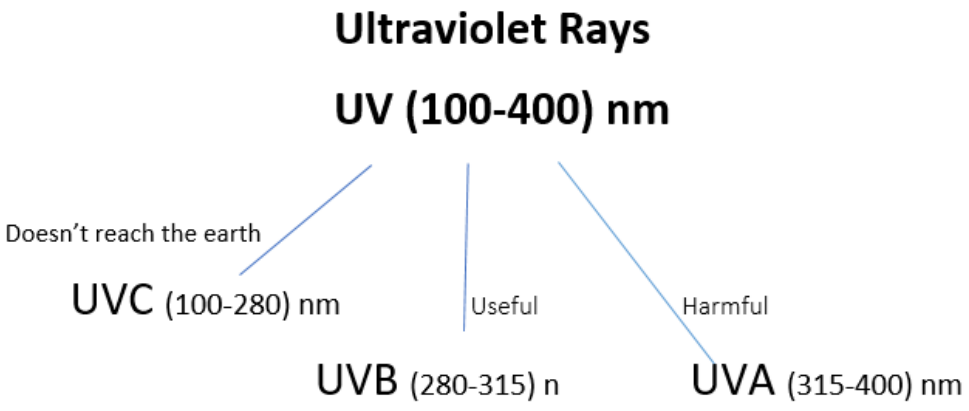


Figure 20: UV rays' types.

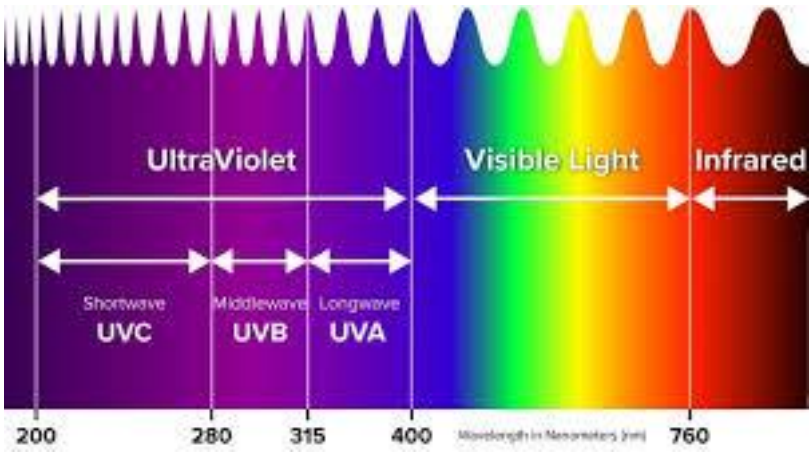


Figure 21: Ultra violet (UV) ray's spectrum.

1.13.3.1. Ultra Violet A Rays (UVA)

It's wavelength (315-400) nm, it has lower energy and longer wavelength than UVB rays, UVA radiation makes up 95% of all UV rays make it to earth's surface, UVA penetrates deep into our skin until the middle layer of skin called dermis, therefore it causes skin tan and burns if the skin too much exposure in summer time (Figure 22).

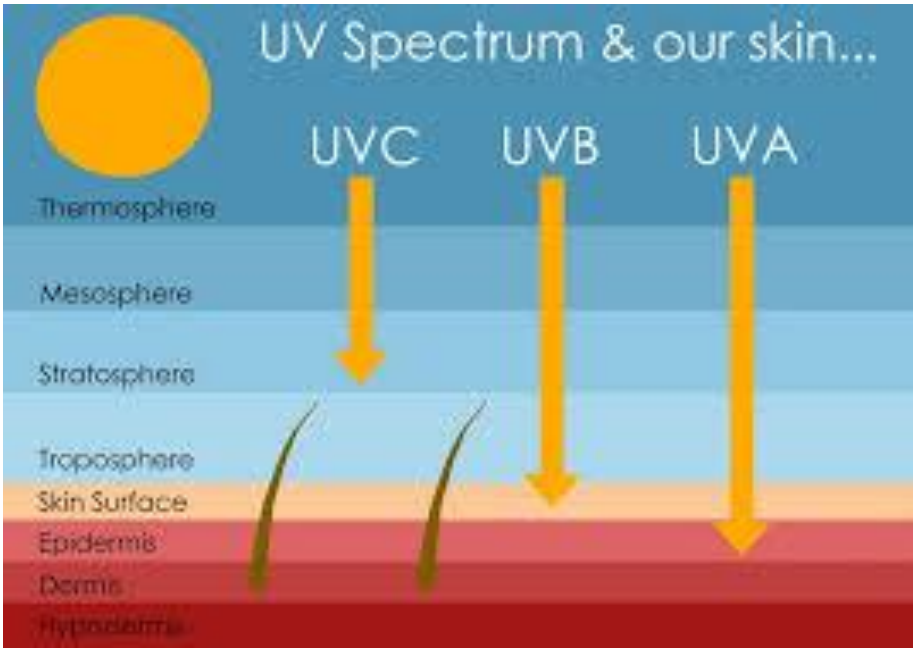


Figure 22: UV rays spectrum and skin.

1.13.3.2. Ultra Violet B Rays (UVB)

Its wavelength (315-280) nm makes up only 5% of the UV rays from the sun, but UVB has higher energy and shorter wavelength than UVA, but UVB does not penetrate as deeply in the skin as UVA, but UVB can be absorbed from skin surface until the epidermis only to transform the cholesterol in the epidermis into D3 naturally and the body can't produce vitamin D without exposure to UVB therefore UVB has a very important benefit for body. UVB ray has exactly the range (280-315) nm and it's the only useful part of solar rays for human health.

That's why we need a new sun product formulation allow UVB to pass through the skin to produce vitamin D naturally in the body.

1.13.3.3. Ultra Violet C Rays (UVC)

Its wavelenght (280-100) nm has the shortest UV wavelength, UVC doesn't reach the earth because its absorbed by the Ozon layer.

1.14. Atmosphere and Ozon Layer

The atmosphere is a mixture of gases that surrounds the Earth. It helps make life possible by providing us with air to breathe, shielding us from harmful ultraviolet (UV) radiation coming from the Sun, trapping heat to warm the planet, and preventing extreme temperature differences between day and night, without the atmosphere, temperatures would be well below freezing everywhere on earth's surface (Figure 23). (Earth and space.,2015).

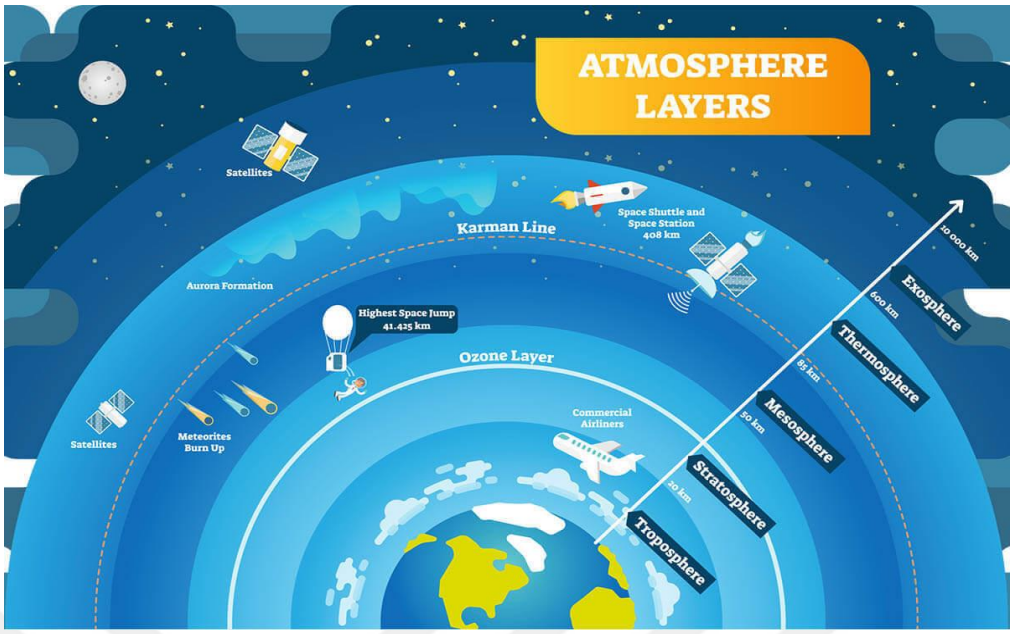


Figure 23: Atmosphere layers.

The ozone layer or ozone shield is a region of Earth's stratosphere that absorbs most of the Sun's ultraviolet radiation. It contains a high concentration of ozone in relation to other parts of the atmosphere, although still small in relation to other gases in the stratosphere (Figure 24). (Earth and space.,2015).

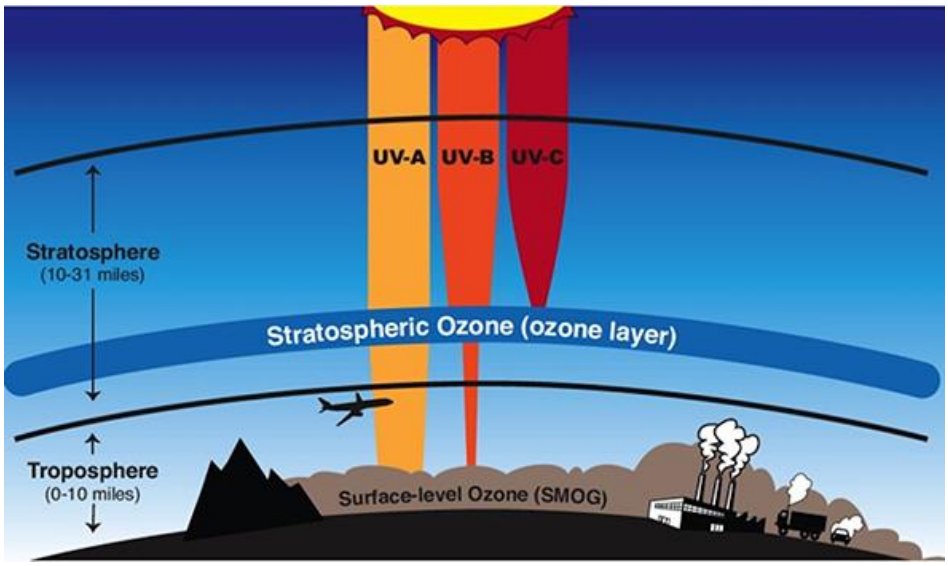


Figure 24: Ozone layer.

1.15. Sun Cream Products

Some sun creams are chemical products called suncream and physical products called sunblock.

1.15.1. Chemical Suncream

This kind of sun products absorbs ultraviolet rays before reaching the skin, its main components are oxybenzone, avobenzone, and para-aminobenzoic acid, typically it is a combination that may include oxybenzone, avobenzone, octisalate, octocrylene, homosalate, and octinoxate and all are hazardous chemicals, chemical sunscreams more available on the market tend to be lighter and easier to use and apply but usually require a waiting period of 15 to 20 minutes before it takes effect and starts working, and its relatively short-lived on the skin and can also clog pores for some skin types and may cause irritation the risks of which increase with a higher SPF, the wider, higher coverage formulas are usually the most irritating and cancer acttivating due to the chemicals required to achieve this level of protection.

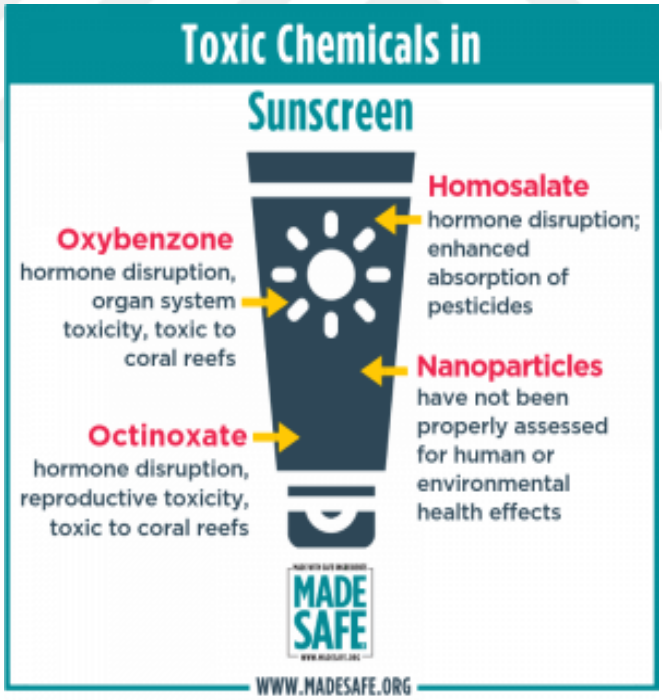


Figure 25: Toxic chemicals in sun products.

1.15.2. Physical Sunblock

This kind of sun products acts as a barrier that reflects ultraviolet rays from the skin, among its most important components zinc oxide and titanium oxide and its

hazardous chemicals, physical sunblock works by completely blocking rays, they often last longer and usually better choice for sensitive and blemish-prone skin as their ingredients are less likely to cause a reaction or irritation, on the other hand, their ingredients and thickness leave a white film on the skin and more susceptible for rubbing due to physical activity.

It is worth note that many products use a combination of physical and chemical called sunscreen, and the ingridiants for both of them are toxic and hazardous chemichals for general health. (Figures 25,26).

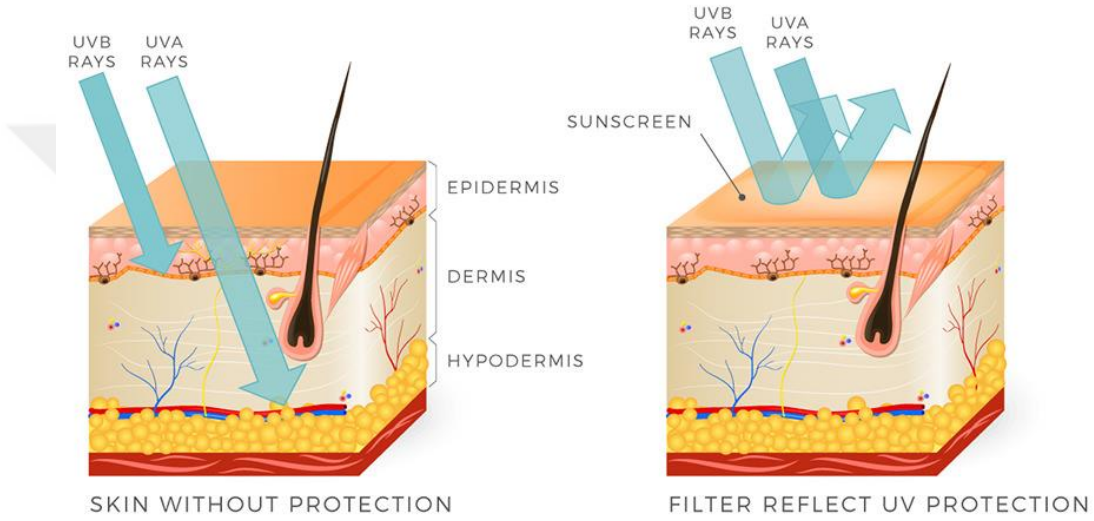


Figure 26: Sun products impact.

1.16. Toxic Effects of Sun Products

Both of chemical and physical sun products contains toxic chemicals effect on the health after using on the skin all these ingredients will be absorbed through the skin and enter the blood to the organs and cells and these chemicals can cause cancer and other dangerous diseases. (Figures 27,28).

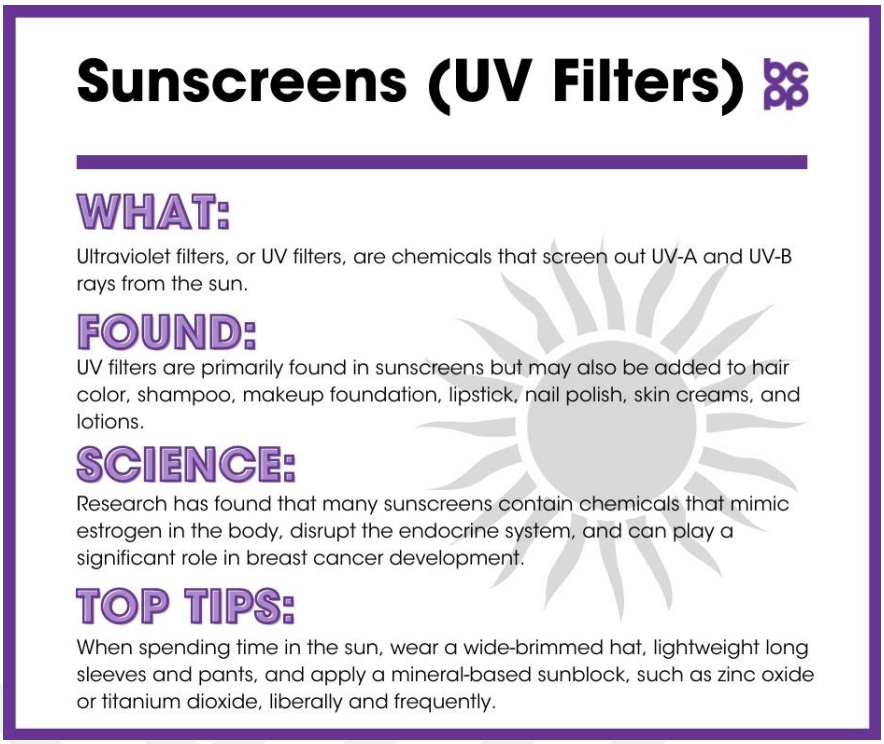


Figure 27: Scientific truths about sun products. (Breast Cancer Prevention Partners)

Figure 28: Toxic ingredients in sun products. (Campaign for Safe Cosmetics)

1.17. How Sun Products Impact on Marine Life and Cause Pollution of Environment

Using sun products while swimming at beaches leads to pollution of natural water and also leads to poisoning of fish and other marine creatures, so much so that a small amount of chemicals of sunscreen's ingredients is enough to whiten coral reefs (Figure 29,30), harmful compounds in sun cream damage fish, dolphins and kill coral reefs (figure31,33).

Figure 29: The impact of sun products on marine life.

Figure 30: The impact of sun products on coral reef.

Figure 31:Sunscreens harmful ingredients.

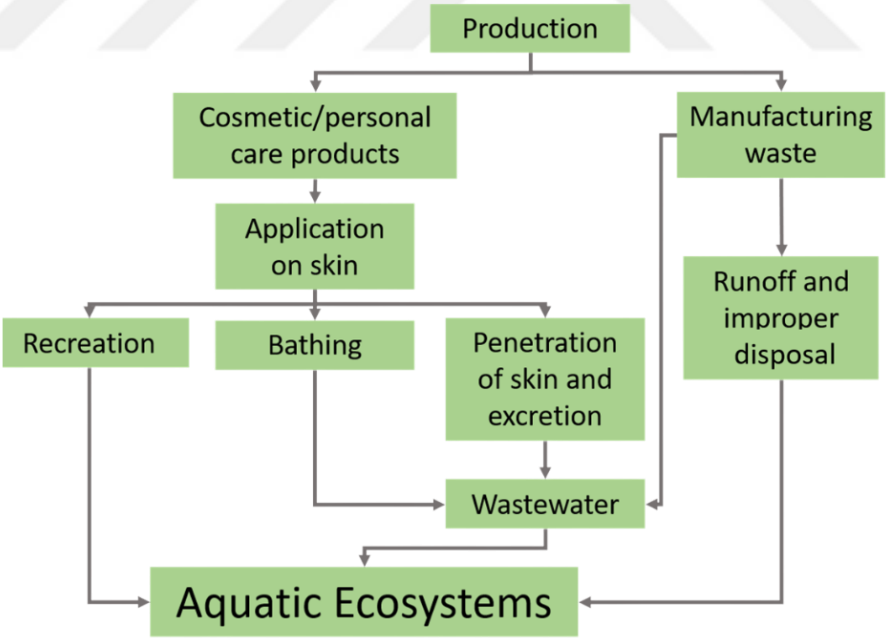


Figure 32: Cosmetic care products causes pollution.

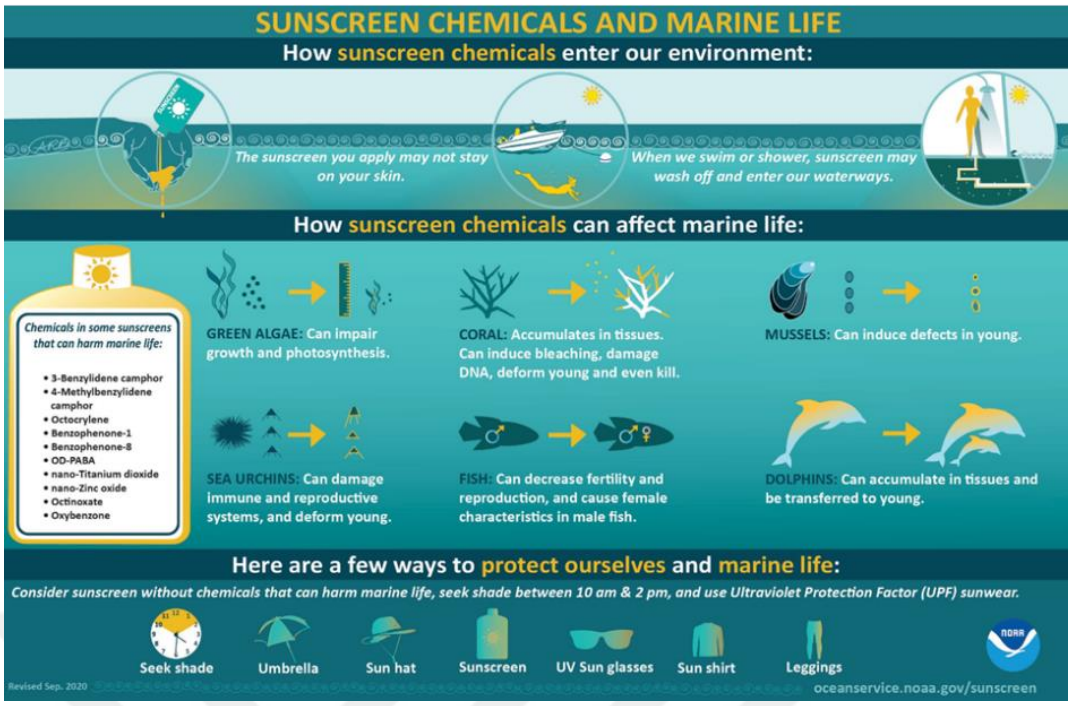


Figure 33: Sun products and marine life.

As we explained previously, sunscreens contain toxic chemicals and metals to block ultraviolet rays, and these sunscreens are washed off in water for example for every 10,000 visitors enjoying the waves, about 4 kilograms of mineral particles wash onto the beach every day. This may seem relatively small, but these minerals stimulate the production of hydrogen peroxide, a known bleaching agent, at a concentration high enough to harm marine organisms. One of the main ingredients in most chemical sunscreens is oxybenzone, it's a synthetic molecule known to be toxic to corals, algae, sea urchins, fish, and mammals (Figure 23).

One drop of this compound in more than 4 million gallons of water is enough to endanger living organisms, an estimated 14,000 tons of sunscreen is thought to be deposited in the oceans annually with the greatest damage found in popular coral reef areas such as Hawaii and the Caribbean, in 2015, the nonprofit Haereticus Environmental Laboratory surveyed Trunk Bay Beach in Saint John, USVI, where up to 5,000 people swim daily. As a result of the survey, an estimated amount of more than 6,000 pounds of sunscreen is deposited on coral reefs annually, that same year, it is found that an average of 412 pounds of sunscreen per day was deposited on the reefs of Hanauma Bay, a popular snorkeling destination on Oahu that attracts an average of 2,600 swimmers per day, the pacific archipelago nation of Palau was the first country to ban "coral reef-toxic" sunscreens.

Signed into law in October 2018, the law prohibits the sale and use of sunscreen that contains any of the ten banned ingredients, including oxybenzone. Tourists bringing banned sunscreen into the country will be confiscated, and companies selling sunscreen will be fined, on May 1, 2021, Hawaii passed a bill prohibiting the sale and distribution of sunscreens containing the chemicals oxybenzone and octinoxate (Figure 34).

Figure 34: Coral reef before and after sun products affection.

1.18. What Happens When Coral Reefs Disappear

The disappearance of coral reefs may lead to the disappearance of many marine species and organisms whose existence depends on coral reefs, such as turtles, fish, crabs, sharks, and thousands of other marine organisms, which affects biodiversity. This, in turn, negatively affects the economy and human life in general, Coral reefs are among the most diverse and valuable ecosystems on Earth, Coral reefs help protect coastal communities from storm surge and wave erosion, both of which are likely to increase in the face of sea level rise, Coral reefs provide millions of jobs for local people through tourism, fishing and recreational activities, coral reefs are also Earth's "medicine cabinet."

Therefore, coral reefs must be preserved to preserve the environment (Figure 35).

Figure 35: The biggest coral reef in the world.

At over 2000 kilometers long The Great Barrier Reef is the largest living structure on Earth, the reef is located in the Coral Sea, off the coast of Queensland, Australia, the Great Barrier Reef can be seen from outer space and is the world's biggest single structure made by living organisms. This reef structure is composed of and built by billions of tiny organisms, known as coral polyps. It supports a wide diversity of life and was selected as a World Heritage Site in 1981, CNN labelled it one of the seven natural wonders of the world, the Queensland National Trust named it a state icon of Queensland, a large part of the reef is protected by the Great Barrier Reef Marine Park, which helps to limit the impact of human use, such as fishing and tourism. Other environmental pressures on the reef and its ecosystem include runoff, climate change accompanied by mass coral bleaching, and cyclic population outbreaks of the crown-of-thorns starfish. According to a study published in October 2012 by the Proceedings of the National Academy of Sciences, the reef has lost more than half its coral cover since 1985 because of chemicals especially the components of sun products used through swimming on the beaches.

1.19. Aloe Vera Gel and Its Benefits for Skin

Aloe vera is a succulent plant known for its healing properties (Figure 36), It's native to arid regions and has been used for its medicinal and cosmetic benefits throughout history, the gel extracted from the aloe vera plant is a clear, thick substance rich in vitamins, minerals, and antioxidants, aloe vera is famous for its soothing, moisturizing, and rejuvenating effects on the skin.

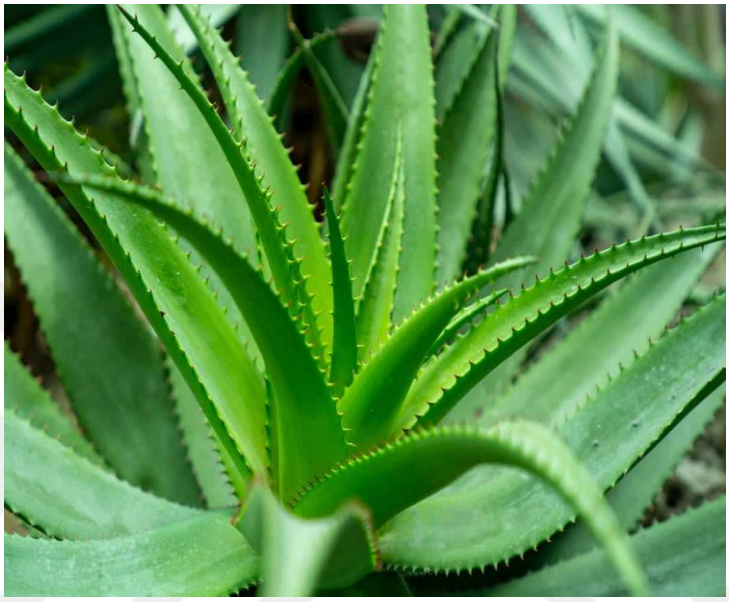


Figure 36: Aloe vera leafs.

Aloe vera offers a wide range of benefits for your skin and hair, its natural gel is renowned for its moisturizing and soothing properties, making it a go-to solution for various skincare concerns. Aloe vera can help with sunburn relief, reducing skin irritation, promoting wound healing, and even improving hair health by reducing dandruff and supporting healthy growth.

Aloe vera can be used in various forms, such as gel, juice, or as a topical application. You can apply aloe vera gel directly to your skin, use it as a base for homemade face masks, or consume aloe vera juice as a dietary supplement. It's essential to ensure you are using high-quality, pure aloe vera products for the best results (Figure 37). (skin food,.2023).

Figure 37: Aloe vera benefits.

1.20. Coconut Oil and Its Benefits for Skin

Coconut oil is one of the natural plant oil (Figure 38), used in medical and cosmetic products because coconut oil is rich of antioxidants and antimicrobial (antibacterial and antifungal) and other properties as explained in coconut oil benefits below. (Skin food,.2023).

1. prevents Inflammation because of containing antimicrobials.
2. Reducing age impact because of containing antioxidants.
3. Soothing and hydrating the skin.
4. Moisturizing the dry skin.
5. Boosting skin cells regeneration.
6. Protect from UV ray.
7. compact acne.
8. Improve collagen production.
9. Soothing sun burns.

Figure 38: Coconut oil.

2. LITERATURE REVIEW

2.1. UVB Impact On Vitamin D Level

Grant et al investigated the effect of UVB on vitamin D and the level of D in the blood in young people between 5-18 years of age, which in turn affects general health, the immune system, and physical strength in other stages of life. The research showed a noticeable increase in the percentage of 25(OH)D in the bblood serum of people who have had sufficient exposure to UVB. (Mac Donald, Helen M.,2013).

While other researchers studied the vitamin D status of 126 healthy adults aged 18-87 years. Vitamin D values in the blood were analyzed and they were evaluated in terms of phenotypic features such as skin, hair, and eye color. It was found that some of them had a low level of less than 25 nano mol/ liter Those with dark skin were the least exposed to the sun, and the highest levels of vitamin D were in the people with light skin most exposed to the sun.

(Michael Kimlin, Simone Harrison.,2007).

And a study in America, it appears that the concentration of vitamin D in the blood serum of American youth under 19 years of age suffer from vitamin D deficiency, ranging between (20-50) nano mol/liter due to lack of exposure to the sun, while the bodies of some Caucasians produce (1000-2000) International units per day through exposure throughout the seasons to outdoor sunlight without using sunscreen or using sunscreen with a protection factor of 15 only. (Godar, Dianne Eyvonn., 2012).

2.2. Development of UVB Led to Support Vitamin D Introduction

In a study on making ultraviolet lamps to provide the body with the ultraviolet radiation it needs to manufacture vitamin D, the researchers placed groups of mice in large cages and designated them as cage A without lamps, cage B with a number of lamps on the ceiling of the cage, and cage C with a greater number of lamps. They measured the level of D in the serum of the rats after each week and for a period of 4 weeks, and it was observed that the percentage of vitamin D increased each week in the cages containing lamps, and a higher percentage in cage C which has more lamps, while vitamin D level decreased in cage A which has no lamps.

Another study about the importance of UVB was revealed in the synthesis of most of vitamin D in the body, while a small portion of it is obtained from food, to solve the problem of the deficiency of these rays, artificial lighting was developed and ultraviolet B lamps were manufactured to provide the body with what it needs of these rays, the rays are important for maintaining public health, the experiment was conducted on mice, and the effectiveness of these lamps was confirmed in increasing the percentage of vitamin D in the blood serum of the mice after 14 days of exposure to these lamps, this light can be used to stimulate the production of vitamin D in residents of closed areas. (Oh Seung Taek, Lim Jae Hyun., 2019).

Another study the effect of ultraviolet lamps on the value of vitamin D in the blood serum of rabbits, as D is important for the health of rabbits, their teeth, and the bones of the skull, and its deficiency causes deformation of their teeth and severe inflammation of the bones. Therefore, the experiment with these lamps gave positive results, and an increase in vitamin D was observed. D in the serum of rabbits after exposing them for 6 hours daily for 14 days. (Molitor, Laure E., 2023).

2.3. Melanin Effect UVB Absorption and Vitamin D Level

A study to confirm whether the skin pigment melanin affects the absorption of ultraviolet rays and causes a deficiency in the production of vitamin D, the level of vitamin D in the blood serum of black-skinned and white-skinned people was compared, and it was found that all black-skinned people suffer from a severe deficiency. In the level of vitamin D, the level of D was measured after exposing their entire body to ultraviolet B rays with an intensity of 0.022 joules/cm for 6 consecutive days, and day 0, all volunteers were suffering from vitamin D deficiency, and on the first day the level of D increased in those with white skin, it remained low in those with black skin, and after the sixth day, the level of vitamin D was compared and it was found that it had increased significantly in those with white skin, while it remained low in those with black skin, with a slight increase, which indicates that melanin hinders the absorption of beneficial ultraviolet rays, causing vitamin D deficiency. (F. Libon, et al.,2013).

While other researchers found in a study that people with brown and dark skin are less absorbing ultraviolet B rays due to the pigment that is present in the layers of the skin, called melanin, which causes the dark color in the skin. It acts as a barrier and self-

protection, which causes a decrease in the level of vitamin D synthesis in the bodies of people with dark and brown skin. (Aleksandra Ilina.,2022).

2.4. Sun Cream Production

In this study, it was proven that the components of sunscreens that are commonly used to protect against sunlight pass through the skin and cause toxicity, which affects the health of users. This study reveals the possibility of using oils, fruit and vegetable juices as alternatives to artificial sunscreens (Figure 39). (Gause S.; Chauhan A.,2016).

While other researchers made a sunscreen containing red algae and vitamins and used it on four groups of furless mice for a period of 5 days, it was noted that the highest protection from the sunscreen was for the group that used the sunscreen with red algae extract and vitamins, with the effect of the vitamins on cell regeneration.

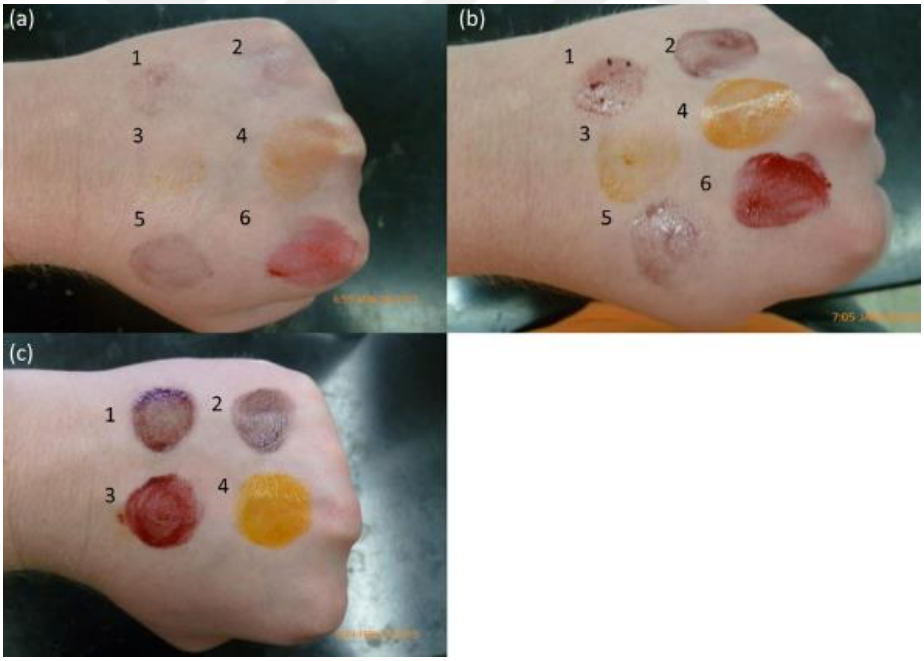


Figure 39: Sun cream formulation by using fruit and vegetables.

3. MATERIALS AND METHODS

In this study we need to determine UVA and UVB transmission of different sunscreen products, natural oils and formulations created in this study, UV-Vis spectrophotometer and photo/radiometer were the main instruments for the measurements, table 2 shows all materials used in this study.

Table 2: Materials used in the procedure of the study.

Devices	Tools	Substances	
Spectrophotometer (Agilent Technologies).	Quartz cuvette.	**Artificial products**	**Natural products**
UV Cabin (UVA&UVC Light) (CAMA).	Glass slide.	Sun cream spf 30 (Nivea sun).	Coconut oil (Life in).
Photo/Radiometer (Delta Ohm).	Watch glass.	Sun cream spf 50 (Benri).	Olive oil (From farm).
UVA Sensor (Delta ohm).	Dropper.	Lotion (Avon).	Rosemary oil (Life in).
UVB Sensor (Delta ohm).	Sticks.	Hydrating cream (dalan d'Olive).	Jojoba oil (Life in).
Scale (RADWAG,AS 220.R2).	Spatula.	Aloe vera gel 98% (Bee Beauty).	Aloe vera from leaf.
Computer.	Petri dish.		Coffee (LEZZ CAFÉ).
	Flask.		Coffee mate (LEZZ CAFÉ).
	Distilled bottle.		Distilled water.

The procedure of this study divided in to three main steps as the following.

3.1. Samples Preparation and Solutions Preparation.

The ingredients were weighted by using a scale according to formula percentage.

The ingredients were mixed in a petri dish and a homogeneous mixture was obtained as showed in (Figure 40).

Figure 40: Mixing the ingredients of the formula in the petri dish.

Table 3 shows all prepared formulations and their ingredients.

Table 3: The recipes of all formulations used in this study.

Solution (Sample)	Ingredients
Formula 1	Aloe vera gel 70% + Coconut oil 30%.
Formula 2	Aloe vera gel 70% + Olive oil 30%.
Formula 3	Aloe vera gel 70% + Coconut oil 15% + Olive oil 15%.
Formula 4	Aloe vera gel 70% + Coconut oil 25% + Olive oil 5%.
Formula 5	Formula 1 90% + Coffee solution 10%.
Formula 6	Aloe vera gel 80% + Olive oil 10% + coffee mate powder 10%.
Formula 7	Formula 1 95% + Coffee solution 5%.
Formula 8	Aloe vera gel 90% + Coffee mate powder 10%.
Formula 9	Formula 1 80% + Coffee solution 20%.
Formula 10	Aloe vera gel 80% + Coffee mate powder 20%.

Coffee Saturated Solution Preparation: Coffee solution was prepared with concentration of 10% coffee using distilled water (Figure 41), this solution was used in some formulations with different percentage (to raise the concentration of the formula and raise the blocking of the formula with a natural ingredient).

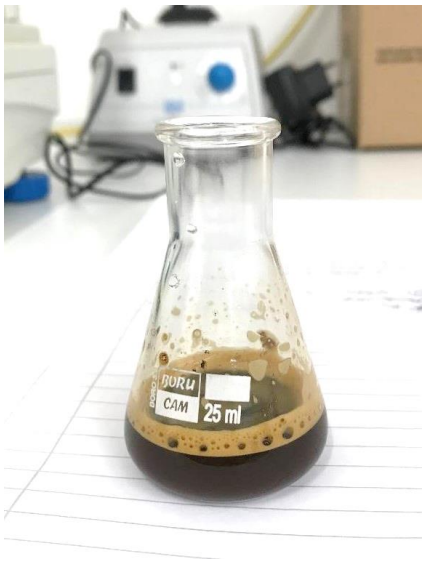


Figure 41: Coffee saturated solution in distilled water.

3.2. UV-Vis Spectrophotometer Measurements

UV-Vis spectrophotometer (Figure 38) was used to obtain UV-Vis transmission of samples between 200-800 nm range (artificial products, natural products and formulations) in %T mode, the procedure as follows:

1-Delivering an enough amount of a sample to fill a quartz cuvette (figure 39) by pipette or dropper.

2-Placing the cuvette filled with sample in the spectrophotometer and read its transmission.

3-Getting the sketch of the reads by equipment's program.

4- Delivering some of the sample as a thin layer inside the quartz cuvette, (Repeating the same steps with same sample but spreading the sample as a thin layer inside the cuvette instead of being full cuvette).

5- Getting the sketch of the reads by using excel.

6- Repeating the steps for each sample.

Figure 42: The spectrophotometer that used in the procedure

Figure 43: The quartz cuvettes that used in the procedure.

3.3. Photo-Radiometer Measurements

Photo/Radiometer device was used to measure thin films (50 µm). Tape band with 50 µm thickness was put on the edges of quartz glass. The sample was dropped on the center of glass and coated homogeneously on the surface of quartz glass by using a glass spatula. The quartz samples were put on the UV sensors by placing a homemade holder for quartz glass. The measurements were done for empty quartz glass and coated quartz glass. The sensors were placed in a UV Cabin for measurements, the readings were collected from radiometer device.

Figure 44: a) UV Cabin b) Photo-radiometer and c) One of the sensors used in the procedure.

4. RESULTS AND DISCUSSION

4.1. Pre-Studies

4.1.1. Pre-studies by UV-VIS Spectrophotometer

Pre-studies have been done using UV-Vis Spectrophotometer, UV-Vis transmissions are measured with full quartz cuvette and quartz cuvette glass coated with products in a layered form, (Figures 45 ,46,47 and 48) shows some measurements of artificial and natural samples artificial products (sun cream spf 50 (Berni), sun cream spf 30 (Nivea), lotion (Avon) and moisturizing (dalan d'Olive)) and some natural samples (Coconut oil, olive oil, jojoba oil, rosemary oil and natural aloe vera from leaf).

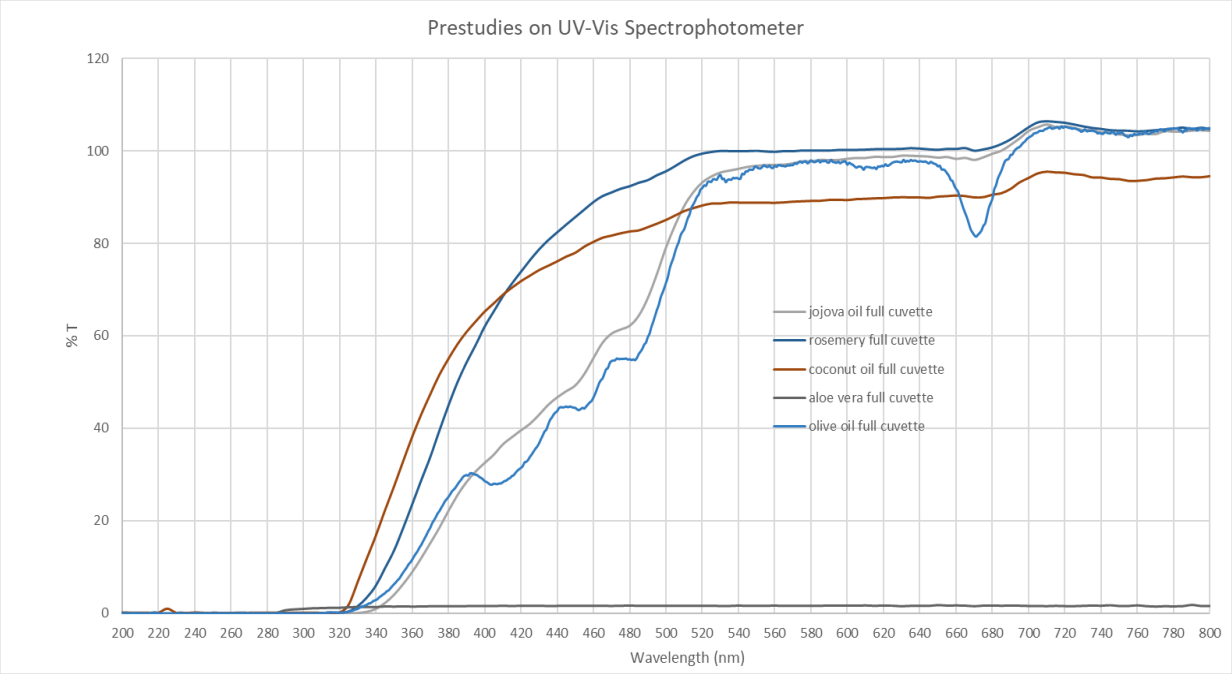


Figure 45: Natural oils UV-Vis transmission results using full quartz cuvette.

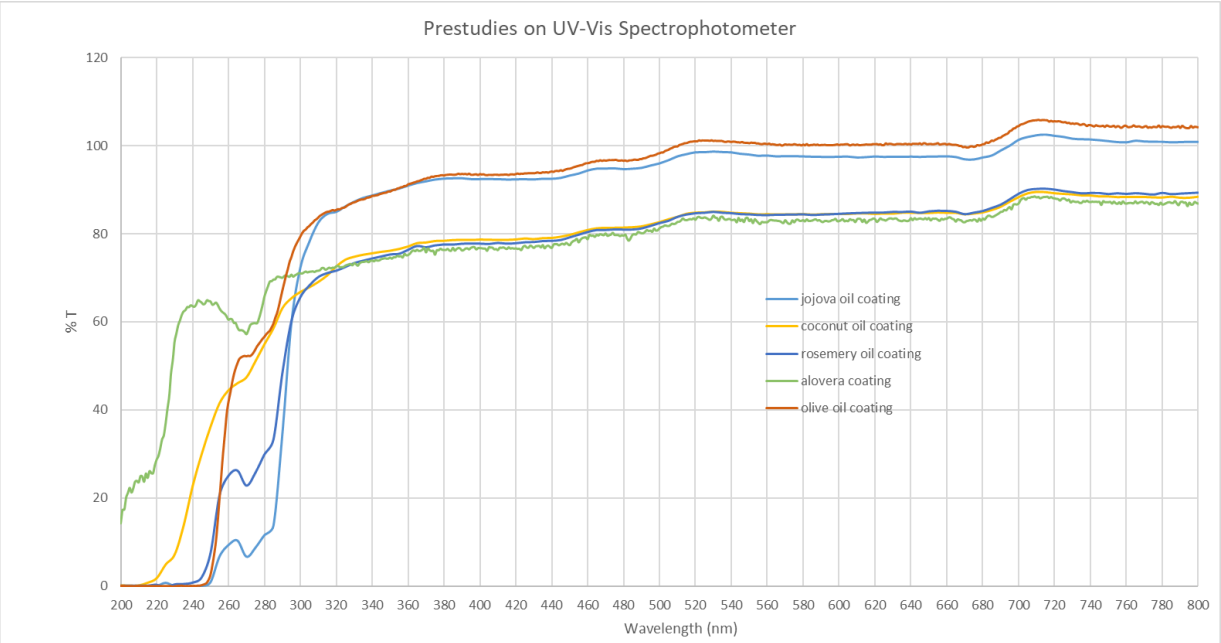


Figure 46: Natural Oils UV-Vis Transmission thin film results using cuvette.

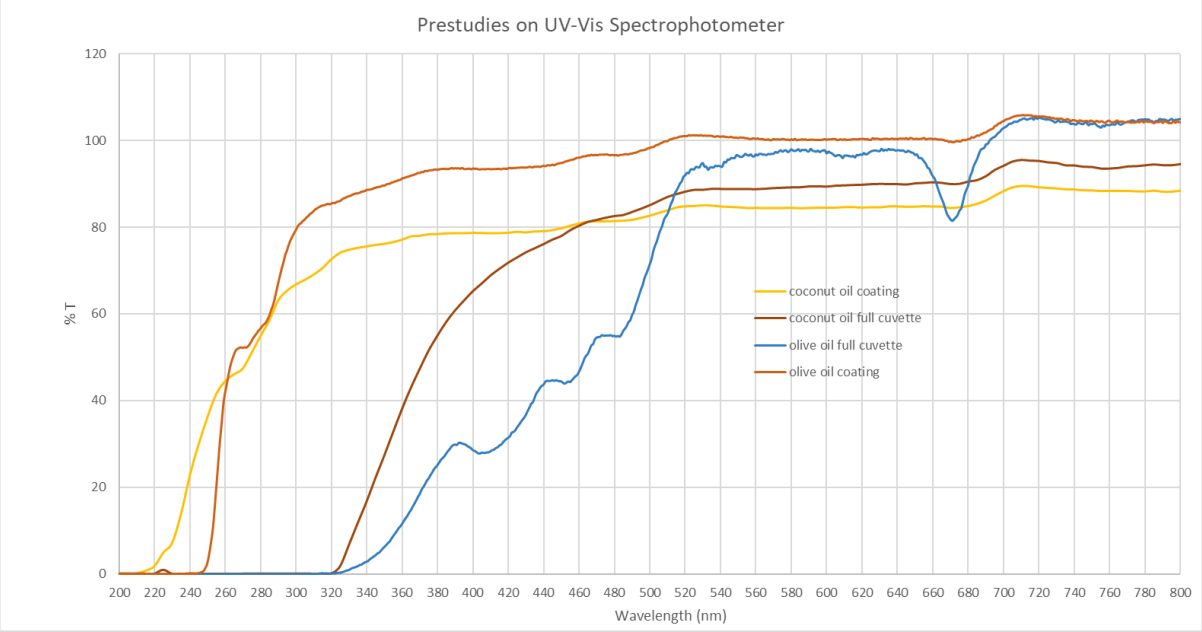


Figure 47: Natural Oils UV-Vis Transmissions comparison of thin film vs full cuvette results

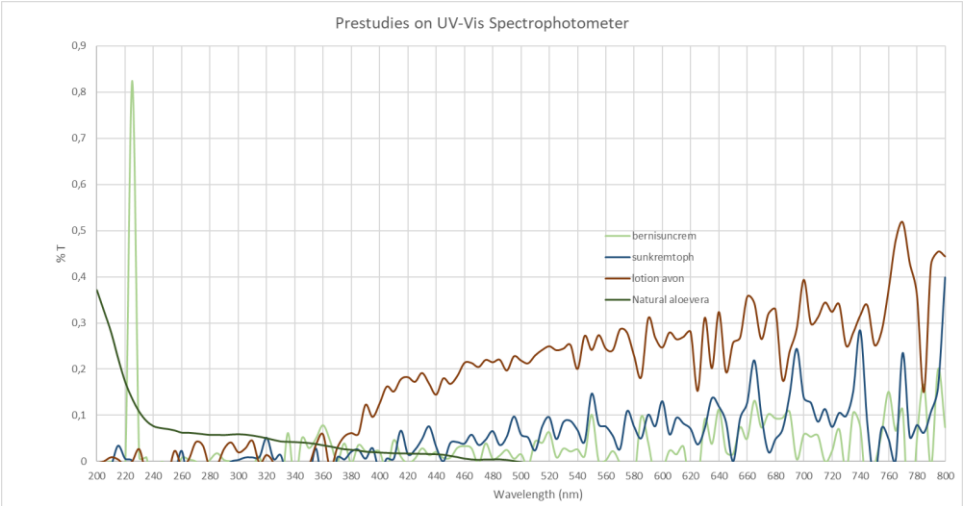


Figure 48: Different commercial products and natural aloe vera.

4.1.2. Pre-formulation study

This formula made in the laboratory, consists of (50%) aloe vera gel and (50%) coconut oil.

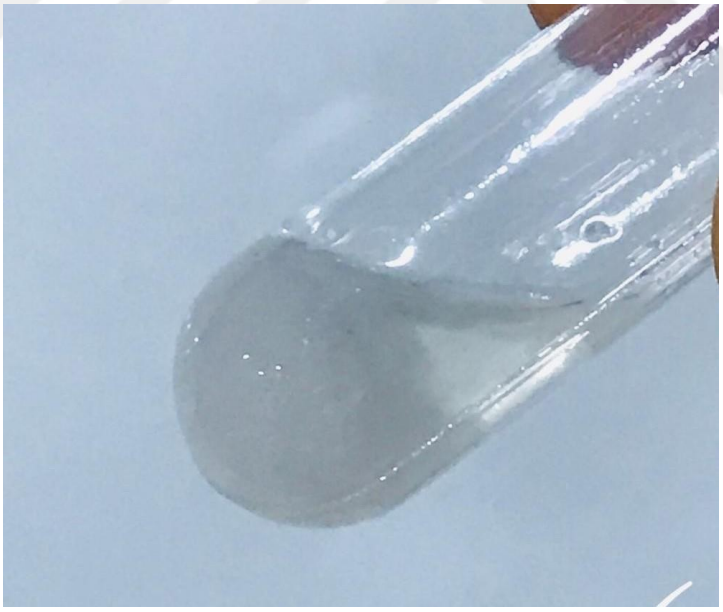


Figure 49: Pre formulation study with (50%) aloe vera gel and (50%) coconut oil.

The result is not homogeneous texture the oil is separated from the gel (Figure 49) because its more than what is supposed to be in the formula, it was the best formulation when the gel was (70%) therefore it must be consisting of not less than (70%) of aloe vera gel to balance the formula.

4.2. Formulation Studies

Formula 1: This formula made in the laboratory, consists of (70%) aloe vera gel and (30%) coconut oil.

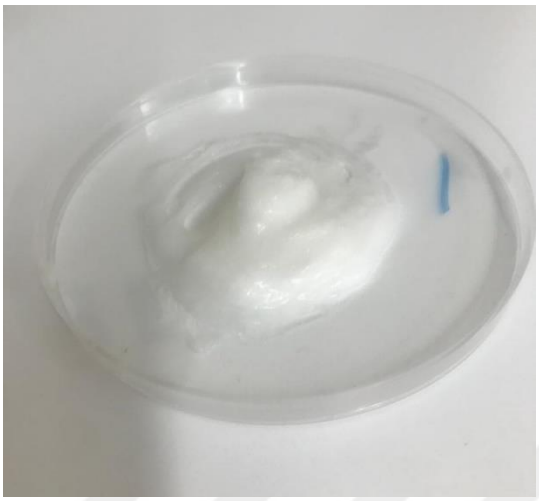


Figure 50: Formula1.

The result was cohesive texture and homogeneous formula (Figure 50), this formula has gelatinous half transparent texture looks like a cloud decrease the intensity of ultraviolet radiation but not blocking to allow to some of UV to pass through the skin to activate vitamin D production in the skin, (Figure 51) shows transmission of both full and layer samples by spectrophotometer and photo-radiometer transmittance, there is approximately 10% blocking of UVA-UVB.

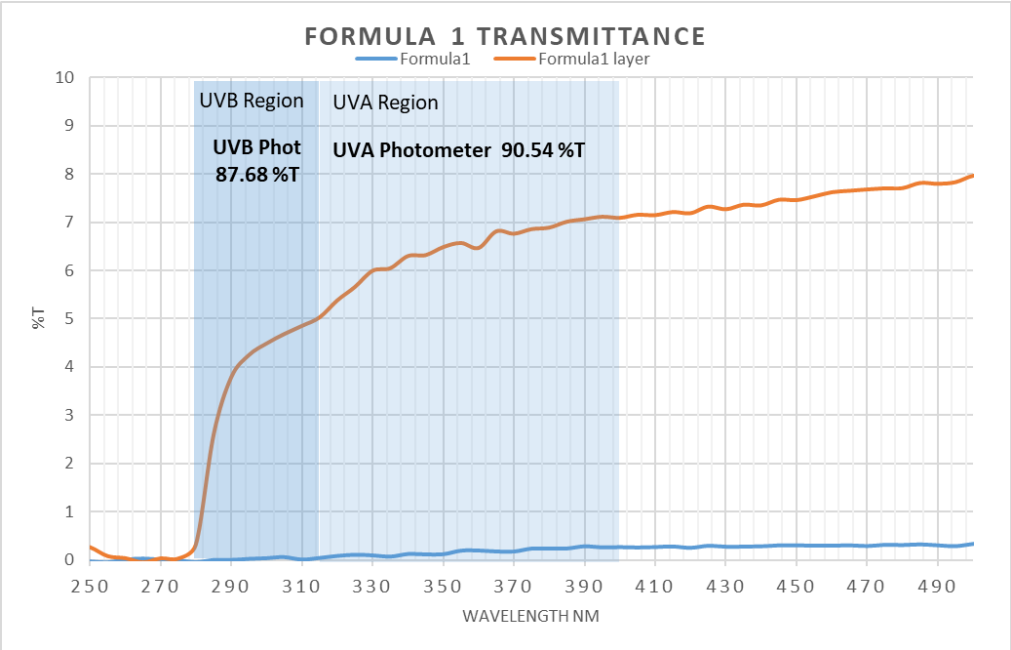


Figure 51: The transmittance of formula 1.

Formula 2: This formula made in the laboratory, consists of (70%) aloe vera gel and 30% Olive oil.

Figure 52: Formula2

The result was not homogenous texture because the oil separated than the gel, this formula was eliminated due to oil/gel separation (figure 52-53).

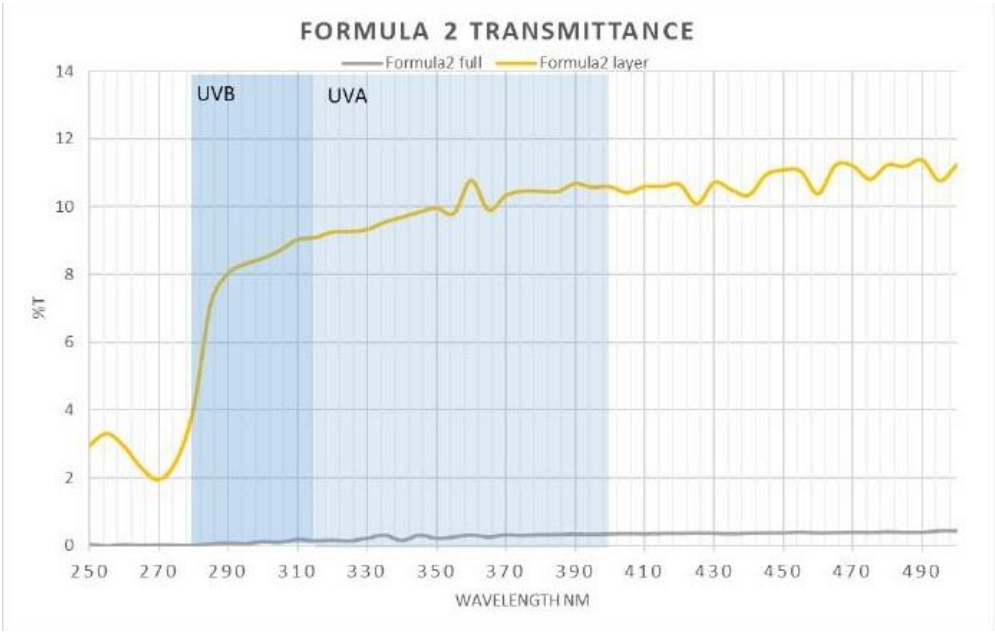


Figure 53: The transmittance of formula 2.

Formula 3: This formula consists of 70% aloe vera gel, 15% coconut oil and 15% olive oil.

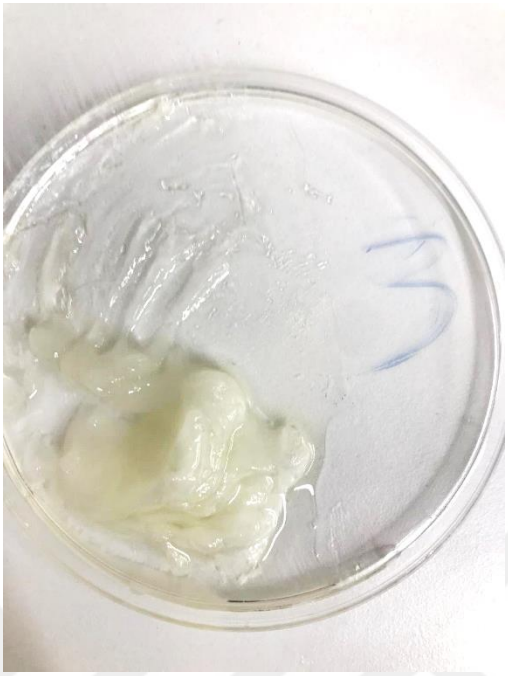


Figure 54: Formula 3.

The result was not homogeneous formula because of separated oil from the gel this formula was eliminated due to oil/gel separation (figure 54-55).

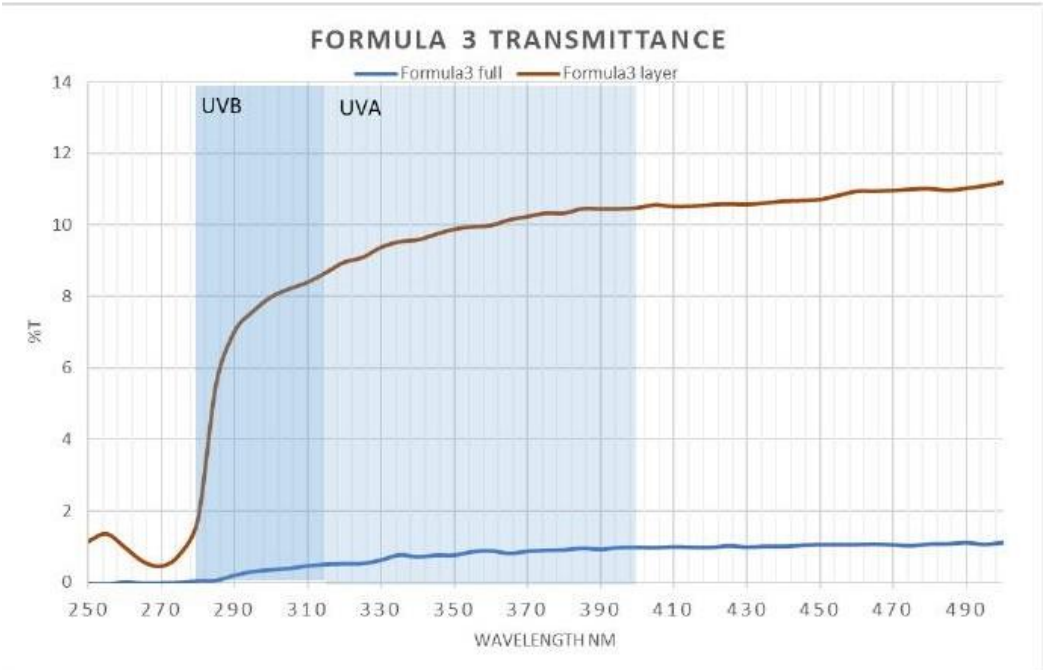


Figure 55: The transmittance of formula 3.

Formula 4: This formula consists of 70% aloe vera gel, 25% Coconut oil and 5% olive oil.

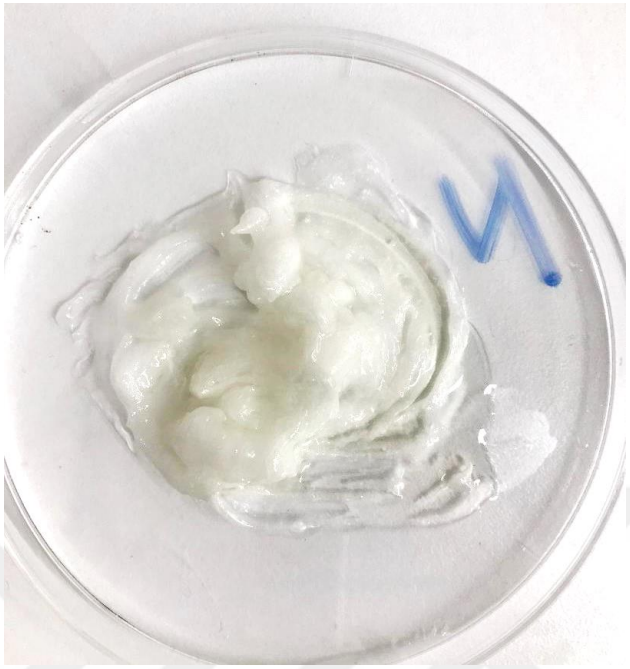


Figure 56: Formula 4.

The result was not homogenous formula as shown in figure57, because olive oil doesn't mix with the gel even in minimum quantity, therefore this formula was eliminated, the UV-Vis spectrum (Figure 57).

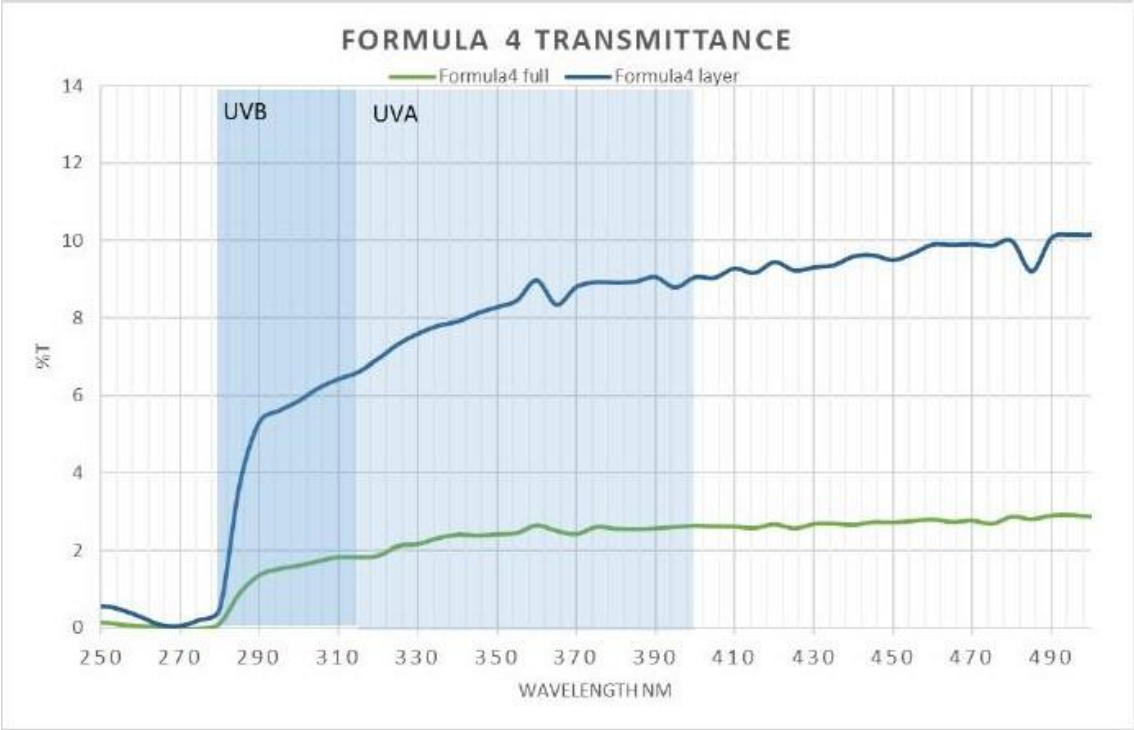


Figure 57: The transmittance of formula 4.

Formula 5: This formula consists of 90% formula1 and 10% coffee solution.

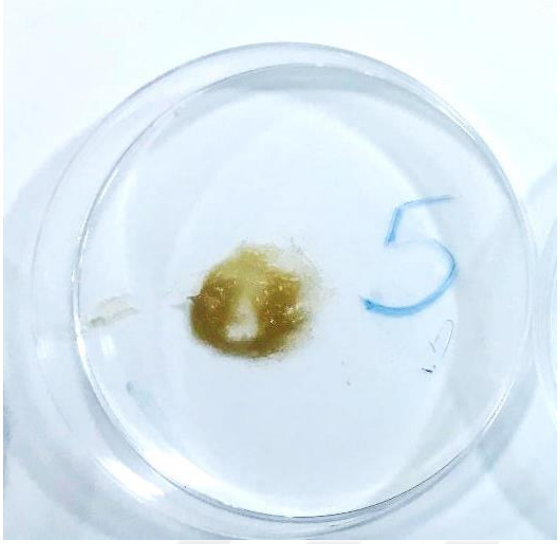


Figure 58: Formula 5.

The result was cohesive texture and homogeneous formula (Figure 58), this formula has gelatinous dark caramel brown half transparent texture, this formula designed to increase UV block properties of the formulation, UV transmission results given in (Figure 59).

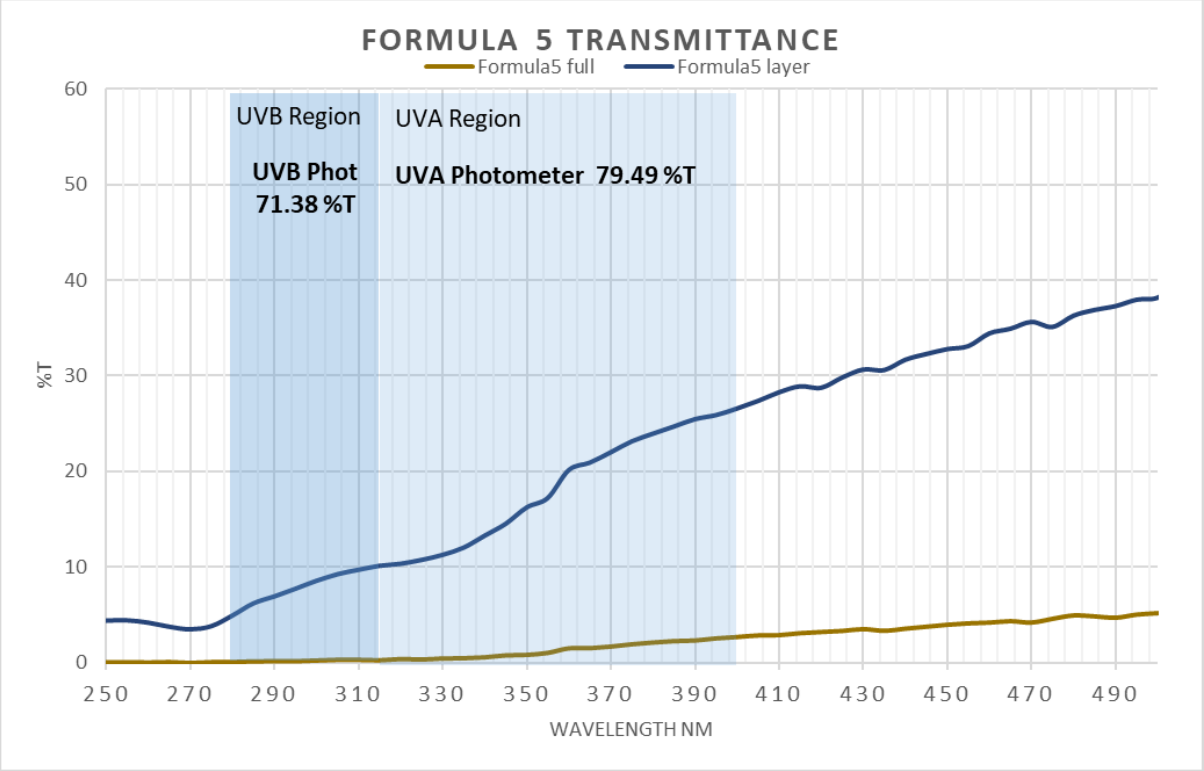


Figure 59: The transmittance of formula 5.

Formula 6: This formula consists of (80%) Aloe vera gel, (10%) olive oil and (10%) coffee mate powder.

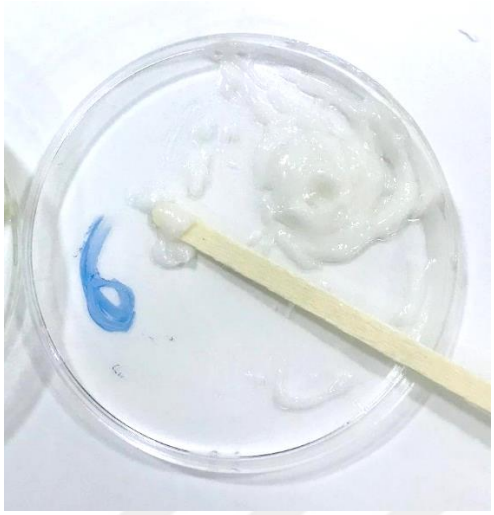


Figure 60: Formula 6.

The result was not homogeneous formula (figure 60), this formula has creamy wight texture but the oil is separated than the texture because olive oil doesn't react with the gel evet in the minimum percentage, UV Transmission is given in (Figure 61).

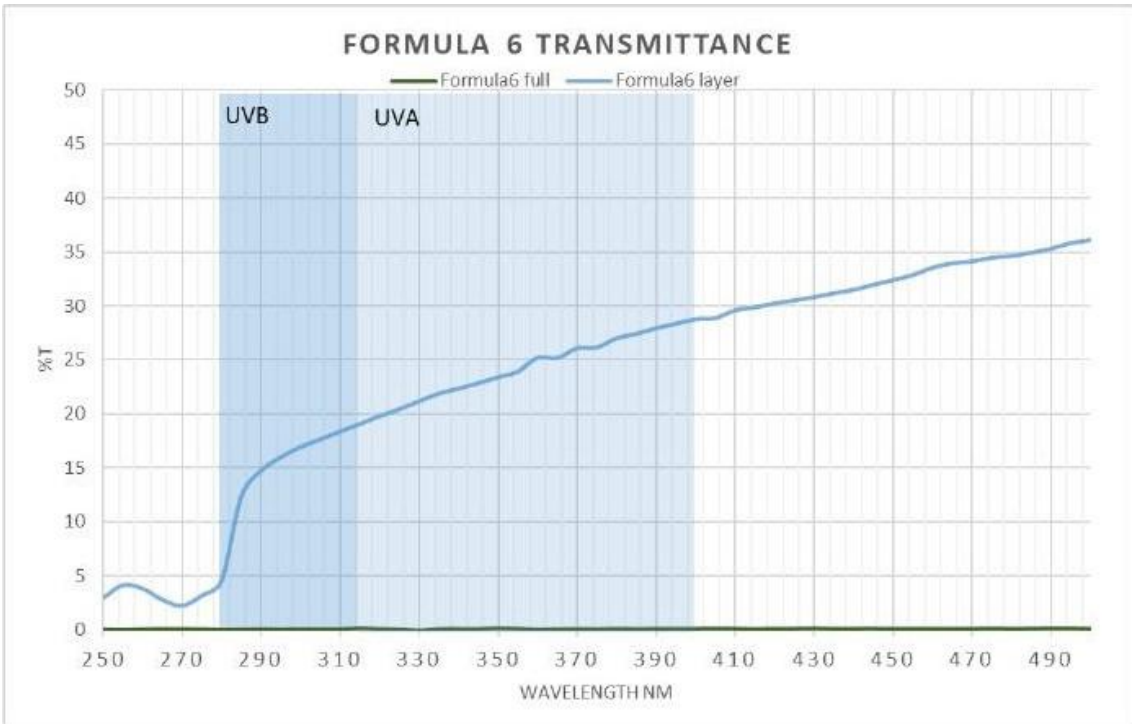


Figure 61: The transmittance of formula 6.

Formula 7: This Formula consists of (95%) Formula 1 and (5%) Coffee solution.

Figure 62: Formula7.

The result was cohesive texture and homogeneous formula (Figure 62), this formula has gelatinous caramel brown half transparent texture, UVA and UVB radio-photometer results show block performance compared to formula 1. UV-VIS Spectrophotometer results shows minimum transmittance (figure 63).

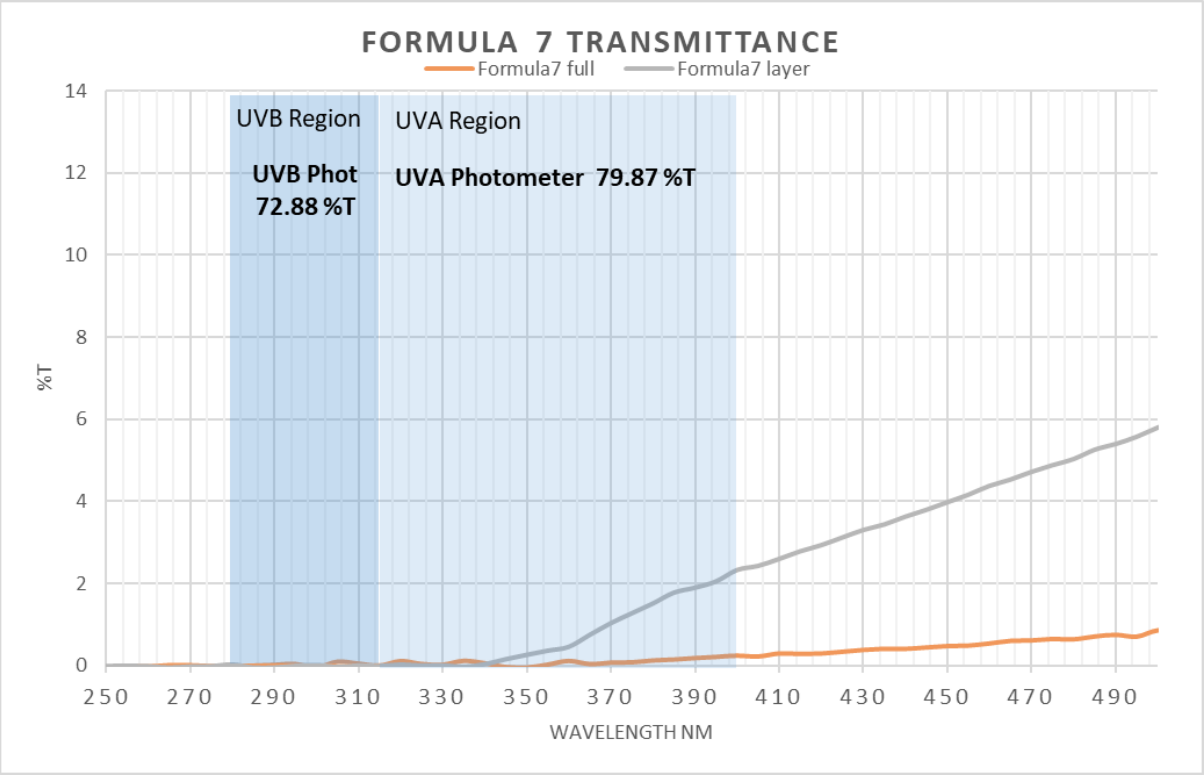


Figure 63: The transmittance of formula 7.

Formula 8: This formula consists of (90%) aloe vera gel and (10%) coffee mate powder.

Figure 64: Formula 8.

The result was cohesive texture and homogeneous formula (Figure 64), this formula has gelatinous wight texture looks like a cloud (more than formula1), radio-photometer results the block% close to the radio-photometer results of formula 1 which is without blocker as shown in (Figure 65).

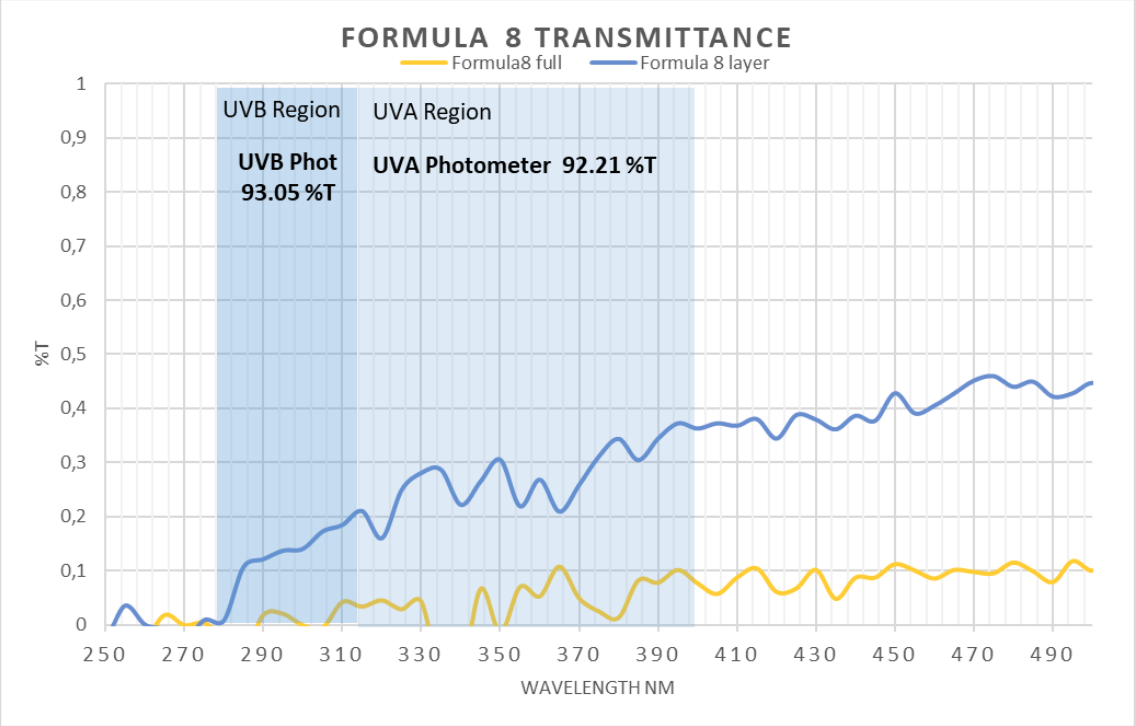


Figure 65: The transmittance of formula 8.

Formula 9: This formula consists of 80% Formula 1and 20% coffee solution.

Figure 66: Formula 9.

The result was cohesive texture and homogeneous formula as in the (Figure 66), this formula has gelatinous very dark brown texture decreases the intensity of UV to approximately the half but not blocking to allow UV to pass through the skin to activate vitamin D production in the skin, transmission results shown in (Figure 67).

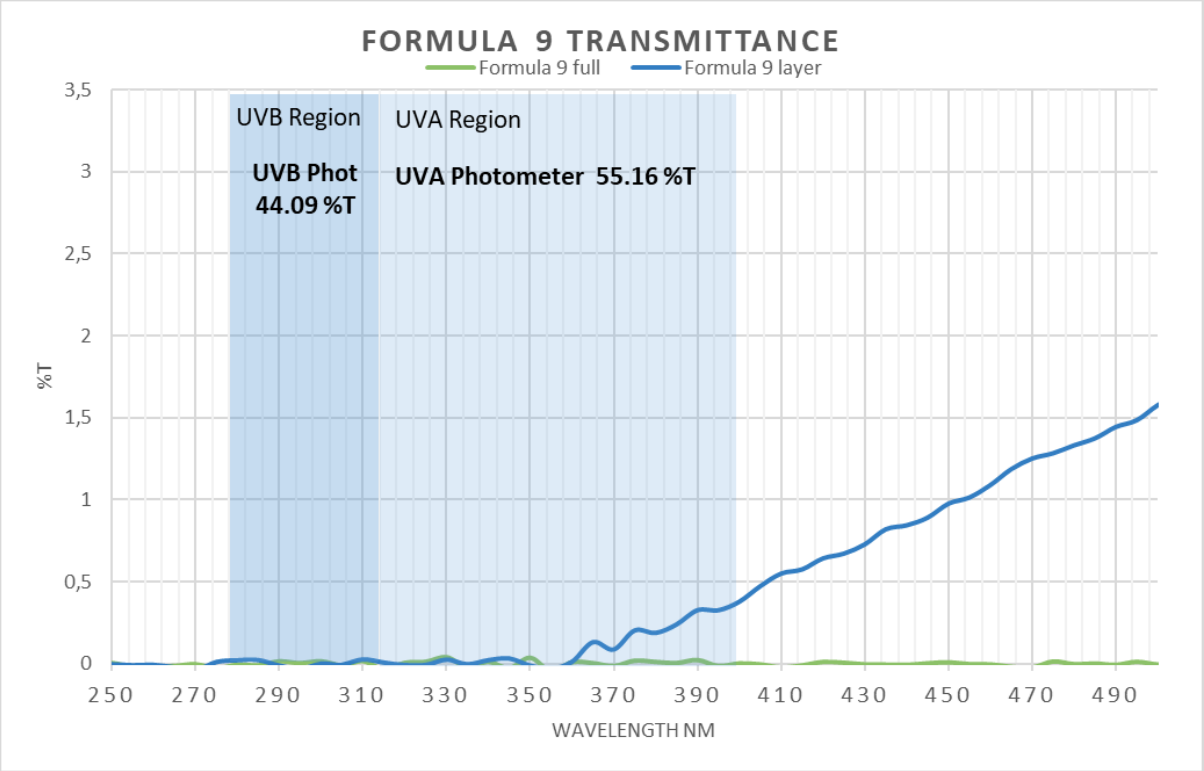


Figure 67: The transmittance of formula 9.

Formula 10: This formula consists of (80%) aloe vera gel and (20%) coffee mate powder.

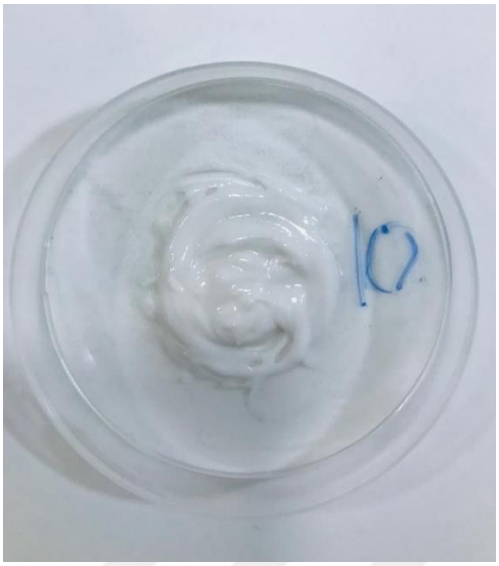


Figure 68: Formula 50.

The result was cohesive texture and homogeneous formula (Figure 68), this formula has creamy wight texture decreases (more than formula 8) the intensity of UV but not blocking to allow to some of UV to pass (less than formula 8) through the skin to activate vitamin D production in the skin, this formulation also shows some noticeable blocking properties looking to the radio-photometer results in (Figure 69).

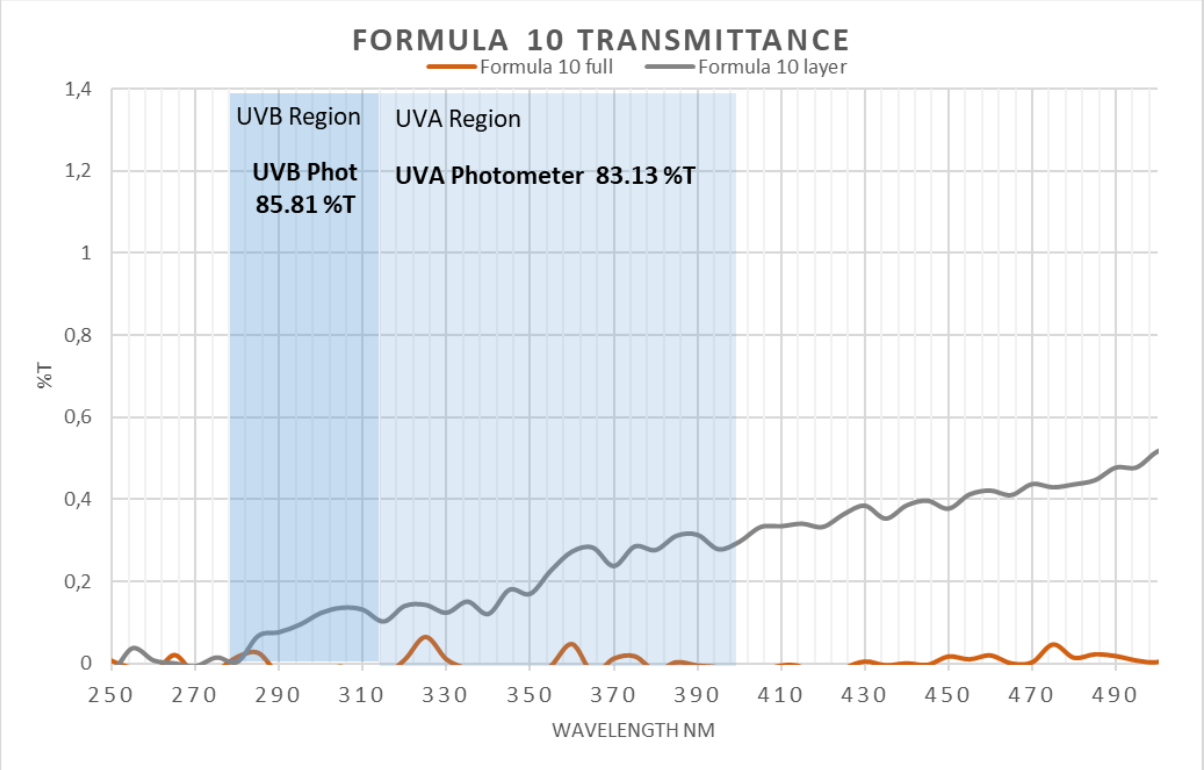


Figure 69: The transmittance of formula 10.

4.3. Shelf Life Studies

It was observed that formula1 left open in a tube for more than 1 month and the formulation's texture didn't spoil as shown in the (Figure 70), there was no preservation chemicals in the product.

Figure 70: Formula 1 after 1 month.

4.4. UV Blocking Studies

UV blocking experiments were done by putting a homemade part on the sensor for consistent measurements, the side of the sensors were partly covered by this equipment (Figure 71).

Table 4 makes a comparison with and without side covering of the homemade part and with and without using quartz glass. T% is similar for repeated measurements. The results are consistent with each other. The quartz glass transmits approximately 93% of the UVA light. Some coated samples are given in (Figure 71).

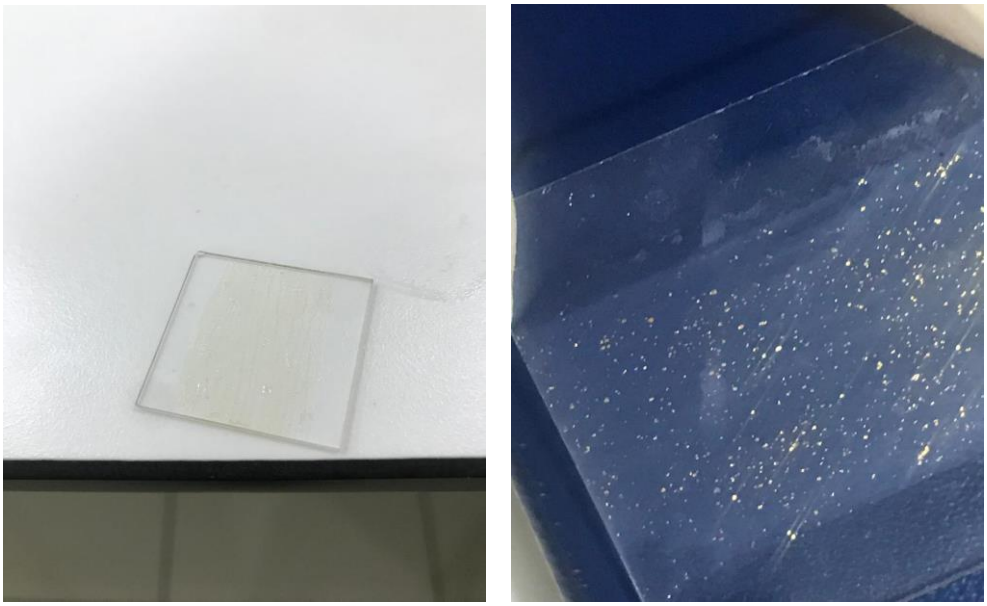


Figure 71: Some photo-radiometer slides coated with 50 µ layer of sample samples.

Table 4: Side cover and quartz glass effect under UVA Lamp with UVA Probe.

	no glass – no side coverage (W/m^2)	clean glass – no side coverage (W/m^2)	%T	no glass – with side cover (W/m^2)	clean glass – with side cover (W/m^2)	%T
Measurement 1	5.05	4.73	93.6	4.79	4.47	93.3
Measurement 2	5.00	4.66	93.2	4.66	4.34	93.1
Measurement 3				4.88	4.51	92.4

Table 5 represents UVA Transmittance of formulations and a commercial product, the measurements were done for clean glass and coated glass. The ratio gives T% and substraction from 100 gives block%, clean glass measurements were averaged and averaged T% and block% were calculated. The commercial product block% is 99.97 percent; it should be at least 98%. the difference should be arised from different techniques used for the measurements and thickness of coating. The highest block% were observed for formula 9. Formula 5, 7 and 10 showed similar block%. Formula 1 shows ~8% block arising from natural ingredients without using any blocker.

Table 5: UV transmittance under UVA lamp.

	Clean glass (W/m^2)	Coated Glass (W/m^2)	T%	Block %	Averaged T%	Averaged Block%
Sunscreen SPF 50 commercial	4.31	0.0012	0.028	99.97	0.028	99.97
Formula 1	4.31	3.99	92.58	7.42	92.15	7.85
Formula 5	4.33	3.55	81.99	18.01	81.99	18.01
Formula 7	4.33	3.63	83.83	16.17	83.83	16.17
Formula 8	4.365	3.93	90.03	9.97	90.76	9.24
Formula 9	4.14	2.36	57.00	43.00	54.50	45.5
Formula 10	4.33(Avg)	3.6	-------	-------	83.14	16.86

Table 6 shows UVA transmittance under UVC lamp, the light intensities are different for this lamp. Formula 9 (20% coffee blocker) shows the highest blocking results followed by formula 7 and 5. The commercial product showed 98.92 block%, which is higher than 98%, and also very near to this result.

Table 6: UVA transmittance under UVC lamp.

	Clean glass ($W/m^2 \times 10^{-3}$)	Coated Glass ($W/m^2 \times 10^{-3}$)	T%	Block %	Averaged T%	Averaged Block%
Sunscreen SPF 50 commercial	94.6	1	1.06	98.94	1.08	98.92
Formula 1	92.8	82.7	89.11	10.89	88.92	10.08
Formula 5	90.5	71.6	79.12	20.88	76.99	23.01
Formula 7	92.1	70.6	76.66	23.34	75.91	24.09
Formula 8	96.5	87.1	90.26	9.74	93.66	6.34
Formula 9	90	51.9	57.67	42.33	55.81	44.19
Formula 10	93 (Avg)	77.3	-------	-------	83.12	16.88

Table 7 shows UVB transmittance measured with UVB sensor under UVA light.

Formula 9 shows best blocking performance with 55.63% block, while formula 5 and 7 are following with 25.7 and 20.35 respectively. Formula 1 shows 6.42% natural block.

Table 7: UVB Transmittance under UVA Lamp.

	Clean glass ($W/m^2 \times 10^{-3}$)	Coated Glass ($W/m^2 \times 10^{-3}$)	T%	Block %	Averaged T%	Averaged Block%
Sunscreen SPF 50 commercial	117.1	0.5	0.43	99.57	0.42	99.58
Formula 1	123.6	112.2	90.78	9.22	93.58	6.42
Formula 5	117	89	76.07	23.93	74.23	25.77
Formula 7	118.8	95.5	80.39	19.61	79.65	20.35
Formula 8	123.5	115	93.12	6.88	95.91	4.09
Formula 9	120.9	53.2	44.00	56.00	44.37	55.63
Formula 10	119.9(Avg)	106.7	------	-------	88.99	11.01

Table 8 shows UVB transmittance under UVC light. The block% order are similar to the previous results.

Table 8: UVB transmittance under UVC lamp.

	Clean glass ($W/m^2 \times 10^{-3}$)	Coated Glass ($W/m^2 \times 10^{-3}$)	T%	Block %	Averaged T%	Averaged Block%
Sunscreen SPF 50 commercial	212	0.3	0.14	99.86	0.14	99.86
Formula 1	206.4	173.2	83.91	16.09	81.78	18.22
Formula 5	216	145	67.13	32.87	68.46	31.54
Formula 7	220	140	63.64	36.36	66.10	33.90
Formula 8	216	191	88.43	11.57	90.18	9.82
Formula 9	208	92.8	44.62	55.38	43.81	56.19
Formula 10	211.8(Avg)	175	-------	-------	82.63	17.37

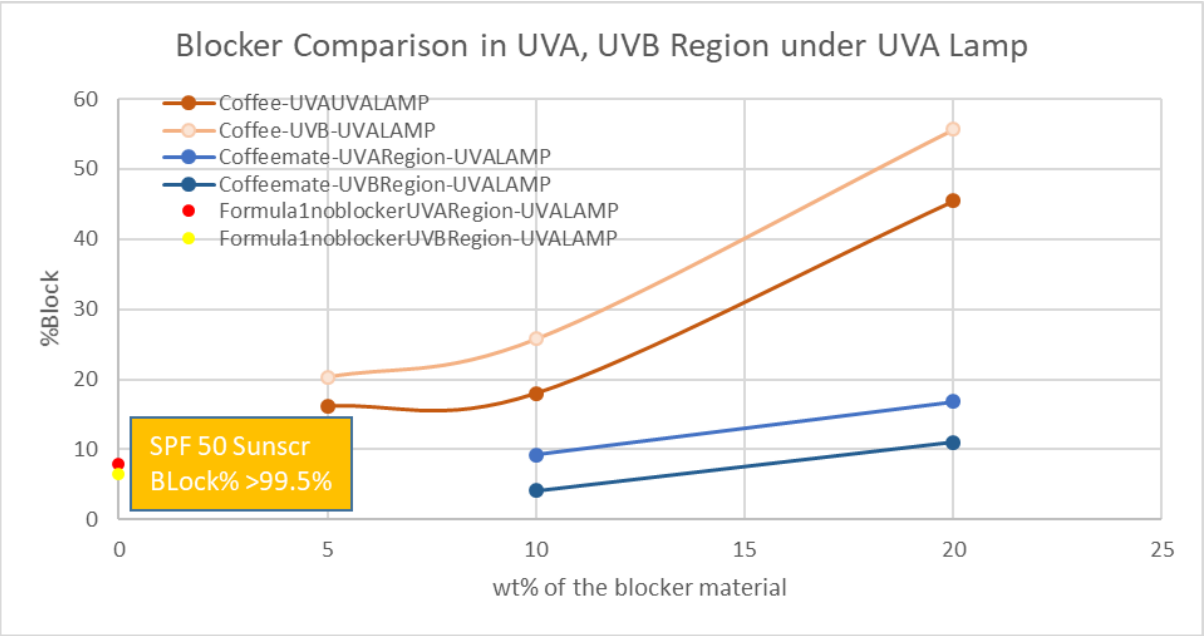


Figure 72: Blocker comparison in UVA and UVB region under UVA lamp.

(Figure 72) compares different blockers coffee and coffee mate with each other, as it is seen, coffee blocks much better than coffee mate.

The formula 1 is also shown on the figure both UVA and UVB block% are similar.

When different coffee % are compared, as coffee % increases block% also increases. UVA and UVB sensor results for coffee and UVA and UVB results for coffee mate followed the same trends.

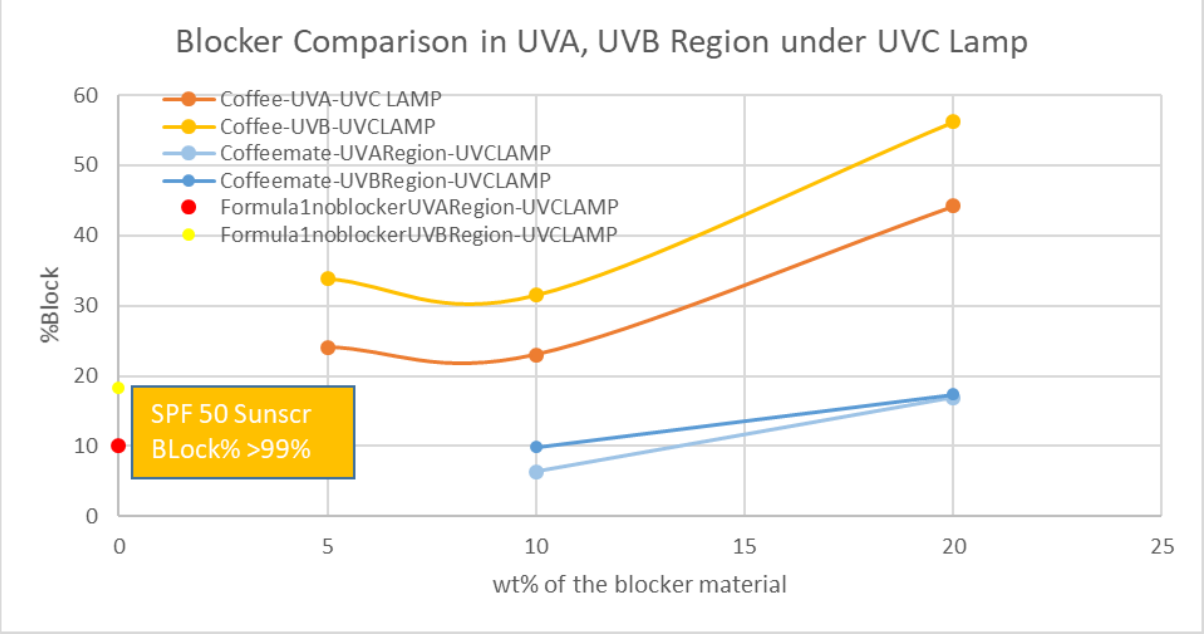


Figure 73: Blocker comparison in UVA, UVB region under UVC lamp.

(Figure 73) shows UVA and UVB block% results under UVC light, the results are somewhat similar, there is an increasing tendency with increasing coffee% for coffee results.

However, the results for 10% is a bit lower than 5%, which is not expected.

For coffee results, UVB block% is higher than UVA block %, which is the same for UVA light. for coffee mate blocker, the block results for UVA and UVB are very similar to each other than UVA light results.

4.5. UV Index Calculations

A typical UV index is shown in figure 75, in a midday, the max UV measurement of the sun is 250 mW/m2. (nowadays, the value changed to 264 mW/m2.). (The max sunlight was changed but the index still used), the UV index is calculated from this maximum by dividing the number by 25 mW/m2. UV Index 1-2 is considered low and you don't need to use any protection equipment. In low UV index after 1 hr sun exposure there is a risk of sunburn.

For moderate, high regions, burn risk starts after 45, 30 and 15-25 minutes respectively. (Wikipedia,.2024*) (Table9).

Figure 74: Standard UV index. (Headhunter Performance).**

By using sunlight UV portion (95%UVA, 5% UVB), we used weighted average to combine averaged block values of UVA and UVB, which is shown in table 9, UVA

lamp (97.3%UVA, 2.7%UVB) was used in this calculation, it is very similar to sunlight UV%. by using sunlight block values UV Index change from max was calculated.

Table 9: Sunlight block% and UV index change from max 10.

	Averaged UVA Block%	Averaged UVB Block%	Under Sunlight Block %	UV index change from max 10
Sunscreen SPF 50 commercial	99.97	99.58	99.95	Almost 0
Formula 1	7.85	6.42	7.78	9.2
Formula 5	18.01	25.77	18.40	8.2
Formula 7	16.17	20.35	16.38	8.4
Formula 8	9.24	4.09	8.98	9.1
Formula 9	45.5	55.63	46,01	5.4
Formula 10	16.86	11.01	16.57	8.3

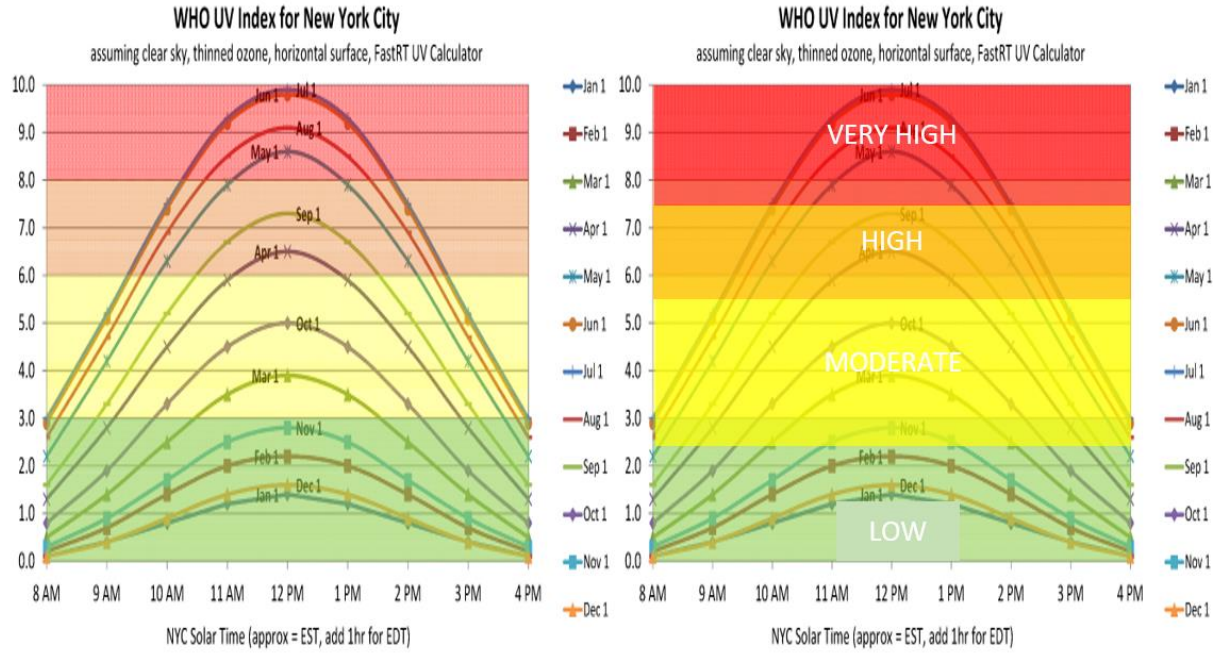


Figure 75: UV Index for New YorkCity for the whole year (2014) (Wikimedia Commons*).**

(Figure 75) shows changes in UV index during day time for the first day of each month for a year. As seen in the figure, the max is reached in june and july. May, june, july and august enters to very high UV index region in the midday. The chart on the left is modified as the right side, the UV index transition points are taken as midpoints, such as low calculations were done up to UV 2.5. Moderate region is accepted up to 5.5. High Region is accepted up to 7.5. Very High region is accepted up to 10.5 (Austuralian Government Radiation Protection and Nuclear Safety Acency****).

Figure 77 shows the UV index after formulation 9 (20% coffee blocker) is applied, in this calculation UV Index points are extended considering the block % of the formulation.

As an example, low UV index point 2.5 is extended to 4.64 if we apply 46% block. And moderate border is increased to 10.2. Since we make an analysis up to UV Index 10, as seen on the figure, this means there is only low and moderate UV Index region for formulation 9 which is shown with green and yellow colors of the index.Therefore if you use formulation 9, there is no risk of sunburn in november, december, january, february and march. For october there is very low risk of sunburn.

For the other months, during the midday, there is moderate risk of sunburn, which is the lowest UV Index with protection for the sunburn. In other saying, for moderate region you do not have sunburn before 45 minutes.

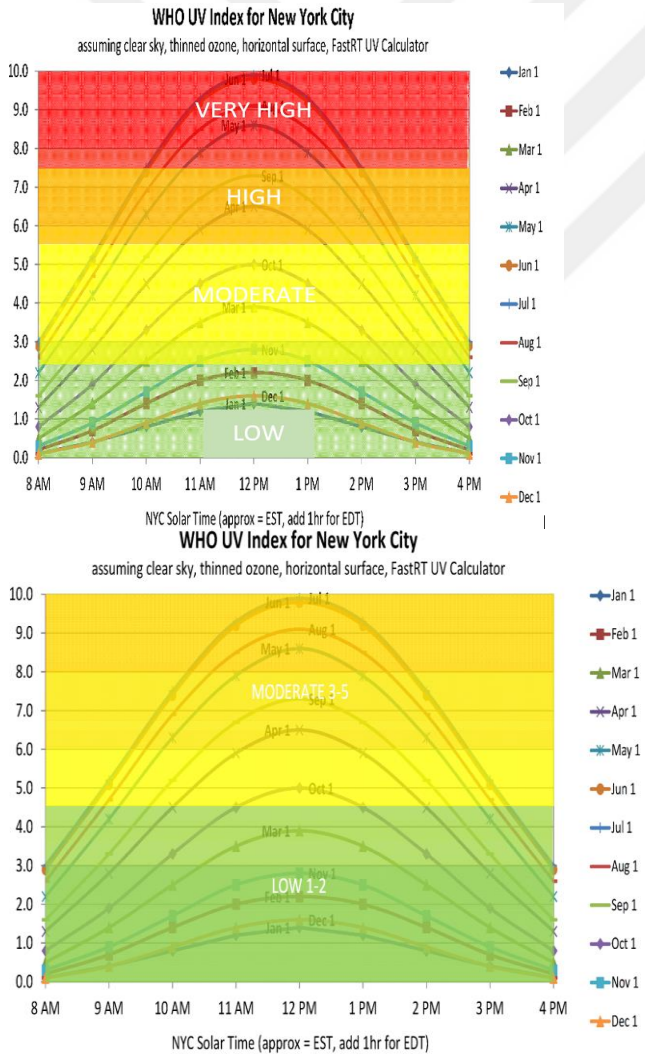


Figure 76: UV Index change when formulation 9 (20% coffee blocker) is used.

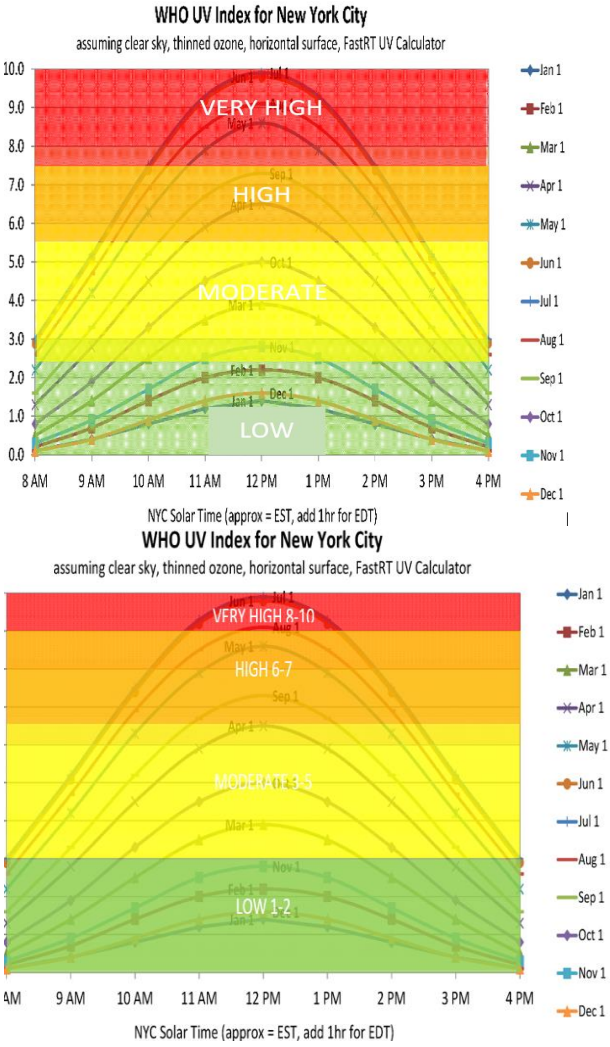


Figure 77: UV Index change when formulation 10 (20% coffee mate) is used.

For (Figure 77), formulation 10 is applied, this time according to UV Index, for november, december, january and february the burn risk is low, for october, march and april, burn risk is moderate, for may and september burn risk is high if you stay under the sun more than 30 minutes, for august, june and july, between 11 am to 1 pm there is a high risk of sun burn if you stay under the sun more than 25 minutes.

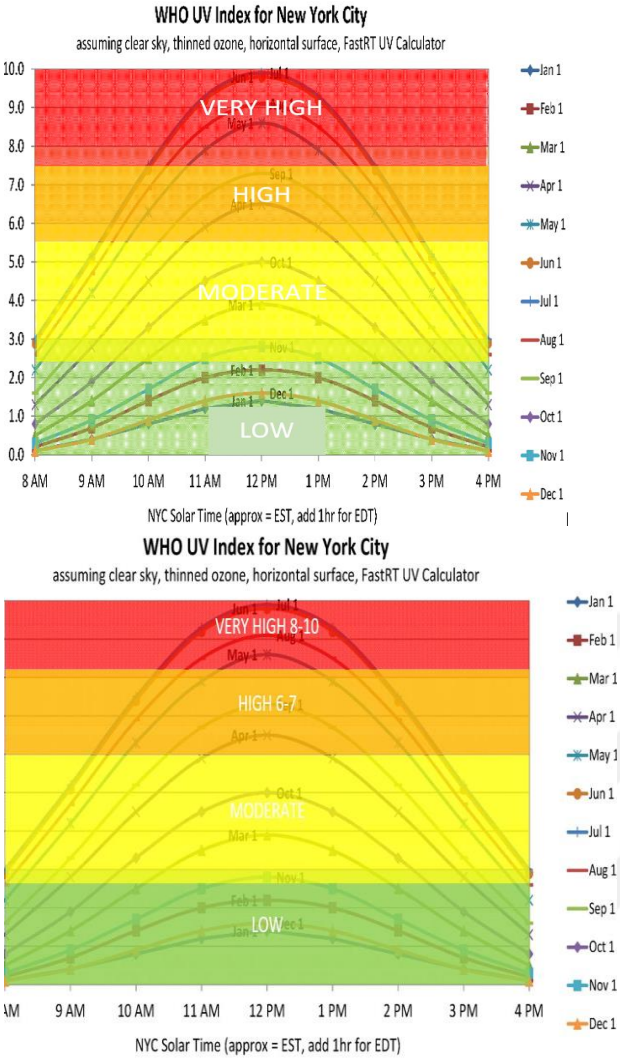


Figure 78: UV index change when formulation 1 (without blocker).

Formulation 1 application is shown in (Figure 78). For may, june, july and august there is a very high risk of sunburn in the midday, for october, march, november, february, december and january the risks are low and moderate, in winter months there is no need to use the blocker formulations.

5. CONCLUSION

According to the results after trying more than 10 different formulations from 100% natural ingredients, formula 1 (70% aloe vera gel-30%coconut oil), formula 8 (90% aloevera-10% coffee mate) and formula 10 (80% aloe vera gel-20% coffee mate) were the most suitable to be used as a homogeneous formula with natural color. Aloe vera and coconut oil mixed very well. Olive oil didn't form good texture with aloe vera.

Formula 9 (with 20% coffee) showed good blocking ability with a good texture. An increase in blocking ability was observed with increasing coffee solution %. However, there may be a pigmentation problem in daily use. Using formula 9 decreased the UV Index low and moderate levels for the whole year for New York City.

Comparing UV-Vis spectrophotometer and radio/photometer results, radio/photometer results were much reliable due to better sample preparation and low thickness and homogeneous coatings on quartz glass.

In initial shelf life study, formula 1 didn't show any visual difference after left open for one month without any preservative additive.

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***https://commons.wikimedia.org/w/index.php?curid=33455958

****https://www.arpansa.gov.au/our-services/monitoring/ultraviolet-radiation-monitoring/ultraviolet-radiation-index

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