Sudan University of Science and Technology
College of graduate studies

Study of the Effect of Nd:YAG Laser on the Raw Cow's Milk Characteristics and its Sterilization

دراسة تأثير ليزر Nd: YAG علي خصائص لبن البقر الخام وتعقيمه

A Thesis Submitted as Partial Fulfillment of the Requirements for the Degree of Master of Science in Physics

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الآيـــــــــة :

قال تعالى:

{ وَإِنَّ لَكُمْ فِي الْأَنْعَامِ لَعِبْرَةً نُسْقِيكُمْ مِمَّا فِي بُطُونِهِ مِنْ بَيْنِ فَرْثٍ وَدَمٍ لَبَنًا خَالِصًا سَائِغًا لِلشَّارِبِينَ }

(سورة النحل الاية 66)

Dedication

To

My fathers

My mothers

My families

My Friends

Acknowledgement

First of all, I would like to thanks Allah for giving me the strength to finish this study.

Special thanks Dr. Ali Abdel Rahman Saeed Marouf, supervisor of my thesis for his guidance and assistance throughout the progress of this thesis .I would like to express my gratitude to Dr. Mubarak Almahal and Dr. Omer Ibrahim ,I remain thankful to whole ABDELMONIEM MEDICAL INDUSTRIES, specially Limia Ibrahim Suliman. My thanks extend to staff of Institute of Laser, and college of science (physics-chemistry) Sudan University of Science and Technology.

Abstract

In this research laser used to irradiant milk and its effect on the pH and absorbance has been studied in this research. Six samples of cow's milk were taken from the farm directly, without any additions of preservatives. five samples from six samples were irradiated by Nd:YAG laser 1064 nm wavelength using different output powers (10, 20, 30, 40 and 50) mW and the sixth sample was left without irradiation as a control, the result shows that by increasing laser dose the absorbance broadness from UV range to the visible range and pH decrease with increasing laser dose and time, and Sterilization 100% occur on 50mW for two minute bacteria and fungi.

المستخلص

في هذا البحث تم استخدام ليزر Nd:yag لتشعيع اللبن . أخذت ست عينات من حليب الأبقار من المزرعة مباشرة دون أي اضافات من المواد الحافظة,وعرضت خمس عينات لليزر(الانديااك ليزر) بطول موجي 1064 نانوميتر بقدرات مختلفة 10و20و30و40و50 ملي واط و تركت عينه واحدة لم تعرض لليزر كمرجع، أظهرت النتائج أن زيادة الجرعة الليزرية تتسبب في اتساع أمتصاصية الحليب من الطيف فوق البنفسجي الى الطيف المرئي وزيادة حموضة الحليب تتناسب عكسياً أيضاَ مع الجرعة و الزمن، ويحدث تعقيم 100% في تشعيع قدره 50 ملي واط لمدة دقيقتين بالنسبة للبكتريا والفطريات.

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Chapter One

Introduction and Literature Review

1.1 Introduction

Many scientific studies contradict the conventional wisdom that milk and dairy consumption help reduce osteoporotic fractures. Surprisingly, studies demonstrating that milk and dairy products actually fail to protect bones from fractures outnumber studies that prove otherwise. Even drinking milk from a young age does not protect against future fracture risk but actually increases it. Shattering the “savings account” calcium theory, Cumming and Klineberg report their study findings as follows.

This research studies the effect of laser on bacteria which is harmful and causes many illnesses(disease) for a human like diarrhea. One group of bacteria which includes 0157:H7 produce powerful toxin that damages the lining of small intestine, which can cause bloody diarrhea. Bacteria are found in milk to be contaminated it. Laser can use in sterilization of drinking milk from contaminated microbes (bacteria, viruses, germs, bugs) because photo-thermal interaction can occurs.

Most investigators agree that laser beam has very strong effect on the damage of bacteria (inactivation, inhabitation growth).Laser wavelength (UV, IR, visible) and exposure time can effect on the shape of decay.

We use different power of ND:YAG laser (10, 20,30,40,50) by two mints constant and we found before and after exposed the sample to different power of radiation we saw when the power is high the growth of organism is low ,and when the power is low the growth of organism is high ,and we read spectrum of milk by UV,and we read the pH.meter of milk in constant temperature, finally we found the radiation of laser in bacteria.

1.2Literature review

Smith WL, Laqunasand Cullor JS (2002)used pulsed ultraviolet laser light for the cold pasteurization of bovine milk,because of concerns that some potentially dangerous microorganisms may survive conventional heat pasteurization of milk and because the heat needed to sterilize milk affects marketability, the ability to efficiently cold pasteurized milk may become more desirable. In this pilot study, we investigated the use of pulsed ultraviolet (PUV) laser light to no thermally (cold) pasteurized bovine milk. Dairy bulk tank milk was treated with UV light (248 nm) emitted from a pulsed excimer laser. The samples were then analyzed for surviving bacteria by spiral plate counting and subculturing in Trypticase soy broth. Other bulk tank milk samples were inoculated with one of eight relevant milk bacterial species before being exposed to laser light. There was no growth observed for any of the plated or subcultured samples exposed to 25 J/cm2. One bacterial isolate was then used to inoculate milk to further investigate bactericidal laser light doses. Growth was observed for samples treated with an average of 0.3 to 6.6 J/cm2 but not for those treated with 12.6 J/cm2. The results indicate that in principle, the bacterial content of milk can be adequately controlled by exposure to PUV laser light.

Zilaitis V.,Rudejeviene J.,Maruska R.,Noreika A.,Vorobjovas G.,andJapertas S(2008)Their study was to monitor the effects of radiation emitted by a low energy laser on the growth of microorganisms in vitro from milk of cows with elevated SCC, microorganism diversification, and SCC after the lead treatment in vivo by the laser. Laser irradiated microorganism cultures exhibited a weaker incidence of environmental microorganisms, especially fungi and Streptococci sp. No laser light effect was noted on S. aureus culture development. Our data shows that after laser treatment the variety of micro-organism species immediately decreases 64.28% and this indicator remains unchanged after 21 days. 21 days after completion of the therapy course the SCC decreased 20.11%. 70 days after treatment the SCC increase compared to the 21 day period increased by 20.3%, which can be associated with factors unrelated to the method of therapy. It is advisable to treat increases in SCC with low intensity laser rays conditional to environmental mastitis causative agents. Moreover, since due to the effect of laser radiation certain irradiated micro-organism cultures become more susceptible to antibiotics, it is advisable to coordinate laser therapy with antibiotic therapy.

Eva Csutak(2009)Considering that the quality of raw milk is a prerequisite condition to obtain a good quality probiotic yoghurt, our studies aimed the measurement of milk factors which can affect the multiplication of probiotic lactic acid bacteria (LABs) Lactobacillus acidophilus (LA-5. The probiotic strains Bifidobacterium BB-12 and Lactobacillus acidophilus LA-5-we used for trials-aretested probiotics by Christian Hansen company. We studied comparatively raw and pasteurized milk, their chemical composition and the correlations between the spontaneous microbial flora(NTG) found in milk samples and the impact of this flora on the multiplication of LABs. We investigated as well the effect milk proteins, added prebiotics(lactose, molasses) on pH and LAB development, the influence of NTG (number of total germs), NCS (somatic cells number) in raw milk before and after pasteurization, on lactic fermentations and LA-5(Lactobacillusacidophilus) Generally multiplication of LA-5 strains was reversely correlated with NTG values. There is adirect correlation between presence of prebiotics and probiotic bacteria activity.

J. H. Naama ; A. Noori& A. Hadi(2011)studied the possibility of using lasers in the sterilization of water and milk h.Two types of diode laser has been used, the first one 2-watt 810 nm wavelength and the second 5 watt wavelength 1064 nm.Irradiation of samples was taken place from the physiological saline containing the Escherichia colibacteria in three sizes (0.3,0.2, 0.1) cm^3 in test tubes of size (0.5) cm^3. Samples were irradiated at different periods of time for each laser. The results showed that after each irradiation we have obtained a highest kill of 100% of the bacteria by laser diode (2 W) through a period of 20 minutes. In the diode laser (5 W) a recording of the highest kill rate of 100% has been obtained in 1.5 min period).The conducted results of disinfecting water with the killing rate 100% have been applied in the sterilization of milk contaminated with bacteria under the same conditions in which 100% kill rate have been achieved for both lasers.

SirelkhatimBallaElhardallou and Ashraf Yehia El-naggar(2014)Determined Micro minerals in Milk from Farm and Pasture-reared Cow, Goat and Camel; using Inductively Coupled Plasma-Optical Emission Spectrometry,This study covers raw fresh milk of cow, goat and camel (farm and pasture-reared), in addition to two brands of commercial milk samples, liquid milk of powder origin and drinking yoghurt samples. Camel milk showed a relatively lower pH range (6.15 - 6.46) compared cow, goat and commercial milk. The pH of drinking yoghurt was found (4.35 - 4.47).Microwave digestion, was selected followed by mineral analysis using Inductively Coupled Plasma-Optical Emission Spectrometry. Micro minerals; Cd, Cr, Cu, Fe, Mn and Pb, ranged from not detected to 23.4$\pm$0.52mg/L for Fe while Sr (0.32$\pm$0.005 – 2.51$\pm$0.043 mg/L) and Zn (1.58$\pm$0.01 – 8.91$\pm$0.14 mg/L) in all milk samples.

1.3 Research Problem:

The field of laser matter interaction may be with metal , tissue or food this research study the effect of laser in milk characteristics and sterilized milk**.**

1.4 The objective of this thesis:

The main goal of this research is to study the effect of laser in milk characteristics and to use laser to kill the bacteria in the milk.

1.5 Thesis Layout:

This thesis is consist of four chapters, chapter one Introduction and Literature Review ,and chapter two consist Basic concepts of laser and milk, and Light interaction with matter, chapter three consist Experimental Part (The materials and device and method), chapter four consist of Results and Discussion and Conclusion, Recommendations and References.

Chapter Two

Basic Concepts

2.1 laser:

The word (laser) is an acronym derived from Light Amplification by Stimulated Emission of Radiation. The light emitted by laser is different from that produced by more conventional light sources. laser is a device that generates or amplifies coherent radiation at frequencies in the infrared, visible or ultraviolet and other regions of the electromagnetic spectrum.

Lasers are distinguished from other light sources by their coherence. Spatial coherence is typically expressed through the output being an arrow beam which is diffraction-limited, often a so-called "pencil beam." Laser beams can be focused to very tiny spots, achieving a very high irradiance, or they can be launched into beams of very low divergence in order to concentrate their power at large distance.

Temporal (or longitudinal) coherence implies a polarized wave at a single frequency whose phase is correlated over a relatively large distance (the coherence length) along the beam. a beam produced by thermal or other incoherent light source has an instantaneous amplitude and phase which vary randomly with respect to time and position, and thus a very short coherence length.

Most so-called "single wavelength “lasers actually produce radiation in several modes having slightly different frequencies (wavelengths), often not in a single polarization, and although temporal coherence implies monochromaticity, there are even lasers that emit broad spectrum of light, or emit different wavelengths of light simultaneously. There are some lasers which are not single spatial mode and consequently their light beams diverge more than required by the diffraction limit. However all such devices are classified as "lasers" based on their method of producing that light: stimulated emission, lasers are employed in applications where light of the required spatial or temporal coherence could not be produced using simpler technologies.

2.2 Properties of laser:

Laser radiation shows as extremely high degree of monochromaticity ,coherence , directionality and brightness as compared to other no coherent light sources.

2.2.1Monochromaticity:

The Monochromaticity of laser radiation is a unique property of laser light, results from the circumstance that light oscillation sets in at one resonance frequency of the optical cavity, and owing to the balance between gain and loss in CW operation the line width ΔvL of the oscillating mode is ultimately limited by quantum noise.

2.2.2 Coherence:

The coherence of the laser radiation refers to the time period Δt in which the phase undergoes random changes, and the coherence length is a measure of the propagation distance over which the beam stays coherence .

2.2.3 Directionality:

The directionality of the laser beam is due to the fact that the gain medium is placed inside an open optical resonator .

2.2.4 Brightness:

The brightness of laser radiation is closely related to the directionality and stems from the capability of a laser oscillator to emit a high optical power in a small solid angle of space.

2.3 Elements of laser:

A laser generally requires three components for its operation:

(a) an active medium in the form of a laser rod, with energy levels that can be selectively populated;

(b) a pumping process to produce population inversion between some of these energy levels;

(c) a resonant cavity containing the active medium which serves to store the emitted radiation and provides feedback to maintain the coherence of the radiation. The main problem in designing a laser is to involve produce a sufficiently high population of atoms in the excited state. For this, many ingenious ways fully all have been evolved. The most common method of center excitation is by sending an intense beam of light from a flash lamp or a continuous source of light through the material in the form of a cylindrical rod or a container tube with a suitable gas. Only those materials which can be pumped to achieve population inversion, are used to give laser radiation. The existence of states whose mean life times are relatively long so as to help pile up considerable energy in the excited levels, is necessary. Long life time of a level and the sharpness of the spectrum lines usually go together, and so, the materials that can be best used to give laser radiation are crystals with sharp lines, and gases at low pressure. An important aspect of the laser operation involves the design of a resonator cavity to maximize the process of stimulated emission. Two carefully aligned mirrors, one having more than 99 percent reflectivity and the other having less reflectivity, are placed at either end of the cavity containing the laser rod and the flash lamp. The stimulated radiation multiplies by bouncing back and forth many times between the two mirrors and passing through the laser medium. And, when it exceeds a certain limit, the laser light comes out citation in the form of a narrow pencil beam through the semi-transparent mirror .

2.4 Laser construction:

A laser system is constructed from three main parts:

2.4.1 Pumping source:

It can provide energy to the laser system for example electrical discharge, flash lamp, light from another laser, chemical reactions and even explosive devices. The type of pumping source uses principally depends on the gain medium, and this also determines how the energy is transmitted to the medium.

2.4.2 Laser gain medium:

Also calls lasing medium results from stimulated emission of electronic or molecular transition from higher to lower energy state populated by a pump source.

2.4.3The optical resonator or optical cavity:

In its simplest form is two parallel mirrors placed around the gain medium which provide feedback of the light. Cavity designed to internally reflect infrared, visible, ultra-violet. It contains gases, liquids and solids, Cavity materials can determine the wavelength of the output.

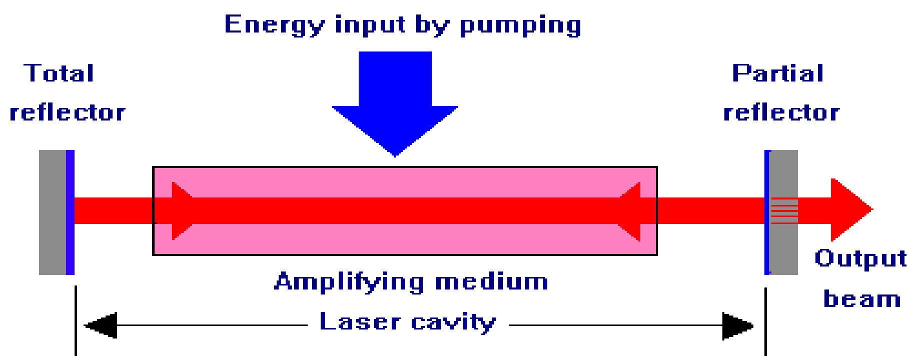


Figure (2.1) Elements of laser

2.5 Laser types:

The various laser types developed so far display a wide range of physical and operating parameters. Indeed, if lasers are characterized according to the physical state of the active material, we call them solid-state, liquid, or gas lasers. A rather special case is where the active material consists of free electrons at relativistic velocities passing through a spatially periodic magnetic field free electron lasers. If lasers are characterized by the wavelength of emitted radiation, one refers to infrared lasers, visible lasers, and ultraviolet (UV) and x-ray lasers.

2.5.1 Gas lasers:

A gas laser contains atoms or molecules. Stimulated transitions occur in atoms between electronic states and in molecules between rotational, vibration, or electronic states. We describe various gas discharge lasers: helium–neon laser; metal vapor laser; argon ion laser; exciter laser; nitrogen laser; CO_2 laser; optically pumped gas lasers .

2.5.2 Solid state lasers:

We discuss solid state lasers that make use of electronic states of impurity ions in dielectric crystals or in glasses — other types of solid state lasers, namely semiconductor lasers that are based on electrons in energy bands of semiconductors. It consists the ruby laser, the titanium–sapphire laser, neodymium-doped YAG laser, of other neodymium lasers, and of other YAG lasers.

Nd:YAG laser:

Nd:YAG lasers are optically pumped using a flash tube or laser diodes. These are one of the most common types of laser, and are used for many different applications. Nd:YAG lasers typically emit light with a wavelength of 1064 nm, in the infrared However, there are also transitions near 940, 1120, 1320, and 1440 nm. Nd:YAG lasers operate in both pulsed and continuous mode. Pulsed

Nd:YAG lasers are typically operated in the so-called Q-switching mode: An optical switch is inserted in the laser cavity waiting for a maximum population inversion in the neodymium ions before it opens. Then the light wave can run through the cavity, depopulating the excited laser medium at maximum population inversion. In this Q-switched mode, output powers of 250 megawatts and pulse durations of 10 to 25 nanoseconds have been achieved The high-intensity pulses may be efficiently frequency doubled to generate laser light at 532 nm, or higher harmonics at 355, 266 and 213 nm.

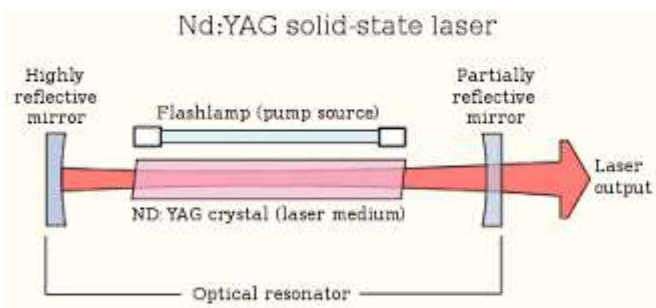


Figure (2.2) Elements of Nd:YAGlaser

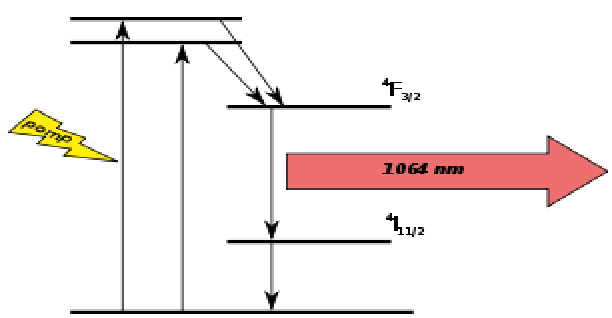


Figure (2.3) energy state of Nd:YAG laser

2.5.3 Semiconductor lasers:

Semiconductor lasers represent one of the most important class of lasers in use today, not only because of the large variety of direct applications in which they are involved, but also because they have found a widespread use as pumps for solid-state lasers.

These lasers will therefore be considered at some length . For the active medium, semiconductor lasers require a direct-gap material, so normal elemental semiconductors (e.g., Si or Ge) cannot be used. The majority of semiconductor laser materials are based on a combination of elements in the third group of the Periodic Table (such as AI, Ga, In) and the fifth group (such as N, P, As, Sb) hence referred to as 1II-V compounds [4].

2.5.4 Liquid Dye lasers

Liquid Dye Lasers use a solution of complex dye material as the active medium. The dyes are large organic molecules, with molecular weights of several hundred. The dye material is dissolved in an organic solvent, like methyl alcohol. Thus the active medium is a liquid. Dye lasers are the only types of liquid lasers which have reached a well developed status.

One of the most important features that dye lasers offer is tenability, that is, the color of the output beam can be varied by adjusting the inter cavity tuning element and also by changing the type of the that is used. The monochromatic output of available dye lasers can be turned over a broad range, from the ultraviolet, to the near infrared. Liquid dye lasers that can be tuned to any visible wavelength, and to portions of the infrared and ultraviolet, are commercially available in both pulsed and continuous models. Dye lasers are chosen for applications, like spectroscopy, in which tenability is important.

2.6 Laser applications:

Lasers are employed over a wide range of applications from scientific research, biomedicine, and environmental sciences to industrial material process, microelectronics and entertainment.

Some applications are: Industrial application like cutting , welding ,drilling by using CO_2 laser, ruby laser, argon ion laser , pulse Nd:YAG laser.

Medical application like phototherapy of eye , tissue surgery , using (CO_2 laser, Nd: YAG laser ,argon ion laser, and dye laser).

Military applications include range finders and beam weapons , by (CO_2 laser, Nd:YAG laser, chemical laser, semiconductor laser). Other applications include Communication , information processing , super market scanners , printers , reading device for compact disc player , holography and spectroscopy .

2.6.1Scientific Research:

Lasers have opened new fields of investigation in science and technology. It has given physics a versatile tool for the study of interaction of light and matter. The powerful beam of laser has become an important tool for spectroscopic analysis. A laser system, known as microprobe, is used for exciting emission from solid samples for spectrographic analysis. In 1928, Prof. CV Raman discovered a new phenomenon, known as Raman Effect. by which molecular structures of different substances can be investigated by passing monochromatic light through them. He found that when light passes through a transparent substance, it is scattered and emerges with a change of frequency caused due to the vibration of molecules in the substance. This produces additional lines (known as Raman lines) in the scattered light spectrum. The discovery of laser is a great boon for recording the Raman spectra. The use of lasers has enabled recording of Raman lines within seconds, which otherwise would require long exposure times of or few hours using ordinary light sources. The analysis of Raman lines gives the fundamental properties of the substances. Similarly, lasers can also be used for analyzing liquids. A laser beam, when passed through a liquid, gives several colures (wavelengths) and the process is called fluorescence. The study of the fluorescence spectra thus obtained gives the properties of the liquids. Lasers offer attractive possibilities in terms of the exploration of molecular structure and determination of nature of chemical reactions. A laser beam can initiate and hasten a chemical reaction. Since different reactions require different wavelengths of light, a 'tunable' laser (i.e., a source whose wavelength can be altered as in radio tuning) is of immense help to a chemist. Tunable lasers, particularly dye lasers, now cover the entire visible spectrum and have revolutionized optical spectroscopy. In photochemistry, lasers with short duration pulses are highly useful for inducing and monitoring ultrafast chemical reactions more efficiently than by any conventional method. Laser also finds application in biological research. Using laser techniques, biological studies have been carried out in enzymes, proteins, cellular components and isolated cells, microorganisms, tissue culture, isolated physiological systems individual organs, etc. Using a ruby laser coupled with a microscope, single cells have been irradiated with laser beams focused on to a spot of the order of one micron to destroy individual chromosomes, thus making available a highly delicate instrument for genetic studies. It is also possible to produce laser beams as narrow as the diameter of a protein molecule and use it to alter genetic properties of living organisms.

2.2 **Milk:**

Milk is an emulsion of butterfat globules within a water-based fluid that contains dissolved carbohydrates and protein aggregates with minerals, Because it is produced as a food source for the young, all of its contents provide benefits for growth. The principal requirements are energy (lipids, lactose, and protein), biosynthesis of non-essential amino acids supplied by proteins (essential amino acids and amino groups), essential fatty acids, vitamins and inorganic elements, and water.

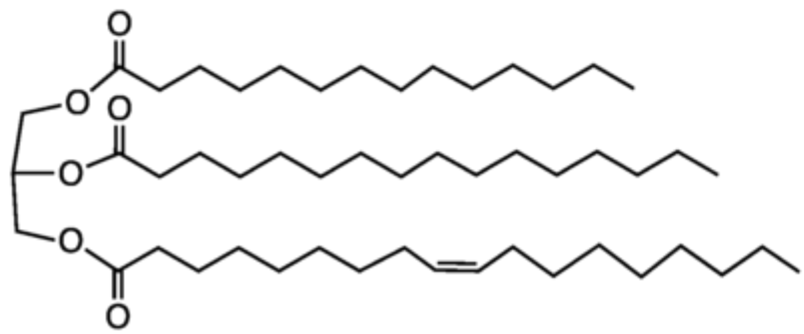


Figure (2.4) chemical bond of milk

Milk is a nutrient-dense food. This means that it provides a high level of essential nutrients compared to its calories. In fact, each serving of milk provides 10% or more of the recommended daily intake for calcium, vitamin D (if fortified), protein, potassium, vitamin A, vitamin B, riboflavin and phosphorus.

Milk is an excellent source of calcium. Regardless of its fat content, milk provides about 300 milligrams (mg) of calcium per serving (8 fluid oz). The chart below provides information on the calcium content of fluid milk products per serving. An adequate intake of calcium helps to reduce the risk of osteoporosis, high blood pressure and colon cancer. It is difficult to obtain enough calcium without consuming milk (or other dairy foods). To help meet calcium needs, the following number of servings of milk (or its equivalent) is recommended each day.

2.2.1**Physical and chemical properties of milk:**

Milk is an emulsion or colloid of butterfat globules within a water-based fluid that contains dissolved carbohydrates and protein aggregates with minerals. Because it is produced as a food source for the young, all of its contents provide benefits for growth. The principal requirements are energy (lipids, lactose, and protein), biosynthesis of non-essential amino acids supplied by proteins (essential amino acids and amino groups), essential fatty acids, vitamins and inorganic elements, and water.

We will cover the following physical properties.

- Density
- Viscosity
- Freezing Point

Density:

The density of milk and milk products is used for the following;

- to convert volume into mass and vice versa
- to estimate the solids content
- to calculate other physical properties (e.g. kinematic viscosity)

Density, the mass of a certain quantity of material divided by its volume, is dependent on the following:

- temperature at the time of measurement
- temperature history of the material
- composition of the material (especially the fat content)
- inclusion of air (a complication with more viscous products)

With all of this in mind, the density of milk varies within the range of 1027 to 1033 kg /m3 at 20° C.The following table gives the density of various fluid dairy products as a function of fat and solids-not-fat (SNF) composition:

Viscosity:

Viscosity of milk and milk products is important in determining the following:

- the rate of creaming
- rates of mass and heat transfer
- the flow conditions in dairy processes

Milk has long been a popular be verage, not only for its flavor, but because of its unique nutritional package. Milk is one of the best sources of calcium in the American diet. It also provides high-quality protein, vitamins and other minerals. Milk and skim milk, excepting cooled raw milk, exhibit Newtonian behavior, in which the viscosity is independent of the rate of shear. The viscosity of these products depends on the following:

- Temperature:
- cooler temperatures increase viscosity due to the increased voluminosity of casein micelles
- temperatures above 65° C increase viscosity due to the denaturation of whey proteins
- pH: an increase or decrease in pH of milk also causes an increase in casein micelle voluminosity.

2.2.2The acidity of the milk:

When milking Lecco n milk completely free of lactic acid, but when the pH estimate Khaamad lactic acidity of the milk to be between (0.14 - 0.16%) and the acidity is due to the existence of an impact in acidic compounds such as milk

1. Dissolved carbon dioxide
2. Salts jackets
3. Phosphate salts
4. casein

This so - called natural heart burn of milk which is about the presence of an acidic effect of the components of which are as previously except lactic acid. But when you leave the milk period of the microbes found naturally in milk breaks down lactose and the formation of lactic acid , and these are called heartburn or acidity generated of emerging or evolving him.

And acids generated pere are calibrated for total acidity of the milk which is the sum of natural acidity + advanced acidity.

2.3 Light interaction with matter:

When optical radiation interacts with matter, it may be reflected, absorbed, or transmitted.

2.3.1Absorption:

If a light wave of a given frequency strikes a material with electrons having the same vibration frequencies, then those electrons will absorb the energy of the light wave and transform it into vibration motion. During its vibration, the electrons interact with neighboring atoms in such a manner as to convert its vibration energy into thermal energy. Subsequently, the light wave with that given frequency is absorbed by the object .It is the transformation of radiant power to another type of energy, usually heat, by interaction with matter. In physics, absorption of electromagnetic radiation is the way in which the energy of a photon is taken up by matter, typically the electrons of an atom. Thus, the electromagnetic energy is transformed into internal energy of the absorber, for example thermal energy. The reduction in intensity of a light wave propagating through a medium by absorption of a part of its photons is often called attenuation. Usually, the absorption of waves does not depend on their intensity (linear absorption), although in certain conditions

(usually, in optics), the medium changes its transparency dependently on the intensity of waves going through, and satiable absorption (or nonlinear absorption)occurs.

The absorbance of an object quantifies how much of the incident light is absorbed by it. This may be related to other properties of the object through the Beer–Lambert law.The absorption coefficient determines how far into a material light of a particular wavelength can penetrate before it is absorbed. In a material with a low absorption coefficient, light is only poorly absorbed, and if the material is thin enough, it will appear transparent to that wavelength. The absorption coefficient depends on the

material and also on the wavelength of light which is being absorbed. Semiconductor materials have a sharp edge in their absorption coefficient, since light which has energy below the band gap does not have sufficient energy to excite an electron into the conduction band from the valence band.

2.3.2Reflection:

Reflection is the process by which electromagnetic radiation is returned either at the boundary between two media (surface reflection) or at the interior of a medium(volume reflection) .It is the change in direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated. Common examples include the reflection of light, sound and water waves. The law of reflection says that for secular reflection the angle at which the wave is incident on the surface equals the angle at which it is reflected. Mirrors exhibit seculars reflection. Reflection of light is either seculars (mirror-like) or diffuse depending on the nature of the interface. In specula reflection the phase of the reflected waves depends on the choice of the origin of coordinates.

Diffuse reflection happen when light strikes the surface of a (non-metallic) material it bounces off in all directions due to multiple reflections by the microscopic irregularities inside the material and by its surface, if it is rough. Thus, an 'image' is not formed. This is called diffuse reflection. The exact form of the reflection depends on the structure of the material. Reflection and transmission of light waves occur because the frequencies of the light waves do not match the natural frequencies of vibration of the objects.

2.3.3Transmission:

It is the passage of electromagnetic radiation through a medium .The transmittance of a material is the proportion of the incident (approaching) light that moves all the way through to the other side. For example, let's say you're shining a flashlight on a semi-transparent glass block.

You start off with 100% of your incident light. The first thing that happens is that30% of that light is reflected off the outer surface of the glass. That leaves you with70% to continue through the glass block. Another 50% of the light is absorbed by the molecules inside the glass block itself. That leaves you with 20% that immerges from the opposite side. So you could say that the glass block has a transmittance of 20%.

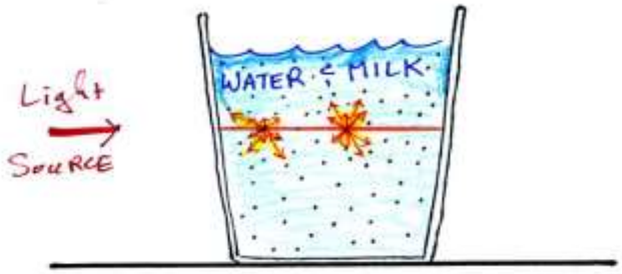
The transmittance of a material depends on its thickness, but it also depends on the type of 'light' (or electromagnetic waves) you are using. A material might have a different transmittance for visible light than it does for infrared, or x-rays. This is why hospital x-rays go through your skin until they reach the bones, even though visible light does not.

2.3.4Lightscattering:

Light scattering can be thought of as the deflection of a ray from a straight path ,for example by irregularities in the propagation medium, particles, or in the interface between two media. Deviations from the law of reflection due to irregularities on a surface are also usually considered to be a form of scattering. Most objects that one sees are visible due to light scattering from their surfaces (Kerker,M.1969)(Mandelstam ,L.I.1928). Indeed, scattering of light depends on the wavelength or frequency of the light being scattered. Since visible light has wavelength on the order of a nanometer, objects much smaller than this cannot be seen, even with the aid of a microscope. (VandeHulst .H.C 1981) (Bohren, C.F and Huffman, D.R 1983).

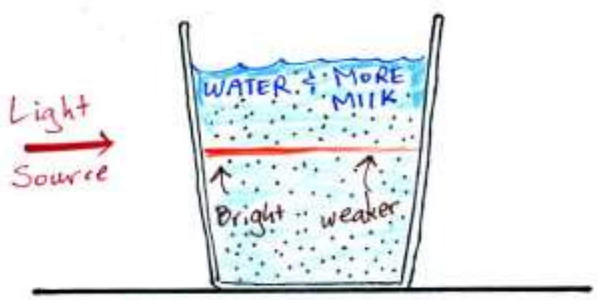
2.3.5Scattering of Light in milk:

Now what we will do to add a few drops of milk to the water in the glass. A just enough to just begin to cloud the water. The beam should now be clearly visible as it passes through the water/milk mixture (but still not visible in the air alongside the glass). A portion of the light in the original beam is intercepted by small particles of milk fat and the light is redirected in all directions (up, down, to the right and left as shown in the picture below but also toward and away from the observer). This is scattering of light. A more descriptive term might be splattering of light. One of those scattered rays of light is directed straight at you, and that is why you are able to see the beam of light passing through the water.



- Scattering is only shown at two points in the figure above, but actually it is occuring along the entire length of the beam. The scattered light is much weaker than the light in the original beam. It is safe to look at scattered light.

  Next we will add more milk to the water in the glass. At some point you should begin to see the intensity of the beam decrease as it moves from left to right. As light is scattered it is removed from the original beam. The unscattered beam of light weakens as it moves through the water.



Sunlight reaching the ground when the sun is high in the sky is usually much more intense than sunlight arriving at the ground when the sun is near the horizon. Sunlight must follow a much longer path through the atmosphere when it is low in the sky. Scattering occurs all along this long path with the result that the sunlight reaching the ground has been attenuated significantly. Of course you shouldn't look directly at the sun even when it is on or near the horizon. Even though the sunlight is much weaker than when the sun is high in the sky, it is still intense enough to damage your eyes.

Once you have added more milk to the water in the glass you may notice scattered light coming from outside the beam. At Point A in the figure below light is being scattered by milk particles in the beam. This is single scattering and is what we have been observing up to this point. Some of the light scattered by particles in the beam may be intercepted and scattered by another milk particle that is outside the beam. This situation is shown at Point B. This is called multiple scattering.

2.4 Spectroscopy:

Spectroscopy means study of the interaction between matter and radiated energy and it used to refer to the measurement of radiation intensity as a function of wavelength. Spectroscopy is basically an experimental subject and is concerned with the absorption, emission or scattering of electromagnetic radiation by atoms or molecules.

Electromagnetic radiation covers a wide wavelength range, from radio waves to grays, and the atoms or molecules may be in the gas, liquid or solid phase or, of great importance in surface chemistry, adsorbed on a solid surface. Ultraviolet (UV) and visible radiation comprise only a small part of the electromagnetic spectrum, which includes such other forms of radiation as radio,infrared (IR), cosmic, and X rays.

The energy associated with electromagnetic radiation is defined by the following equation:

$$E=hv$$

Where E is energy (in joules), h is Planck's constant ($6.62 \times 10\text{-}^{34}$Js), and is frequency (in seconds).

Electromagnetic radiation can be considered a combination of alternating electric and magnetic fields that travel through space with a wave motion. Because radiation acts as a wave, it can be classified in terms of either wavelength or frequency, which are related by the following equation:

$$v=c/\lambda$$

Where ν is frequency (in seconds), c is the speed of light (3×10^8 ms^{-1}), and λ is wavelength (in meters).

In UV-visible spectroscopy, wavelength usually is expressed in nanometers (1 nm $=10^{-9}$ m). It follows from the above equations that radiation with shorter wavelength has higher energy. In UV-visible spectroscopy, the low-wavelength UV light has the highest energy. In some cases, this energy is sufficient to cause unwanted photochemical reactions when measuring sample spectra (remember, it is the UV component of light that causes sunburn).

When radiation interacts with matter, a number of processes can occur, including reflection, scattering, absorbance, fluorescence/phosphorescence (absorption and reemission), and photochemical reaction (absorbance and bond breaking). In general, when measuring UV-visible spectra, we want only absorbance to occur. Because light is a form of energy, absorption of light by matter causes the energy content of the molecules (or atoms) to increase. The total potential energy of a molecule generally is represented as the sum of its electronic, vibration, and rotational energies:

$$Total=Eelectronic + Evibrational + Erotational.$$

The amount of energy a molecule possesses in each form is not a continuum but a series of discrete levels or states. The differences in energy among the different states are in the order:

Eelectronic>Evibrational>Erotational.

In some molecules and atoms, photons of UV and visible light have enough energy to cause transitions between the different electronic energy levels. The wavelength of light absorbed is that having the energy required to move an electron from a lower energy level to a higher energy level.

2.4.1 UV-Visible spectrometer:

refers to absorption spectroscopy or reflectance spectroscopy in the ultraviolet-visible spectral region. This means it uses light in the visible and adjacent (near-UV and near-infrared [NIR]) ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. In this region of the electromagnetic spectrum, molecules undergo electronic transitions. This technique is complementary to fluorescence spectroscopy, in that fluorescence deals with transitions from the excited state to the ground state, while absorption measures transitions from the ground state to the excited state.

A hydrogen, deuterium or discharge lamp covers the ultraviolet range, and a tungsten filament (usually tungsten \halogen lamp) covers the visible range. The radiation is separated according to it‘s frequency\wavelength by a diffraction grating followed by a narrow slit. The slit ensures that the radiation is of a very narrow waveband it is monochromatic. The cells in the spectrometer must be made of pure silica. Detection of the radiation passing through the sample or reference cell can be achieved by either photomultiplier or photo diode, that converts photons of radiation into tiny electrical currents; or semiconducting cell (that emits electrons when radiation is incident on it) followed by an electron multiplier similar to those used in mass spectrometers. The spectrum is produced by comparing the currents generated by the sample and the reference beams.

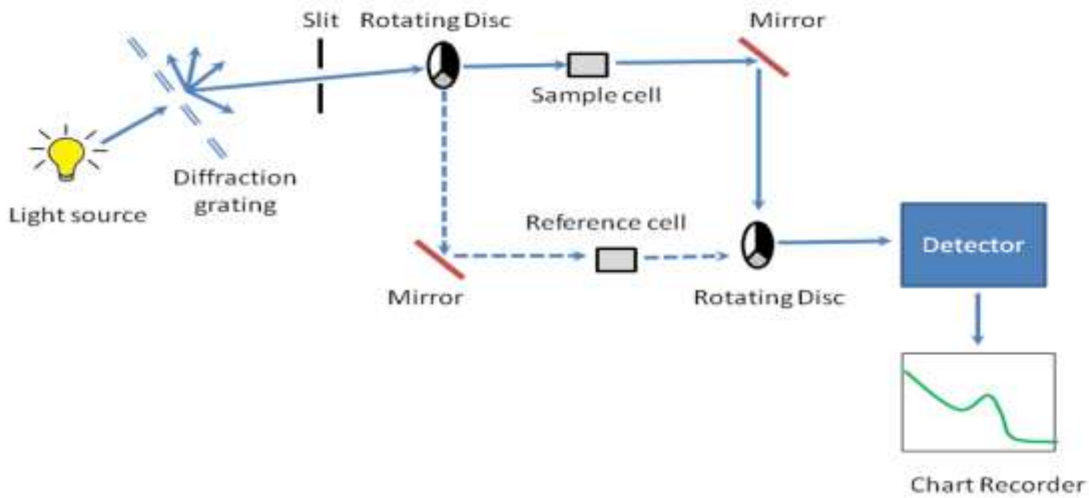


Figure (2.5) block diagram of visible spectrometer

Chapter Three

Experimental Part

3.1 Introduction:

This chapter includes the materials used in this work and the following methods (sample preparation and setup) and the procedure.

3.2 Materials:

3.2.1 Milk

Milk has long been a popular beverage, not only for its flavor, but because of its unique nutritional package. It also provides high-quality protein, vitamins and other minerals, we brought the milk fresh from SOBA FARM directly from udder cow non extras event for milk .

3.3 Devices:

3.3.1 Nd:YAG laser:

Nd:YAG lasers are optically pumped using a flash tube or laser diodes. These are one of the most common types of laser, and are used for many different applications.

Nd:YAG laser typically emit light with a wavelength of 1064 nm, and maximum output power 100 Watt, adjusted 1 Watt in step ,the Nd:YAG laser model DORNIER med Tech Medilas 5100 fibertom GlassI.

Figure (3.1) photo of theNd:YAG laser

3.3.2 UV-VIS 1240 Spectrophotometer:

The UV-VIS device was used to measure the absorption of the solution before and after irradiation by laser light . it is covering a wavelength from 190-1100 nm with auto lamp switch from visible to ultraviolet . the UV Spectrophotometer used here was supplied from SHIMADZU contains a quartz cell of thickness 1 cm as a sample holder.

Figure (3.2) photo of theThe UV-VIS 1240 Spectrophotometer

3.3.3magnetic stirrer:

The magnetic stirrer device is used to make homogenous solution by mixing the milk compound with Nd:Yag laser radiation .A rotation field of magnetic force is employed to induce variable speed a stirring action within either closed or opened vessels .The stirring is accomplished with the aid of small permanent magnets sealed in Pyrex glass. This device was manufactured by Scott science and healthcare limited it speed 60 to 1500 pm.The magnetic stirrer is hot plate stirrer :Model L M S -1003 scott science U k.

Figure (3.3) photo of theThemagnetic stirrer

3.3.4 PH Meter:

pH Meter is a scientific instrument that measures the hydrogen-ion concentration (or pH) in a solution, indicating its acidity or alkalinity. The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode. It usually has a glass electrode plus a calomel reference, or a combination electrodel in addition to measuring the pH of liquids, a special probe is sometimes used to measure the pH of semi-solid substances , model JENWAY.UK 3505 .

Figure (3.4) photo of the pH meter

3.4Method:

We division six samples and stride sample from SOBA FARM prepared on suitable container to complete this samples by milk cow five samples were irradiated by laser using the magnetic stirrer then the laser irradiation on the laser and using the magnetic stirrer so irradiation at the same time be a pain thus rotating beam passes all the milk ,and pass different power of laser by Nd:YAG laser1064 nm (10,20,30.40.50 mW) for two mints for each sample.

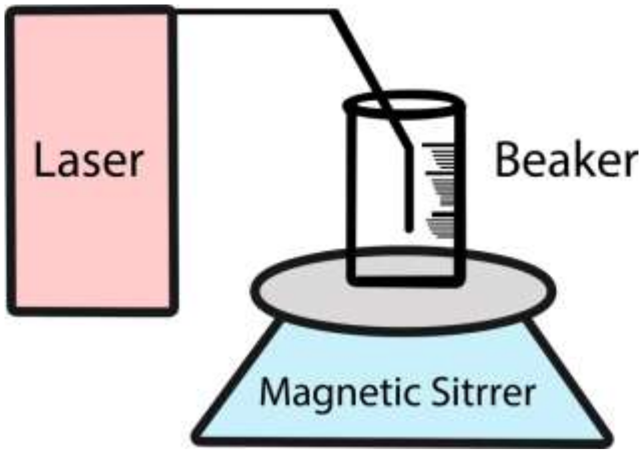


Figure (3.5) photo of theirradiation setup

Treatment	Power/mW	Time/mint
Sample(control)	_	_
Sample 1	10	2
Sample 2	20	2
Sample 3	30	2
Sample 4	40	2
Sample 5	50	2

Table (3.1) milk samples and its doses.

The hydrogen_ion consecration was measured for the milk in a fixed temperature and inter the refrigerator every day for 5 days and read pH number every day.

Using the absorption UV –visible spectrometer spectra of the samples was carried out after inoculation of six samples of milk in bacteria .

First step: Dilution:

10 fold serial dilution was made to the six milk samples by using peptone water medium.

This dilution $10^5$was best dilution that used to sample analysis.

Figure (3.6) photo of the Dilution of milk

Figure (3.7) photo of the Dilution of milk

Second step: microbial count:

For counting all samples were inoculated on to try tone soya agar plates (for bacteria) and sabourand dextrose Agar plates (for fungi).Bacteria incubated in 35-37c for 2days and fungi combated in 25-27c for 5days.

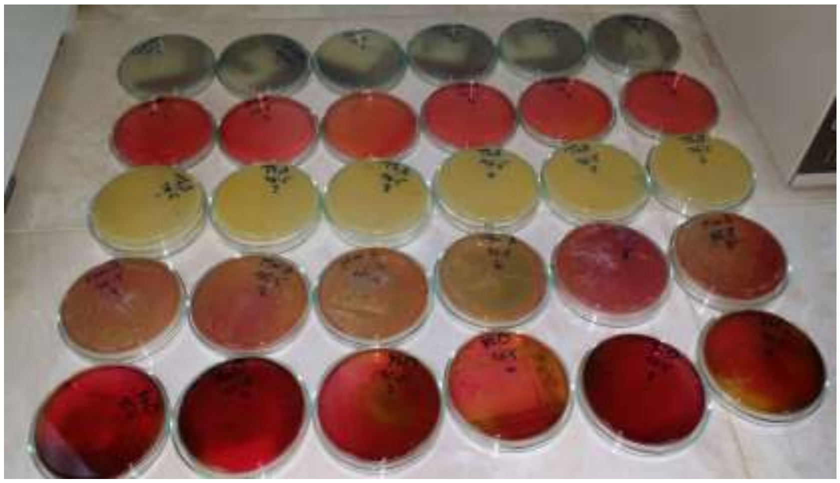


Figure (3.8) photo of the bacteria

Third step: Detection of microorganisms:

three types of Bacteria Targeted following the Analysis:

1-Salmonellaspp

2-Escheridria coli

3-P.seudomonas aeruginosa

For Salmonella sppxylose_lysineDeoxycholate Agar medium was used and Macconlaey Agar medium for E.coli and Cetrimide Agar medium for D.aeruginosa, which those media work as selective differential media. Six samples were cultured into those media and incubated in 35.37c for 3days , and for E.coli detection the sample were inoculated into tubes of macconleey broth medium and incubated in 43c for 24 hours and after that cultured on to plates of maccnleey Agar medium.

Before and after exposed the sample to different power of radiation we saw when the power is high the growth of organism is low, and when the power is low the growth of organism is high.

Chapter Four

Results and Discussion

4.1 Introduction:

This chapter summarize results obtained during the work. Results include photographs, figures and tables as shown below. Data fitting of experimental results was also shown, discussion and conclusion.

4.2 Results:

4.2.1 The pH of the milk samples:

The results in table (4.1) indicated that the pH of the milk samples dropped from 6.55 for the control samples up to 6.18 for the milk samples treated with 50 mW beams. The results revealed the power of the light beams increased, the pH of the milk samples decrease ,this probably due to the effect of the light beams on the buffering capacity and the milk components not on the acidity.

Table (4.1) pH of milk at the first day.

Treatment	PH meter	Temperature
Raw milk	6.55	23
Sample 1	6.45	23
Sample 2	6.31	23
Sample 3	6.29	23
Sample 4	6.24	23
Sample 5	6.18	23

Table (4.2) shows pH of the milk at the second day. The results at day two showed that the pH of the milk samples almost decreased slightly for all the milk samples still the higher pH was for the milk samples without treatment (6.18) while the lowest one was for the milk samples treated with 40 and 50 mW beams(5.86 – 5.81) respectively. The slight variations in the pH of the milk samples might be due to the high intensity of the beam light on the milk components at second day.

Table (4.2) pH of milk at the second day.

Treatment	pH meter	Temperature
Raw milk	6.15	22.3
Sample 1	6.02	22.2
Sample 2	5.98	21.0
Sample 3	5.91	19.7
Sample 4	5.86	21.3
Sample 5	5.81	21.3

Table (4.3) shows pH of the milk at day three .The results (table 4-3) demonstrated that the pH of the milk samples in all treatments decreased at the third day. Small differences were observed in the pH values of the milk samples between the control and those treated with 10, 20, and 30 mW light beams which indicate that the effect of concentrations of the light beam is of no significance among this day. However, the pH of the milk samples treated with 40 and 50 mW beams had lower pH values compared to the others. The Low pH of the milk samples could be due to the effect of microbial load on the carbohydrate of the milk which leads to decrease the pH and increased the acidity of the milk.

Table (4.3) pH of milk at the third day

Treatment	PH meter	Temperature
Raw milk	5.80	23.1
Sample 1	5.76	22.2
Sample 2	5.72	21.9
Sample 3	5.72	19.7
Sample 4	5.66	22.1
Sample 5	5.60	21.3

Table (4.4) shows pH of the milk at day four. the results pH of the milk samples decrease further still the untreated milk sample showed the highest pH(5.60) value while the lowest pH was for the milk sample treated with 50 mW beams. The drop in the pH could be due to extended storage of the milk samples that may lead to increase the acidity of the milk samples.

Table (4.4) pH of milk at the fourth day

Treatment	PH meter	Temperature
Raw milk	5.60	23.1
Sample 1	5.49	22.1
Sample 2	5.40	21.9
Sample 3	5.35	22.7
Sample 4	5.18	22.1
Sample 5	5.14	21.5

Table (4.5) shows pH of the milk at the fifth day .the results Table (4.5) showed that the pH of the milk samples break and mess of all the milk samples.

Table (4.5) pH of the milk at day five

Treatment	PH meter	Temperature
Raw milk	4.86	23.1
Sample 1	4.72	22.0
Sample 2	4.66	21.9
Sample 3	4.64	22.4
Sample 4	4.58	22.1
Sample 5	4.50	22.5

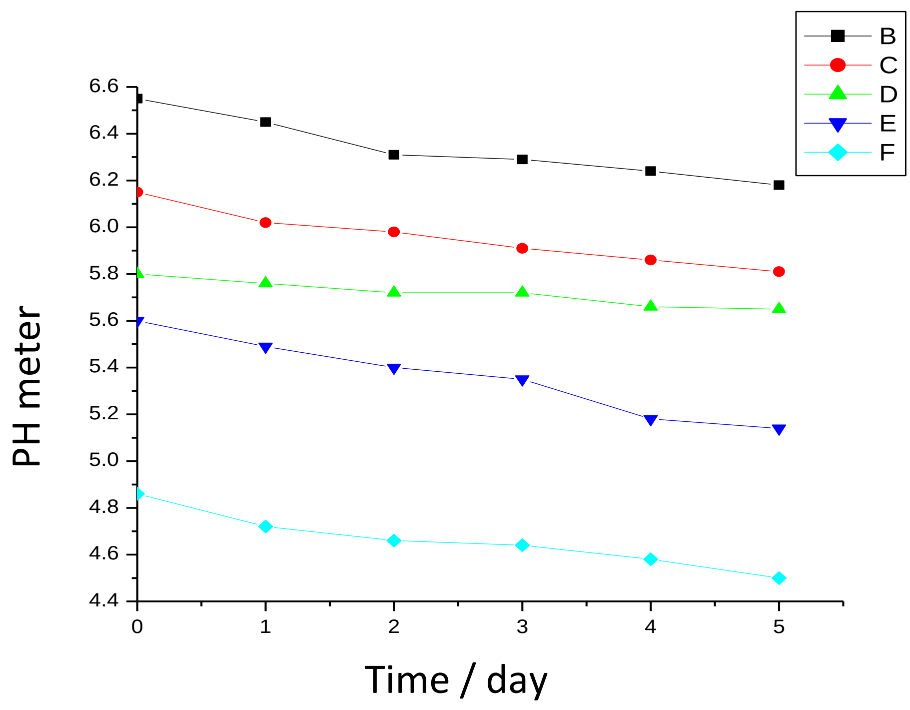


Figure (4.1) The relation of pH and time/days

Figure shows increase of acidity by increasing laser dose, also the acidity increase propotion to the time .

4.2.2The UV-visible spectra of the milk samples:

Figures (4.2) ~ (4.7) show the spectra of UV-visible spectrometer for milk samples for the five days.

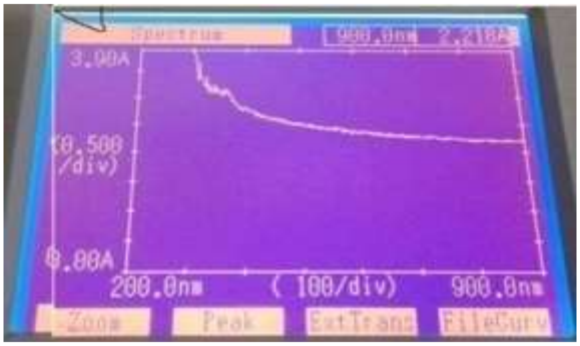


Figure (4.2) shows the spectrum of Raw milk.

This spectrum referred to Raw milk sample which specification by wavelength range(200-900)nm, it shows that the absorbance is very high at the range (200-300)nm and greater than 300 nm the absorbance is above (0.500)/au.

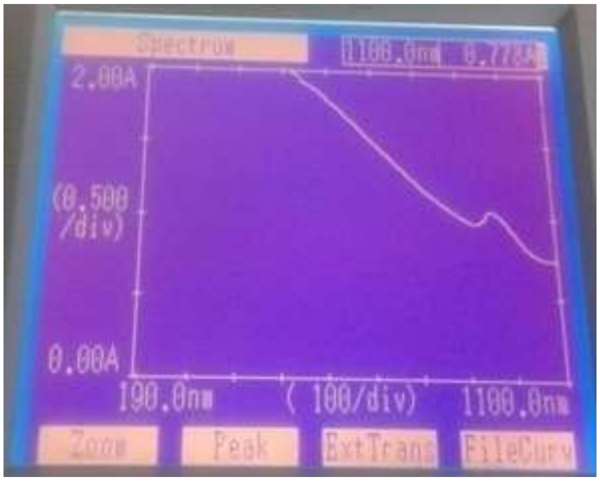


Figure (4.3) shows the spectrum of sample(1).

This spectrum referre to sample(1) which specification by wavelength rang (190--1100) nm ,it shows that the high absorbance range shifted to the direction of the visible range(200-500)nm instead of (200-300)nm and there is a gradually change from (500-900)nm from (2-0.5)nm.

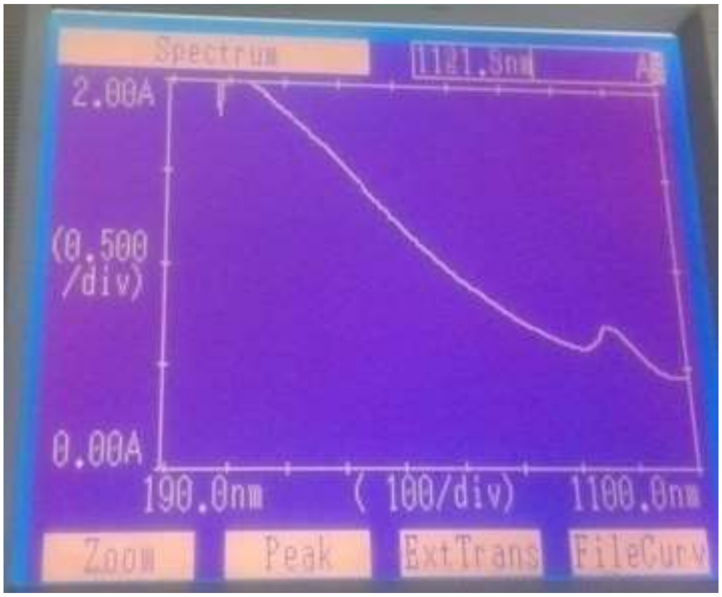


Figure (4.4) shows the spectrum of sample(2).

This spectrum referred to sample(2) it shows that the high absorbance range (190-200)nm it is the same of the control sample, and there is a gradually change from (300-700)nm in the absorbance from (2-0.5)/au, and from (700-1100)nm the absorbance less the (0.5)au that appear in the control samples.

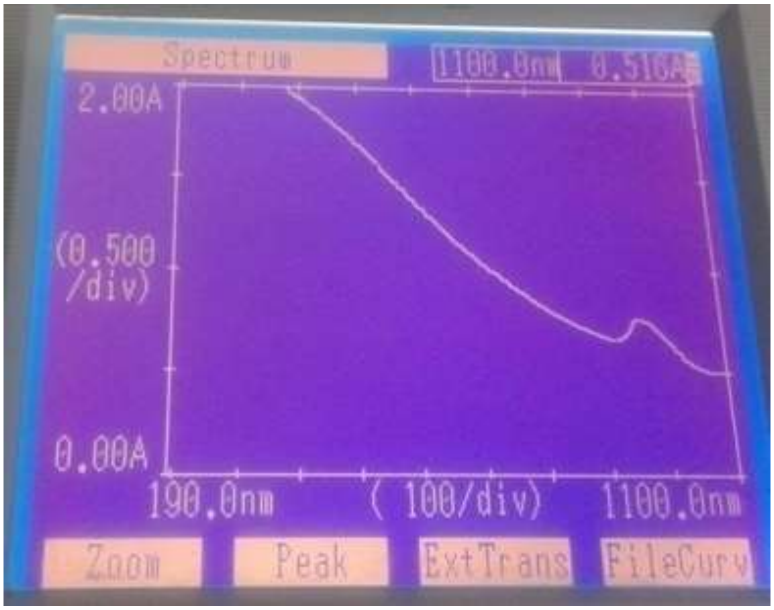


Figure (4.5) shows the spectrum of sample(3).

This spectrum referred to sample(3) ,It shows that the high absorbance from (190-400)nm, and the absorbance from (400-800)nm there is a gradually (2.0-0.5)au , but the absorbance from (800-1100)nm less than (0.5)/au.

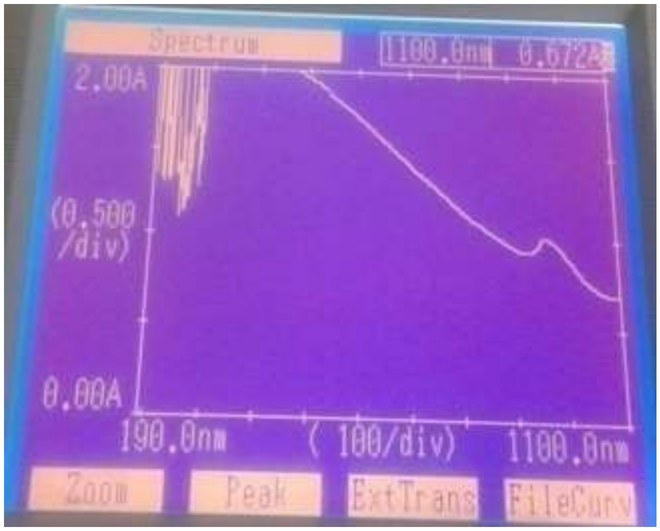


Figure (4.6) shows the spectrum of sample (4).

This spectrum referred to sample(4) It shows that the absorbance from (900-100)nm <(0.5)/au , (500-900)nm>(0.5)/au , but the absorbance from (190-300)nm decreased to (0.5)/au.

Figure (4.7) shows the spectrum of sample (5).

This spectrum referred to sample(5) It shows that the high absorbance from (200-600)nm, and the absorbance from (600-100)nm there is a gradually from (2.0-0.5)au .

4.2.3 The microbial load of the milk samples

Results appear as follow for bacteria:

Table (4.6) shows Microbial count (CFU/ml)

sample	Raw Milk	Sample A	Sample B	Sample C	Sample D	Sample E
Count of Bacteria	10×10^5	8×10^5	6×10^5	4×10^5	2×10^5	0×10^5
Count of Fungi	9×10^5	7×10^5	7×10^5	4×10^5	2×10^5	0×10^5

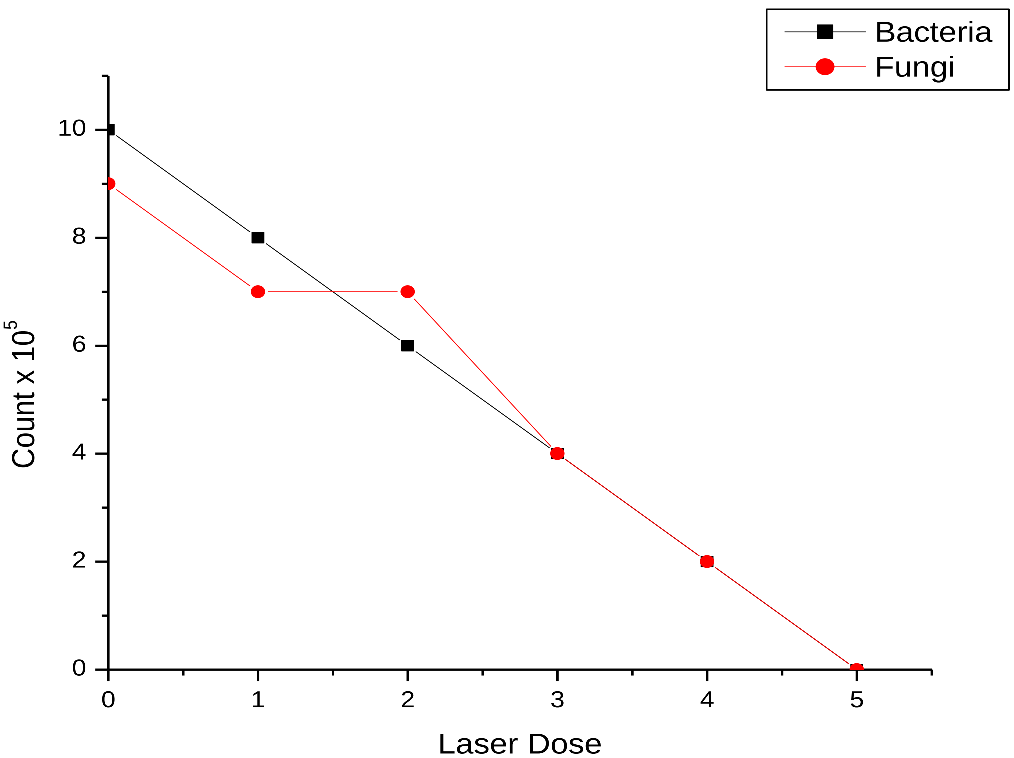


Figure (4.8) The relation between count$\times10^5$ and laser dose

The result (Table 4.6) showed that the increase power of the laser beams had clear effect on the population of total bacterial load in the milk the higher bacterial load was in the milk samples without treatment (10×10^5 CFU/ml) However the lowest CFU/ml was for the milk samples treated with 50 mW beams .There duction of colony forming unit in the microbial load as the dose of Nd:YAG laser increase. The low bacterial load in the milk samples with 50 mW beams possibly due to the clear effect of the laser on the bacterial cells which might be killed or lyses by the high power of the laser beams, from the low dose (10-20)mW it difference account of bacteria but have a same in fungi and from the high dose (30-40-50)mW it is a same account of bacteria and fungi. Also the results indicated strong effect of increasing the power of the Nd:YAG laser on the fungal load of the milk samples the higher the power the lower the fungal loads.

4.4 Conclusion:

As a conclusion the acidy of milk pH is increase by increasing dose of irradiation, with each passing day increases the acidity so sour milk, for the absorbability with increasing the dose of radiation shifted absorbability from UV to visible, the increase of acidy may be due to shifting of absorbance towards visible range. For sterilization the bacteria is decrease with increase the dose of irradiation and you kill in high irradiation.

4.5 Recommendations:

Further studies could be acure by using the effected another laser with different wavelength , also studing the effect of laser in another feature of the milk like shelf time fat , protein .

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