Soild- Liquid Extraction and Control of Fixed Oil from English Cherry (Mahleb) Purnus Mahaleb

By

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B.Sc (Hons.) in Chemical Engineering Technology, University of Gezira (2003)

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Department of Applied Chemistry and Chemical Technology

Faculty of Engineering and Technology

May - 2014
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الإيّة

بسم الله الرحمن الرحيم

قال تعالى:

(1) أقرأ بصدد ربيّ الفَّلْدِ خلَقَ ٨ خلق الإنسان من علَيّ (4) أقرأ علَمَ ﷺ

الذي علم بالقُلْبِ (5) علم الإنسان ما لم يعلم (5)

العلق: ١ - ٥

صدق الله العظيم

العلق: ١ - ٥
Dedication

Special dedication to my beloved father and mother, husband.

Also for all my family members that always inspire, love and

Stand beside me, my supervisors, and all faculty members.

For all your love, care, support, and believe in me.

Thank you so much.
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Praise be to God for his help and guidance that finally I am able to end this final year project as one of my study requirement.

First of all, a special thank to my supervisor for his willingness in over seeing the progress of my research work from its initial phases till the end.

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Soild- Liquid Extraction and Control of Fixed Oil from English Cherry (Mahleb) Purnus Mahaleb
Ayat Hmed Ahmed Mohammed
Master of Science in Chemical Engineering 2014
Department of Applied Chemistry and Chemical Technology
Faculty of Engineering and Technology
University of Gezira

ABSTRACT

Puruns mahleb seeds commonly known in Sudan, the best kind of these seeds are the clear white kind which is used in traditionally perfumery industry, and in folk medicine. The objectives of this research is to extract the fixed oil from these seeds, investigation of the leaching process of mahleb seeds oil, investigation of the chemical compounds in the oil, investigation of the antioxidant, anti microbiological activities and controllability, stability, tuning and simulation response analysis of the process.100g of the crushed seed was leached by petroleum ether solvent (40-60°C).GCMS apparatus was used to investigate the fatty acids in this oil, then many tests of anti bacteria and anti fungal ,anti oxidant activity were carried out. Furthermore a control strategy was developed for leaching process. The results have shown that the mahleb seeds contain 33.139g of fixed oil, the efficiency of the process was 95%.Also the oil contains high activity against pseudomonas aeruginosa which causes skin disease, pneumonia, and the oil has med activity against bacillussubtilis, Ecoli which causes diarrhea and abdominal pain, and Staphylococcus bacteria that causes skin infection, bronchitis and endocareritis, also for Aspergillus niger which causes Asthma, and no activity for Candida Ibicans. In addition to that the anti oxidant test has shown that the mahleb fixed oil contains54% of anti oxidant activity. In addition to that there are three major fatty acids in the fixed oil which are oleic,α-linolenic and Linoleic acid. Moreover a control strategy of the leaching process has shown stability after the overall transfer functions were determined, the response diagrammed has plotted. From all these results puruns mahleb fixed oil was recommended to be used in cosmetic industries, and may be added in industrial food products due to its antioxidan activity that protect from cancers.Finllay the mahleb fixed oil may enter pharmaceutical industries after carrying out investigations in to pharmacological properties.
عملية استخلاص سائل - صلب وضبط عملية استخلاص الزيت الثابت من نبات الكرز الإنجليزي (المحلب)

عوانيت اختصال سالت – صلب وضبط عملية استخلاص الزيت الثابت من نبات الكرز الإنجليزي (المحلب)

ماجستير العلوم في الهندسة الكيميائية 2014
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جامعة الجزيرة

ملخص الدراسة

تعتبر حبوب نبات المحلب البري أو الأبيض من الحبوب المعروفة في السودان وهي شائعة الاستخدام في مجال العطور البلدية والطب الشعبي. يهدف البحث لاستخراج الزيت الثابت من هذه الحبوب ومعرفة المركبات الكيميائية التي تحتوي عليها والفعالية ضد الميكروبات البكتيرية والفيروسية، كذلك الشفافية من احتوائه على مضادات الأكسدة ومن ثم وضع استراتيجية تحكم لضبط عملية الاستخلاص. استخدم الأطر البترولية كعيوب لاستخراج الزيت واستخدمت كذلك تقنية جهاز الكرومتوغرافيا معرفة ما تحتويه الزيت من المركبات الكيميائية ومن ثم دراسة استراتيجية التحكم لعملية الاستخلاص والضبط وفق طريقة روث والتعويض المباشر واستخدام المؤشرات المتصول عليها في رسم مخطط الاستجابة. تم التوصل لنتائج متعددة من خلال هذه الاختبارات وقد وجد أن محلب يحتوي على 33.139 جم من الزيت الثابت وكانت كفاءة العملية 95%. أظهرت نتائج الاختبارات الاختبارات العملية فعالية الزيت ضد بكتيريا السيدوموناس المسببة للالتهابات التهابية والالتهابات الجلدية كما له فعالية متوسطة ضد بكتيريا الأيكولاي التي تسبب الالتهابات والالتهابات المعالجة، كما له فعالية ضد فطر الاسبروسيا الذي يسبب الالتهاب الرئوي والاكلوزا. كما وجد أن الزيت يحتوي على فعالية 54% من مضادات الأكسدة ومن ثم وجد أيضا أن الزيت يحتوي على أعلى نسبة من ام ثلاثية احماض دهنية يحتاجها جسم الإنسان وهي أوليك واللاوكليك والفاليوراوليك. كما كانت استراتيجية التحكم لعملية الاستخلاص ذات نتائج جيدة فقد تم الحصول على المعادلات المميزة والتوابع الناقلة الكلية وتم فحص اختبار الاستمرارية ورسم مخطط الاستجابة والتي كانت مستقرة وبانحراف قليل جدا، وذكرنا من كل هذه النتائج. وفق تجميعها وتحليلها، إن البحث بامكانية استخدام زيت المحلب الثابت في مجال الصناعات التجارية وامكانية استخدامه كمادة مضافة في الصناعات الغذائية. كما وصم البحث بأجزاء المذابة من الاختبارات الطبية لتحديد الجرعة التي تسمح باستخدامها بحرية في مجال الصناعات الغذائية. كما يمكن تطبيق نفس استراتيجية التحكم بصورة رقمية للحصول على نتائج أفضل لعملية الاستخلاص.
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**Nomenclature**

E.s          Escherichia coli  
P.s          Pseudomonas aeruginosa  
B.s          Bacillus subtilis  
S.a          Staphylococcus aureus  
A.u.         Aspergillus Niger  
C.a          Candida Ibicans  
Z.N          Ziegler – Nichols.  
GP           process transfer functions  
Gm           Sensor transfer functions  
Gc           Controllers transfer function  
Gv           Valve transfer function  
Kc           proportional gains  
Ku           Ultimate gain  
Pu           Ultimate period  
D.S          Direct substitution  
P            proportional control  
PI           proportional Integral control  
PID          proportional Integral derivative control  
NUM          Numerator  
Den          Denominator
Greek Letters

$\pi f$  Multiplication of the forward transfer function

$\pi l$  Multiplication of the loop transfer function
Chapter one
Chapter one

Introduction

1.1 Introduction of medicinal plant

The medicinal plants consider as a rich resources of ingredients which can be used in drug development and synthesis. Besides that these plants play a critical role in the development of human cultures around the whole world.

Moreover, some plants consider as important source of nutrition and as a result of that these plants recommended for their therapeutic values.

These plants include ginger, green tea, puruns mahleb. Other plants their derivatives consider as important source for active ingredients, which are used in aspirin and tooth past and so on...

Plants are directly used as medicines by a majority of cultures around the world, for example Chinese medicine and Indian medicine.

Many food crops have medicinal effects, for example garlic, soya and mahleb.(1)

1.2 History of mahleb in human use

The Arabic mahleb meaning the mahleb cherry is in medieval Arabic writings by among others, like Al-Razi who died in 930, Ibn al-Baitar who died in1248 and Ibn al-Awwam. Ibn Al-Awwam in his book on agriculture dated late 12th century described how to cultivate the mahleb tree. He says the tree is a vigorous grower, easy to grow, but a thing to watch out for is that it is not resistant to prolonged drought. He also described how to prepare the mahleb seeds by boiling them in sugared water. The word, and probably the mahleb itself, does not appear in classical Latin, nor early or midmedieval Latin, and is rare in late medieval Latin. One early record in Latin is year 1317 in an encyclopedia by Matthaeus Silvaticus who wrote that the "mahleb" is the kernel seed of the fruit of both domesticated and wild cherry trees in Arabic countries(2).

Another early record in Latin is in a medical-botany book by Ioannis Mesuae in 1479 spelled almahaleb (where "al" is the Arabic definite article). In 1593 the Latin botanist Carolus Clusius spelled it Mahleb. Syria is the main exporting, and here in Sudan mahleb is imported from Syria. (3). The figure 1.1 below shows the mahleb seeds.
1.3 Puruns mahleb classification and uses

The genus Puruns belongs to the family Rosaceous and comprises more than 400 species including many desirable ornamentals as well as the stone fruit-plums, apricots, almonds, peaches, and cherry laurels. Puruns mahleb commonly known in Europe as Santa Lucia cherry and in the Arabia as mahleb, which is a species of cherry native to central and southern Europe, western and central Asia, and northwest Africa. The mahleb tree is well known in the Mediterranean and where it grows in cold regions and on mountain tops (4). The best kind of mahleb is the clear white kind, which is used for our oils. These oils are often used in folk medicine as a tonic for sensory organism and in the heart treatment also for asthma, and relief of pains arising from liver, kidney and gastro intestinal troubles.

Also here, in Sudan the seeds are imported from Syria and used as sedative and vasodilator as well as for scenting and preservation purposes. In Egypt, the plant is not cultivated, but the fruits are imported to be used in the baking and candy industries. The inner most kernels is ground and mixed with white flour as a flavoring material. Mahleb oil is extracted from white puruns mahleb seeds, which is the best kind of mahleb which is used in Sudan in cosmetic traditional uses. These oils are often used for their flavor and their therapeutic or odoriferous properties, in a wide selection of products such as foods, medicines, and cosmetic industries. (5)

1.4 Mahleb oil uses in the traditional medicine

The oil is used as cough analgesic, to relieve cough it has been taken a teaspoon every day, mix with honey, for one week. Also mahleb oil is tonic for senses, it prevents palpitations and
shortness of breath, addition to that it cleans stomach and intestines and is a carminative, it soothes liver, kidney and spleen pain, if it has been taken with honey and water, it is useful for colon, kidney stone and bladder, and to gain weight using mahleb oil with almonds and sugar.(5).

### 1.5 Pharmacological Properties of mahleb Oil

The previous research, done by Khalid A. Shams and Richard Photochemistry Dept., National Research Centre, Cairo, Egypt, School of Pharmacy, Cardiff, University of Wales, U.K in 2007, in mahleb oil show that oil fraction proved to be extremely safe and free from any acute lethal toxicity in intraperitoneal (imp.) and oral doses up to 1000 ml/kg. In vivo assessment of prophylactic efficacy was afforded by 7 days course of daily medication schedule of sensitized adult male guinea pigs against ovalbumin broncho spasm. The prophylactic anti-inflammatory activity of the total ethanolic extract was higher than that of the defatted ethanolic extract. In addition, the lipid fraction of Puruns mahleb seeds evoked complete anti-inflammatory efficacy among the survival animals receiving low and medium doses. Also the lipid fraction of Puruns mahleb seeds oil evoked complete anti-inflammatory efficacy among the survival animals receiving low and medium dose.

### 1.6 Statements of the research problem

Mahleb plant which is one of medicinal plants have a promising future because there are about half million plants around the world, and most of them their medical and uses activities have not been investigated yet, and their medical activities could be decisive in present or future studies. Also the control of leaching process is important and has to be investigated.

### 1.7 A scope of research work

This research is based on experimental studies of solvent extraction using petroleum ether. In order to achieve the objectives mentioned above, three scopes which has been identified:-

I. The scientific ways of controlling mahleb oil extraction and uses in traditional medicine with the standard procedure, and microbiological testes and the availability of antioxidant compounds that can be found from this research work.

II. To determine optimum feed ratio of mahleb oil seeds and ability of petroleum ether solvent producing highest quality and substantial yield of fixed oil.

III. To analyze the product major composition from the extraction process.
1.8 Objectives

1- Investigation of the leaching process of mahleb seeds oil.
2- Investigation of the chemical compounds in the oil.
3- Investigation of the antioxidant, anti microbiological properties.
4- Controllabiltiy, stability, tuning and simulation response analysis of the process.
Chapter two
Chapter two

Literature Review

2.1 Extraction of Liquid -Solid or (Leaching)

Leaching is a liquid-solid operation. The two phases are in intimate contact, which can diffuse from the solid to the liquid phase, which causes a separation of the components originally in the solid. A special leaching process, when an undesirable component is removed from a solid with water, is called washing.

Leaching is widely used in the biological and food processing industries, such as the separation of sugar from sugar beets with hot water, the extraction of oils from peanuts, soybeans, sunflower seeds, cotton seeds, and mahleb. In pharmaceutical industry, many products are obtained by leaching plant roots, leaves, as well as seeds.

In the metals processing industry, leaching is used to remove the metals from their ores, which contains many undesirable constituents, as solute salts. A good example is gold leaching.

2.2 Preparation of Solids for Leaching

This depends on the proportion of the soluble constituent present, its distribution throughout the original solid, the nature of the solid, and the original particle size.

If the soluble material is surrounded by a matrix of insoluble matter, the solvent must diffuse inside to contact and dissolve the soluble material and then diffuse out. This is common in leaching metal salts from mineral ores. In these cases crushing and grinding of the ores is used to increase the rate of leaching since the solution portions are made more accessible to the solvent.

Biological materials are cellular in structure and the soluble constituents are inside the cells. Because the cell walls provide another resistance to diffusion, the rate of leaching may be slow. In this case the biological materials are cut into thin wedge-shaped slices to reduce the diffusion distance of solvent.
2.3 Solvent selectivity

The solvent to be used is Petroleum ether due to its properties as the following:-

1- Low boiling point (40-60) C, and light hydrocarbon.
2- Contain non aromatic compounds.
3- Non corrosive, no radioactivity, non reactive.
4- Non toxic, safety, non polar compound.
5- Cheap.

2.4 Rates of Leaching

Generally there are five rate steps in the leaching process:-

1. The solvent is transferred from the bulk solution to the surface of the solid.
2. The solvent penetrates or diffuses into the solid (intraparticle diffusion).
3. The solute dissolves from the solid into the Solvent.
4. The solute diffuses through the mixture to the surface of the solid (intraparticle diffusion).
5. The solute is transferred to the bulk solution.

Step 1 is usually fast. The controlling rate process is generally the intraparticle diffusion or the dissolving Step.

2.5 Factors effect in the rate of solid liquid extraction process

2.5.1 Partial size

Partials size influences the extraction in number of ways. The smaller the size, the greater is the interfacial area between the solid and liquid, and therefore the higher is the rate of transfer of material and smaller is the distance the solute must diffuse within the solid as already indicated. On the other hand the surface may not be so effectively used with a very fine material if circulation of the liquid is impeded, and separation of the particles from the liquid and drainage of the solid a residue are made more difficult. It is generally desirable that the range of partial size should be small so that each partial requires approximately the same time for extraction and, in the particular, the production of a large amount of fine material should be avoid as this may wedge in the interstices of the larger particles and impede the flow of the solvent.
2.5.2 Solvent
The liquid chosen should be a good selective solvent; and it is viscosity must be low for it to circulate freely. Generally, a relatively pure solvent will be used initially, although as the extraction proceeds the rate concentration of solute will increase and the rate of extraction will progressively decrease, first because the concentration gradient will progressively decrease, also the concentration of solute will increase and the rate of the extraction will be reduced, and secondly because the solution will generally become more viscous.

2.5.3 Agitation of the fluid
Agitation of the solvent is important because this increases the eddy diffusion and there for the transfer of the material from the surface of the particles to the bulk of the solution. Furthermore agitation of suspensions of fine particles prevents sedimentation and more effective use is made of the interfacial surface.

2.5.4 Temperature
In most case, the solubility of the material which is being extracted will increase with temperature to give a higher rate of the extraction. Furthermore, the diffusion coefficient will be expected to increase with rise in temperature is determined by secondary concentrate, for example, the necessity to avoid enzyme action during the extraction of the sugar (6).

2.6 Fatty acids
Fatty acids, both free and as part of complex lipids, play a number of key roles in metabolism – major metabolic fuel (storage and transport of energy), as essential components of all membranes, and as gene regulators. In addition, dietary lipids give polyunsaturated fatty acids (PUFAs) that are precursors of powerful locally acting metabolites, i.e. the eicosanoids. As part of complex lipids, fatty acids are also important for thermal and electrical insulation, and for mechanical protection. Moreover, free fatty acids and their salts may function as detergents and soaps owing to their amphipathic properties and the formation of miceler.

2.6.1 Properties of Fatty Acids
Fatty acids are poorly soluble in water, where as they are relatively hydrophillic as potassium or sodium salts. Thus, the actual water solubility, particularly of longer-chain acids, is often very difficult to determine since it is markedly influenced by pH, and also because fatty acids have a
tendency to associate, leading to the formation of monolayer or micelles. The formation of micelles in aqueous solutions of lipids is associated with very rapid changes in physical properties over a limited range of concentration. The point of change is known as the critical micellar concentration (CMC), and exemplifies the tendency of lipids to associate rather than remain as single molecules. The CMC is not a fixed value but represents a small concentration range that is markedly affected by the presence of other ions and by temperature.

Fatty acids are easily extracted with non polar solvents from solutions or suspensions by lowering the pH to form the uncharged carboxyl group. In contrast, raising the pH increases water solubility through the formation of alkali metal salts, which are familiar as soaps. Soaps have important properties as association colloids and are surface active agents.

The influence of a fatty acid’s structure on its melting point is such that branched chains and cis double bonds will lower the melting point compared with that of equivalent saturated chains. In addition, the melting point of a fatty acid depends on whether the chain is even- or odd number, the latter have higher melting points.

Saturated fatty acids are very stable, where as unsaturated acids are susceptible to oxidation.

**2.7 Introduction of the control process**

Control is went back to Routh who in 1922 developed the theory of the automatic steering of ships. The process dynamic of a process start from rest or steady state to the desired final steady-state.

**2.7.1 Industrial application**

The control applied in Chemical and nuclear industries, power industry, metallurgical industries. Automobile industries, agricultural industry, transportation applications, military application, space application, domestic application also biological and medical industry.

**2.7.2 Control classification**

Control classification is divided to tow class manual, automation control.

The means of automation control over manual control that, the system is freedom of the human limitations, the efficiency of the human operator varies among individuals depending upon health,fatigues,environmental conditions,energy saving, safety, productively gains that automation considerably improves productively of labour and lower product cost.
Process control system normally operated with several variables held normally at constant operation levels. These variables are subjected to some departure from these levels due to disturbances, but if the system is well designed these perturbation from the normal values were relatively small, and dynamic behavior of the system can be described reliably by linear differential equations even though the basic process equation are non linear. There for the system can be adequately represented by linear relation. The feedback measures the controlled variable, sends signal to controller to make the appropriate correction to track the desired value (S.P), but the feed for ward control were measure the inlet stream and adjusts appropriately the manipulated variable so that the manipulated variable will track the set point value before it enters the process. The system stability is determined by the location of the roots of its characteristic equation of its transfer function. (7)

2.8 Process control

Process control refers to the methods that are used to control process variables when manufacturing a product. For example, factors such as the proportion of one ingredient to another, the temperature of the materials, how well the ingredients are mixed, and the pressure under which the materials are held can significantly impact the quality of an end product. Manufacturers control the production process for three reasons:-
Reduce variability, increase efficiency and ensure safety.

2.8.1 Proportional Mode

The proportional mode is used to set the basic gain value of the Controller. The setting for the proportional mode may be expressed as either:
1. Proportional Gain
2. Proportional Band

Proportional gain. Proportional Gain (Kc) answers the question:
"What is the percentage change of the controller output relative to the percentage change in controller input?"
Proportional Gain is expressed as:-
Gain, (Kc) = Output% /Inputs %
Single Control Loops
Control loops can be divided into two categories: Single variable loops and multi-variable loops.

2.8.2 Feedback control

A feedback loop measures a process variable and sends the measurement just before a controller for comparison to set point. If the process variable to set point.

2.8.3 Feed back loop

An everyday example of a feedback loop is the cruise control system in an automobile. A set point is established for speed. When the car begins to climb a hill, the speed drops below setpoint and the controller adjusts the throttle to return the car’s speed to setpoint.

Feedback loops are commonly used in the process control industry. The advantage of a feedback loop is that it directly controls the desired process variable. The disadvantage to feedback loops is the process variable must leave setpoint for action to be taken.

The type of control loop takes action in response to measured deviation from setpoint. Action in response to measured deviation from set point:-

Discrete control loop, Multi-step control loop, open loop and Feedback control loop.(8)
Chapter three
Chapter three

Material and methods

3.1 Puruns mahleb fixed oil

Puruns mahleb white seeds oil was selected due to its pharmaceutical properties and it is high efficiency in leaching and ability to control process. The oil has a yellowish colour, boiling point 43°C, density 0.8g/cm3 and have low melting point. (1)

3.2 Extraction of fixed oil from mahleb seeds

100g of crushed mahleb seeds oil were weighted and put into soxhlet apparatus. 500 ml of petroleum ether (40-60 °C) solvent were introduced into the soxhlet. The system was heated to 40 °C for a period of 6 hours as shown in figure3.2(A). The oil and the solvent mixture were taken to the Rota vapour apparatus to separate the oil and recover solvent as shown in figure3.2(B).
3. 3 Microbiological tests

The test microorganisms for Bacter 923 (Gram +ve Bacteria) which was national Collection of Type Cultaryland, USA. Also the test was done for tow type of fungle which was Aspergillus niger ATCC9763 and candida albicans ATCC7596.

3.3.1 Preparation of the test organisms

For preparation of bacterial suspension, one ml aliquots of a 24 hours broth culture of the test organisms were aseptically distributed onto nutrient agar slopes and incubated at 37° C for 24 hours. The bacterial growth was harvested and washed off with 100 ml sterile normal saline, to produce a suspension containing about $10^8 - 10^9$ C.F.U/ ml. The suspension was stored in the refrigerator at 4° C till used.

The average number of viable organisms per ml of the stock suspension was determined by means of the surface viable counting technique. Serial dilutions of the stock suspension were made in sterile normal saline solution and 0.02 ml volumes of the appropriate dilution were transferred by micro pipette onto the surface of dried nutrient agar plates. The plates were allowed to stand for two hours at room temperature for the drops to dry and then incubated at 37 °C for 24 hours. After incubation, the number of developed colonies in each drop was counted. The average number of colonies per drop (0.02 ml) was multiplied by 50 and by the dilution factor to give the viable count of the stock suspension, expressed as the number of colony forming units per ml suspension.

Each time a fresh stock suspension was prepared. All the above experimental conditions were maintained constant so that suspensions with very close viable counts would be obtained.

After that the preparation of fungal suspension made by the fungal Cultures which were maintained on Sabouraud dextrose agar, incubated at 25 °C for 4 days. The fungal growth was harvested and washed with sterile normal saline and finally suspension in 100ml of sterile normal saline, and the suspension were stored in the refrigerator until used. (10)
3.4 In vitro testing of extracts for antimicrobial activity

3.4.1 Testing for antibacterial activity

The cup-plate agar diffusion method was adopted with some minor modifications to assess the antibacterial activity of the prepared extracts.

One ml of the standardized bacterial stock suspension $10^8 - 10^9$ C.F.U/ml were thoroughly mixed with 100ml of molten sterile nutrient agar which was maintained at 45 ºC. 20ml aliquots of the inoculated nutrient agar were distributed into sterile Petri-dishes.

The agars was left to set and in each of these plates 4 cups (10 mm in diameter) were cut using a sterile cork borer (No. 4) and agar discs were removed.

Alternate cups were filled with 0.1 ml sample of each of the oils dilutions in methanol using automatic microlitre pipette, and allowed to diffuse at room temperature for two hours. The plates were then incubated in the upright position at 37 ºC for 18 hours.

Two replicates were carried out for each extract against each of the test organisms. After incubation the diameters of the resultant growth inhibition zones were measured, averaged and the mean values were tabulated.

3.4.2 Testing for antifungal activity

The same method as for bacteria was adopted. Instead of nutrient agar, Sabouraud dextrose agar was used. The inoculated medium was incubated at 25 ºC for two days for the Candida albicans and three days for Aspergillums niger. (10)

3.5 Anti oxidant

3.5.1 DPPH radical scavenging assay

The DPPH radical scavenging was determined according to the method of Shimada (11), with some modification. In 96-wells plate, the test samples were allowed to react with 2.2Di (4-tert-octylphenyl)-1-picryl-hydrazyl stable free radical (DPPH) for half an hour at 37ºC. The concentration of DPPH was kept as (300μm). The test samples were dissolved in DMSO while DPPH was prepared in ethanol. After incubation, decrease in absorbance was measured at 517nm
using multiplate reader spectrophotometer. Percentage radical scavenging activity by samples was determined in comparison with a DMSO treated control group. All tests and analysis were run in triplicate. (11)

3.6 Fatty acids

5ml of methanol was added to 10 ml of the fixed oil, 1 micro litter of the this solution were put into GSMS-QP2010 apparatus at 50°C. The heat was increased gradually 25°C every one mint until it reach 175°C. The heat was continued increasing again 4°C until it reached 250°C, after that the apparatus was read the pikes and send it as the following diagram, which was represent the 13 fatty acids.

Figure 3.6

Temperature programming:

Column: 50– 270 °C, 10 °C/min

Injector: 300 °C

Detector: 300 °C.

Flow rate of gases:

N₂: 30 ml/min

H₂: 33 ml/min

Pressure: 68.1 kPa
3.7 Tuning of Control

The method of tuning control process is named Direct substitution method, Routh, which is compared the respect to offset and adjustable parameters, $k_c, \tau_i, \tau_D$. Also Ziegler- Nichols Tuning is used to calculate the adjustable parameter above.

3.7.1 Routh-Hurwitz criterion

Apply the Routh test on the loop1 and loop2 characteristic polynomial to find if there are poles on the right-hand- plane. Evaluated the establish limits on the controller gain.

If the characteristic polynomial passes the coefficient test, we then construct the Routh array to find the necessary and sufficient conditions for stability. This is one of the few classical techniques that we do not emphasize and the general formula is omitted. The array construction up to a fourth order polynomial is used to illustrate the concept.

Generally, for an n-th order polynomial, we need (n+1) rows. The first rows are filled in with the coefficients of the polynomial in acoulm-wise order. The computation of the array entries is very much like the negative of normalized determination anchored by the first column.

The Routh criterion state that in order to have stable system, all the coefficients in the first column is negative, there is at least one root with a positive definite. If any coefficients in the first column are negative, there is at least one root with appositive real part. The number of sign changes is the number of positive poles. (7)

3.7.2 Ziegler-Nichols ultimate-cycle method

This empirical method is based on closed-loop testing (also called on-line tuning) of processes which are inherently stable, but where the system may become unstable. We use only proportional control in the experiment. If it is not possible to the integral and derivative control modes, we set the integral time to it is maximum value and the derivative time to its minimum.

The portioned gain is slowly increased until the system is beings to exhibit sustained oscillation with a give small step set point or load change. The proportional gain and period of oscillation at this point are the ultimate gain, $K_{cu}$, and ultimate period. These two quantities are used in asset of empirical tuning relation developed by Ziegler and Nichols-again listed in table 3.7.2(7).
<table>
<thead>
<tr>
<th>Type of control</th>
<th>Kc1</th>
<th>$\tau, I, 1$</th>
<th>$\tau, D, 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0.50 Ku</td>
<td>----</td>
<td>---</td>
</tr>
<tr>
<td>PI</td>
<td>0.45 Ku</td>
<td>Pu /1.2</td>
<td>---</td>
</tr>
<tr>
<td>PID</td>
<td>0.60 Ku</td>
<td>Pu /2</td>
<td>Pu /8</td>
</tr>
</tbody>
</table>

3.8 MATLAB Software

Mat lab is integrated technical environment that combines numeric computation, advanced graphical and visualization, and a high level programming language.

The develop MATLAB software was originally developed to matrix laboratory.

It is a leading tool for engineering concepts in mathematics. Being able to plot mathematical function and data MATLAB, which can be used in research development and in industry.

3.9 Tuning procedure

- The ultimate gains and ultimate periods are calculated first for the first loop and then for the secondary loop.
- The adjustable parameters are used to get the response due to unit step Change in set point.
Chapter four
4.1 Leaching oil from mahleb seeds

The seeds were crushed to small particle size of 4-6 µm and the following factors were investigated:

- Solvent: Solid ratio, temperature of the extraction, agitation and time.
- The solvent is petroleum ether, boiling point (40-60°C).
- The solvent: solid ratio was 1: 5 (12)
- The temperature is 25°C.

In all previous work on leaching of oil, the speed of the pump in evaporation is important and the recommended speed of agitation is 50 rpm.

The time required for equilibrium is 2 hours at the above specific conditions.

The efficiency of separation:
- Basis=100 gram of crushed oil feed.
- Oil content=0.34884g/g.
- Amount of oil=0.34884*100=34.884g.
- Amount of oil leached=33.1398g.
- Efficiency of extraction=33.1396/34.884*100 = 95%
- Oil left with cake=34.884-33.1398=1.7442g.
- Percentage losses=1.7442/34.884*100=5%
4.2 Flow sheet of leaching and recovery column

Motor mixer

Crushed seeds

Solvent

Cake

Filter

Oil to solvent recovery column

Condenser

Solvent-Oil mixture

Reboiler

Figure 4.1

Figure 4.2
4.3 Anti microbial

Table 4.3 Analysis of microbes inhibition area with concentration

<table>
<thead>
<tr>
<th>Oil concentration(mg/ml)</th>
<th>E.C</th>
<th>PS</th>
<th>B.S</th>
<th>S.a</th>
<th>Ca</th>
<th>A.u</th>
</tr>
</thead>
<tbody>
<tr>
<td>100mg/ml</td>
<td>17</td>
<td>19</td>
<td>18</td>
<td>16</td>
<td>-</td>
<td>18</td>
</tr>
<tr>
<td>50mg/ml</td>
<td>16</td>
<td>18</td>
<td>17</td>
<td>15</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td>25mg/ml</td>
<td>15</td>
<td>17</td>
<td>16</td>
<td>14</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>12.5mg/ml</td>
<td>14</td>
<td>16</td>
<td>15</td>
<td>13</td>
<td>-</td>
<td>15</td>
</tr>
</tbody>
</table>

E.C = Escherichia coli
P S = pseudomonas aeruginosa
B.S = Bacillus subtilis
S.a = Staphylococcus aureus
Ca = Candida albicans
A.u = Aspergillus niger
*if inhabitation area <18mm the oil is sensitive, 14-18 the oil is intermediate sensitive, and>14 the oil is resistance.

Figure 4.3

From figure 4.3 in concentration oil 100mg/ml, puruns mahleb oil contains high activity against pseudomonas aeruginosa which causes skin disease, pneumonia, and the oil has med activity against bacillus subtilis, Ecoli which causes diarrhea and abdominal pain, also for Staphylococcus bacteria that causes skin infection, bronchitis and endocarditic, and in fungal activities the oil have a high activities for Aspergillus niger which causes Asthma, and no activity for Candida ibicans.
4.4 Antioxidant

The free radical scavenging activity of extract was evaluated by DPPH, and the result shows that
the mahleb oil contains 54.1% of anti oxidant compounds as in table 4.4 which allow using it in
food industries as spices oil to prevent from cancers.

Table 4.4 Anti oxidant % activity

<table>
<thead>
<tr>
<th>NO</th>
<th>Sample code</th>
<th>% RSA(DPPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mahleb oil</td>
<td>54.1±0.11</td>
</tr>
<tr>
<td>2</td>
<td>standard</td>
<td>80.0±0.04</td>
</tr>
</tbody>
</table>

4.5 Fatty acids

The results shows about 13 of fatty acids compounds, the major compounds was 8-octadecenoic acid (oleic acid), 9,12,15-octadecatrienoic (α-Linolenic acid, methylester) and 9,12-octadecadienoic (Linoleic acid), as in figure 4.5 and table 4.5.
### Table 4.5 the investigation of fatty acids compounds

<table>
<thead>
<tr>
<th>No</th>
<th>Fatty compounds</th>
<th>Formula</th>
<th>Mwt</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8-octadecenoic acid(z),methyl ester</td>
<td>C19H38O2</td>
<td>298.4562</td>
<td>oleic acid</td>
</tr>
<tr>
<td>2</td>
<td>9,12,15-Octadecatrienoic acid,methyl ester</td>
<td>C_{19}H_{36}O_{2}</td>
<td>292.4562</td>
<td>α-Linolenic acid, methyl ester</td>
</tr>
<tr>
<td>3</td>
<td>9,12-octadecenoic acid(z,z)</td>
<td>C_{19}H_{34}O_{2}</td>
<td>294.4721</td>
<td>Linoleic acid</td>
</tr>
<tr>
<td>4</td>
<td>Pentadecanoic acid,14-methyl</td>
<td>C_{17}H_{34}O_{2}</td>
<td>270.4507</td>
<td>Methyl isohexadecanoate</td>
</tr>
<tr>
<td>5</td>
<td>9,11- octadecadienoic acid,methyl ester</td>
<td>C_{19}H_{34}O_{2}</td>
<td>294.4721</td>
<td>Linoleic acid, methyl ester</td>
</tr>
<tr>
<td>6</td>
<td>6,9,12- Octadecatrienoic acid,methyl ester</td>
<td>C_{19}H_{32}O_{2}</td>
<td>292.4562</td>
<td>γ-Linolenic acid, methyl ester</td>
</tr>
<tr>
<td>7</td>
<td>11- octadecenoic acid,methyl ester</td>
<td>C_{19}H_{36}O_{2}</td>
<td>296.4879</td>
<td>Octadec-11-enoic acid, methyl ester</td>
</tr>
<tr>
<td>8</td>
<td>10-Nonadecenoic acid,methyl ester</td>
<td>C_{20}H_{38}O_{2}</td>
<td>310.5145</td>
<td>Methyl 10-nonadecenoate</td>
</tr>
<tr>
<td>9</td>
<td>Eicosanoic acid,methyl ester</td>
<td>C_{21}H_{42}O_{2}</td>
<td>326.5570</td>
<td>Arachidic acid methyl ester</td>
</tr>
<tr>
<td>10</td>
<td>Heptadecanoic acid,methyl ester</td>
<td>C_{18}H_{36}O_{2}</td>
<td>284.4772</td>
<td>Margaric acid methyl ester</td>
</tr>
<tr>
<td>11</td>
<td>Hexadecanoic acid,15-methyl ester</td>
<td>C_{18}H_{36}O_{2}</td>
<td>284.4772</td>
<td>Methyl isoheptadecanoate</td>
</tr>
<tr>
<td>12</td>
<td>Heptacosanoic acid,methyl ester</td>
<td>C_{28}H_{56}O_{2}</td>
<td>424.7430</td>
<td>Methyl heptacosanoate</td>
</tr>
<tr>
<td>13</td>
<td>9- octadecenoic acid(z),methyl ester</td>
<td>C_{19}H_{36}O_{2}</td>
<td>296.4879</td>
<td>Oleic acid, methyl ester;</td>
</tr>
</tbody>
</table>
Figure 4.5 chromatography fatty acids pikes
4.6 The importance of the three major fatty compounds in mahleb oil

4.6.1 Oleic acid is a common monounsaturated fat in human diet. Monounsaturated fat consumption has been associated with decreased low-density lipoprotein (LDL) cholesterol, and possibly increased high-density lipoprotein (HDL) cholesterol. However, its ability to raise HDL is still debated.

Oleic acid may hinder the progression of adrenoleukody trophy (ALD), a fatal disease that affects the brain and adrenal glands. Oleic acid may be responsible for the hypertensive (blood pressure reducing) effects of olive oil. Adverse effects also have been documented, however, since both oleic and monounsaturated fatty acid levels in the membranes of red blood cells have been associated with increased risk of breast cancer, although the consumption of oleate in olive oil has been associated with a decreased risk of breast cancer.

4.6.2 α-Linolenic acid: (ALA) is an essential omega-3 fatty acid and organic compound found in seeds (chia, flaxseed, see also table below), nuts (notably walnuts), and many common vegetable oils. In terms of its structure, it is named all-cis-9,12,15-octadecatrienoic acid. α-Linolenic acid is a carboxylic acid with an 18-carbon chain and three cis double bonds. The first double bond is located at the third carbon from the methyl end of the fatty acid chain, known as the n end. Thus, α-linolenic acid is a polyunsaturated n−3 (omega-3) fatty acid. It is an isomer of gamma-linolenic acid, a polyunsaturated n−6 (omega-6) fatty acid.

α-Linolenic acid, an n−3 fatty acid, is a member of the group of essential fatty acids (EFAs), so called because they cannot be produced within the body and must be acquired through diet. Most seeds and seed oils are much richer in an n−6 fatty acid, linoleic acid. Exceptions include flaxseed (must be ground for proper nutrient absorption) and walnuts. Linoleic acid is also an EFA, but it, and the other n−6 fatty acids, compete with n−3s for positions in cell membranes and have very different effects on human health.

In the year 2011 a longitudinal study of over 50,000 women, conducted at Harvard University, over a period of ten years, found that a higher intake of α-linolenic acid (combined with a lower intake of linoleic acid) was positively associated with a significant reduction in depression in the
same group (the same study also found that by contrast an intake of EPA and DHA found in fish oils did not reduce depression).

4.6.3 **Linoleic acid** (LA) is an unsaturated omega-6 fatty acid. It is a colorless liquid at room temperature. In physiological literature, it has a lipid number of 18:2 cis, cis-9, 12. Chemically, Linoleic acid is a carboxylic acid with an 18-carbon chain and two cis double bonds; the first double bond is located at the sixth carbon from the methyl end.(13)

Linoleic acid belongs to one of the two families of essential fatty acids. The body cannot synthesize Linoleic acid from other food components. The word "Linoleic" comes from the Greek word linon (flax). Oleic means "of, relating to, or derived from oil of olive" or "of or relating to oleic acid" because saturating the omega-6 double bond produces oleic acid.(12)

Some medical research suggests that excessive levels of certain omega-6 fatty acids relative to certain omega-3 fatty acids, but likely in conjunction with exogenous toxins, may have negative health effects.(13)

Linoleic acid has become increasingly popular in the beauty products industry because of its beneficial properties on the skin. Research points to Linoleic acid's anti-inflammatory, acne reductive, and moisture retentive properties when applied topically on the skin.(14)

4.7 **Uses of Fatty Acids in the Pharmaceutical/Personal Hygiene Industries**

Fatty acids are widely used as inactive ingredients (excipients) in drug preparations, and the use of lipid formulations as the carriers for active substances is growing rapidly.

The largest amount of lipids used in pharmaceuticals is in the production of fat emulsions, mainly for clinical nutrition but also as drug vehicles. Another lipid formulation is the liposome, which is a lipid carrier particle for other active ingredients. In addition, there has been an increase in the use of lipids as formulation ingredients owing to their functional effects (fatty acids have several biological effects) and their biocompatible nature. For instance, very long-chain o may be used as a drug to reduce plasma triacylglycerol concentration and to reduce inflammation among patients with rheumatoid arthritis.
4.8 control strategy of the system

This is shown in figure 4.8

Figure 4.8: Control Strategy of the system
4.9 Identification of transfer function

The transfer function can be identified from mathematical models or from on-line experiments. As these are not possible, they being cited from the literature (7)

In loop1:-

\[ G_{c1} = K_{c1} \]

\[ G_{v1} = \frac{1}{0.5s+1} \]

\[ G_{p1} = \frac{1}{60s+1} \]

\[ G_{m1} = \frac{1}{0.35s+1} \]

LOOP2:-

\[ G_{c2} = K_{c2} \]

\[ G_{v2} = \frac{1}{0.5s+1} \]

\[ G_{p2} = \frac{1}{30s+1} \]

\[ G_{m2} = \frac{1}{0.15s+1} \]

Figure 4.9 Block diagram for loop1

Where:-

Gc = controllers transfer function

Gv = Valve transfer function
Gp = process transfer function
Gm = sensor transfer function

4.9.1 Over all transfer function:-

Using figure 4.6

\[
G(s) = \frac{\pi f}{1+\pi l} k c1 \frac{l}{(0.5s+1)} \frac{l}{(60s+1)} \frac{l}{(0.3s+1)}
\]……………………………………………………………………………………………………..4.5

\[
\pi f = \frac{Kc1}{(0.5s+1)(60s+1)(0.3s+1)}
\]……………………………………………………………………………………………………..4.6

\[
l + \pi f = \frac{Kc1 + (0.5s+1)(60s+1)(0.3s+1)}{(0.5s+1)(60s+1)(0.3s+1)}
\]……………………………………………………………………………………………………..4.7

\[
G(s) = \frac{Kc1 (0.3s+1)}{Kc1 + (0.5s+1)(60s+1)(0.3s+1)}
\]……………………………………………………………………………………………………..4.8

4.9.2 Characteristic Equation:-

1+OLTF=0……………………………………………………………………………………………..4.9

Kc1+ (0.5s+1) (60s+1) (0.3s+1) =0………………………………………………………………………..4.10

4.9.3 System stability and tuning from the characteristic equation of loop1

Using Routh- Hurwitz Method

Refer to equation 4.10

The OLTF= Kc1+(0.5s+1)(60s+1)(0.3s+1)

9S3+48.15S2+60.8S+1+ Kc1=0………………………………………………………………………..4.11

Number of rows 3+1=4
Then:

\[ 2927.52 - 9(1 + kc1) = 0 \]

\[ 324.28 = kc1 \] ............................... (a)

\[ Ku1 = 324.28. \] ............................... (b)

### 4.9.4 Determination of adjustable parameters of loop1

Referring to equation 4.11, when put \( kc1 = 324.28 \) the equations become:

\[ 9S^3 + 48.15S^2 + 60.8S + 1 + Kc1 = 0 \]

\[ 9S^3 + 48.15S^2 + 60.8S + 324.28 = 0 \] ............................... 4.12

When \( S = \omega_i \), \( i_2 = -1 \)

\[-9(\omega_i)^3 - 48.15(\omega_i)^2 + 60.8(\omega_i) + 324.28 = 0 \] ............................... 4.13

\[-9(\omega_i)^3 + 60.8\omega_i = 0 \] ............................... 4.14

\[ \omega_i 2 = 6.8 \] ............................... 4.15

\[ \omega_i = \sqrt{6.8} = 2.6 \text{ rad/sec} \] ............................... 4.16

\[ Pu1 = 2\pi/\omega = 2*3.14/2.6 = 2.42 \text{ sec} \]

### 4.9.4 Ziegler-Nichols tuning parameter, loop1, root locus method

<table>
<thead>
<tr>
<th>Type of control</th>
<th>( Kc1 )</th>
<th>( \tau, I, 1 )</th>
<th>( \tau, I, 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>162.14</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PI</td>
<td>145.93</td>
<td>2.02</td>
<td>-</td>
</tr>
<tr>
<td>PID</td>
<td>194.57</td>
<td>1.21</td>
<td>0.303</td>
</tr>
</tbody>
</table>
4.9.5 Response of the system

The OLTF \( G(s) = \frac{\pi f}{1+\pi l} \)

\( \pi f = kc1. kc2. Gv. GP1. GP2 \)

\( \pi l = Kc1. Kc2. Gv. GP1. GP2. Gm1 \)

\[ \pi f = \frac{65180.28}{(0.5S + 1)(60S + 1)} \]

\[ \pi l + 1 = 65180.28 + (0.3S+1)(0.5S+1)(60S+1)(30S+1) \]

\[ (0.5S + 1)(60S + 1)(30S+1)(0.3S+1) \]

\[ G(s) = \frac{65180.28(0.3S+1)(30S+1)}{65180.28 + (0.3S+1)(0.5S+1)(60S+1)(30S+1)} \]

Application of MATLAB software

Num= [65180.28];

A=conv ([0.3 1], [60 1]);

B=conv ([0.5 1], [30 1]);

Den= conv (a, b);

Step (num, den);
Figure 4.9.5 step response (D.S)

Figure 4.9.6 Block diagramme of loop2
4.9.6 Overall transfer function loop2

Using figure 4.7

\[ G(s) = \frac{\pi f}{1+\pi l} \]

\[ \pi f = Kc2 \cdot \frac{1}{(0.5s+1)} \cdot \frac{1}{(60s+1)} \] \hspace{1cm} \text{4.17}

\[ \pi L = Kc2 \cdot \frac{1}{(0.5s+1)} \cdot \frac{1}{(30s+1)} \cdot \frac{1}{(0.15s+1)} \] \hspace{1cm} \text{4.18}

\[ 1 + \pi L = \frac{Kc2 + (0.5s + 1)(30s + 1)(0.15s + 1)}{(0.5s+1)(30s+1)(0.15s+1)} \] \hspace{1cm} \text{4.19}

\[ G(s) = \frac{Kc2 (0.15s+1)}{Kc2+(0.5s+1)(30s+1)(0.15s+1)} \] \hspace{1cm} \text{4.20}

4.9.7 Characteristic Equation:

\[ 1+\text{OLTF}=0 \] \hspace{1cm} \text{4.21}

\[ Kc2+(0.5s+1)(30s+1)(0.15s+1)=0 \] \hspace{1cm} \text{4.22}

4.9.8 System stability of tuned system from the characteristic equation of the loop2

Using Routh-Hurwitz Method

Refer to equation 4.10

The OLTF = Kc2+(0.5s+1)(30s+1)(0.15s+1)

\[ 2.25S3+15.075S2+30.15S+1+ Kc2=0 \] \hspace{1cm} \text{4.23}
Number of rows 3+1=4

\[
\begin{pmatrix}
2.25 & 30.15 \\
15.075 & 1+kc^2 \\
\frac{454.5-2.25 (1+kc^2)}{15.075} & 0 \\
1+kc^2 & 0
\end{pmatrix}
\]

Then:-

454.5 - 2.25 (1+kc^2)=0 ........................................... \(4.24\)

201=\(kc^2\) ........................................................................... (a)

\(Ku^2\)=201 ............................................................................. (b)

**4.9.9 Tuning of loop2**

Referring to equation 4.11, when put \(kc^2\)=201 the equation become:-

9\(S^3\)+48.15\(S^2\)+60.8\(S\)+1+\(Kc^1\)=0

2.25\(S^3\)+15.075\(S^2\)+30.15+201=0 ...........................................\(4.25\)

When \(S=\omega i = \omega 2\)= -1

-2.25(\(\omega i\))^3 − 15.075(\(\omega i\))^2 + 30.15(\(\omega i\)) + 201=0 ...........................................\(4.26\)

-2.25(\(\omega i\))^3+30.15\(\omega i\)= 0 ...........................................\(4.27\)

\(\omega 2= 5.6\) ..........................................................\(4.15\)

\(\omega = \sqrt[3]{5.6} = 2.34\)rad/sec ...........................................\(4.16\)

\(Pu1 = 2\pi/ \omega\)

\(2*3.14/2.34 = 2.68 \) sec
4.9.10 Ziegler -Nichols tuning parameter, loop2, root loci method

Table 4.9.10 (Z-N) tuning parameter

<table>
<thead>
<tr>
<th>Type of control</th>
<th>Kc2</th>
<th>( \tau, I, 2 )</th>
<th>( \tau, D, 2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>100.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PI</td>
<td>90.45</td>
<td>2.23</td>
<td>-</td>
</tr>
<tr>
<td>PID</td>
<td>120.6</td>
<td>1.34</td>
<td>0.335</td>
</tr>
</tbody>
</table>

4.9.11 Response of the system

The \( \text{OLTTF} = G(s) = \frac{\pi f}{1+\pi l} \)

\( \pi f = k c_1.k c_2.G v.G P_2 \)

\( \pi l = K C_1.K C_2.G V.G P_1.G P_2.G m_2 \)

\( \pi f = \frac{65180.28}{(0.5S + I)(60S + I)} \)

\( \pi l + 1 = \frac{65180.28+(0.3S+1)(0.5S+1)(60S+1)(30S+1)}{(0.5S + I)(60S + I)(30S+1)(0.15S+1)} \)

\( G(s) = \frac{65180.28(0.15S+1)(30S+1)}{65180.28+(0.15S+1)(0.5S+1)(60S+1)(30S+1)} \)

Application of MATLAB software

Num=[65180.28];
A=conv([0.15 1],[60 1]);
B=conv([0.5 1],[30 1]);
Den= conv(a,b);
Step( num,den);
4.10 Discussion of the result:-

The results of the present study found that purun mahaleb fixed oil contains 34.448% of fixed oil and efficiency of the leaching is 95%. Also the oil contains antimicrobial properties against bacteria, some bacterial pathogens and fungi as well as antioxidant activity. In addition to that the oil contains three essential fatty acids compounds (oleic, α-linolenic and Linoleic acid compounds). Also in this work a control strategy was develop by tuning method of substitution in loop1 and loop2, the value of ultimate gain (ku1) is by characteristic equation and Rouch array. The same procedure was repeated for loop2 to determined (ku2).

Then the adjustable parameters obtained by (Z – N) of tabulated in tables 4.9.4, 4.9.10 the system stabilities were determined with the result and the systems were found to be stable.

The system response were determined using MATLAB program as shown in Figures 4.9.5 and 4.9.11
Chapter five
chapter 5
Conclusion and Recommendation

5.1 Conclusion

The investigation of antimicrobial, anti oxidant and fatty acids in the puruns mahleb oil were Carried out. Also the oil extraction efficiency was 95 %.

A control strategy was developed, the transfer function were determined and consequently the characteristic equations. Each loop was tuned and response there of was plotted and found to be stable.

5.2 Recommendations

- The puruns mahleb fixed oil is recommended to be used in cosmetic(soap) industries, may be added to industrial food products due to its antioxidant activity that prevent from cancers. Finally the mahleb fixed oil may enter pharmaceutical industries after carrying out more investigations in to pharmacological properties which have a promising industries future.

- The control system is to be made into digital control for it is important to optimize the leaching conditions.
References


