

A COMPREHENSIVE REVIEW OF VINEGAR IN UNANI LITERATURE: AN EVIDENCE BASED APPROACH

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Abstract: Vinegar is derived from the French word vinaigre, meaning “sour wine”. *Sirka* (Vinegar) has a long historical background and besides its usage as a common condiment, food ingredient, preservative, flavoring and culinary agent it has also been extensively exploited as a potent medicinal substance. According to Unani classical literature, it is obtained after fermentation of various substances such as grapes, sugarcane, dried grapes, figs, jamun, honey, onions, grains etc and prepared by a specific procedure in which the juice of ingredient is taken in a vessel and kept in sunlight, until proper fermentation of that liquid takes place. In India, the most commonly used and prepared *sirka* is of *Aab e neeshkar* (Sugarcane juice) or of Jaggery called as *Sirka Qandi*. Various actions and clinical indications have been elaborated in the Unani classical literature and some properties namely Anti-infective, Antihypertensive, Cardio-protective, Antitumor, Antiglycemic, Antioxidant and Antitubercular activities have been revalidated in the light of recent scientific researches. A number of clinical researches have also been performed to explore medicinal properties of *Sirka* (Vinegar). This review provides both modern as well as Unani aspects of *sirka* (vinegar).

Key words: *Sirka*, Vinegar, sourwine, Unani.

INTRODUCTION

Sirka (vinegar) is one of the common culinary agents, and had been used as a condiment and food ingredient for thousands of years. Although *sirkais* highly valued as a flavoring and preservative for foods, much scrutiny surrounds its medicinal use. Due to *Saree-al-nufooz* (rapidly diffusible), *muhallil* (resolvent), *qabiz* (astringent) properties of *sirka*, it is used internally as well as externally in many diseases. In approximately 400 BC, the ancient Greek Hippocrates began to use fruit vinegars to treat wound inflammations, cough, ulcers and infectious diseases. The most ancient prescriptions displayed in the Chinese Book *Fifty-Two Diseases* (300 BC) include 17 remedies based on the use of vinegars to treat burns, hernias, cellulitis, and psoriasis.^[1]

METHODOLOGY

For present manuscript Unani classical treatise like *khazainul advia*, *kitabul mukhtarat filtibb*, *bayaze kabeer*, *makhzanul mufradat*, *kitabul advia*, *Kamil us sana*, *Al Qanoon fit tib*, *ilmul advia nafeesi*, *muhite azam* were explored for terms like *sirka*, *khal*, *khala*, *aabe-nishkar* etc. for their morphology, types, dosage, substitutes, actions and characteristics etc. Contemporary search were done on a variety of scientific websites such as pubmed, orchid, google scholar, SCOPUS, Crossref, CAS Abstracts, Publons, CiteFactor, Open J-Gate, ROAD, Indian Citation Index (ICI), Indian Journals Index (IJINDEX), Internet Archive, IP Indexing, Scientific Indexing Services, Index Copernicus, Science Central, Revistas Medicas Portuguesas, EBSCO, NEWJOUR, ResearchGATE, DocStoc, PdfCast, getCITED, SkyDrive, Citebase etc by using key words vinegar, acetic acid etc. for their morphology, ethanobotanical description, chemical constituents, chemical properties, characteristics, action and scientific studies in different diseases etc.

MAHIYAT: (UNANI MORPHOLOGY)

Sirka is a common condiment, obtained after fermentation of various substances such as grapes, sugarcane, dried grapes, figs, jamun, honey, onions, grains. There are different methods of preparation of *sirka desi*. The juice is attenuated with the heat of sun light or wine kept in open containers and converted into vinegar at 60 degree -80 degree or at room temperature or few months. *Sirka* is prepared with the help of an organism called *ummulkhal* or *mycoderma aceti* (mother of vinegar) which play a key role in the process of fermentation. In India, most commonly used and prepared *sirka* is of *aabe-neeshkar* (sugarcane juice) or of jaggery called as *sirka qandi*.^[2]

TYPES OF SIRKA^{[2],[3],[4],[5]}

1. *Sirka-e Seb* (Apple) or *Bihi* (Quince fruit) or *Nashpaati* (Avocado)

Method of preparation: It is prepared by chopping fruits (apple or quince or avocado), adding water and leaving them at room temperature until the natural sugars ferment and form ethanol. Bacteria then convert this alcohol into acetic acid.

Iste'mal (Uses): It supports digestive system and hence promotes digestion

2. *Sirka-e Jamun* (black plum) or *Taadi* (plum)

Method of preparation: Prepared by crushing plums and collect their juice in a bowl. After 2-3 days, this juice fermented then remove thick impurities and pour the remaining juice in an earthen pot and seal the pot and buried deep in the ground for 3 months after that is ready to use.

Iste'mal(Uses): It acts as tonic for stomach and spleen.
It is beneficial in diabetes mellitus.

3. Sirka-e Qandi (Jaggery)

Method of preparation: Mix 12 kg of jaggery with 40 litres of water in a container and buried deep in the ground in a pit, left ¼ of upper portion of pit empty and cover this empty part of pit with grass so that fermentation easily takes place, remove froth in rainy season and in winter season it is ready to use.

Iste'mal(Uses): Distillate of this sirka which is obtained by addition of Pudina is more concentrated, *saree-al-nufooz* (rapidly diffusible) and *murakkabulquwa* (multipotential). It resolves *WarneTihal* (spleenomegaly) removes obstruction and also acts as antihelminthic

4. Sirka –e- angoori

Method of preparation: Collect grapes in a large size bowl, crush them and pour their juice in an earthen pot and sealed it properly. After that buried it deep inside the ground by covering its all sides by mud. After 21 days, add alum, salt 50 grams each and again close the pot and buried till 30 days. Sirka-e-angoori is ready to use.

Iste'mal(Uses): It improves digestion
It is used to enhance the effect of medicine.
It is used as a cardiac and brain tonic.

5. Sirka-e Janglipyaaz (wild onion) It is also known as sirka-e unsal.

Method of preparation: According to Ibnesina Mix 1 part of 1 year old wild onion with 9 parts of sirkaangoori and keep it as such for 6 months, fermentation process takes place in it, after removing impurities it is ready to use.

Iste'mal(Uses): It helps to remove adhesive humours from the body, increases digestive power, clears voice, increases vision, remove odour from mouth, and also beneficial for the people suffering from *Melancholia*, *Junoon* (madness), *Sara* (epilepsy), *Irqunnasa* (sciatica), *Hisatemasana* (cystic stones), facial palsy, paralysis, headache, increases complexion, can be used in deafness, asthma, cough, ascites, etc

VERNACULARS:

Arabic: Khal^{6,7,8,9}
English: Vinegar^{2,6}
Hindi: Sirka⁶
Persian: Khale^{6,7}
Syrian: Khala⁹
Urdu: Sirka⁶
Scientific name: Acetum vinegar²

MIZAJ (TEMPERAMENT) OF SIRKA: *Murakkabul quwa*, *Barid yabis*^{[1],[2],[10]}

MUZIR (ADVERSE EFFECTS): Persons with cold temperament², Harmful for uvula^[11], Neurasthenia and anaphrodisiac^[6]

MUSLEH (CORRECTIVES): *Sheereen halwajat*, *shahed khali*⁷, *Roghanebadamis* used as *musleh* in cough. Grapes juice is used as *musleh* in old age, women and children^[2]

BADAL (SUBSTITUTE): *Aabe- limu kaghzi*

MIQDAR KHURAK (DOSAGE): 25 ml^[2]

AF'AL: (ACTIONS ACCORDING TO UNANI MEDICINE)

Dafi-i- qay– Antiemetic, *Mushtahi*–Appetizer, *Musakkin-i-attish*, *Muqawwi-i-mi'da*–Stomachic, *Hadim*– Digestive, *Mufarrih*– Exhilarant, *Saree-un-nafooz*– Rapidly diffusible, *Muqawwi-i-tihal* - Spleen tonic, *Muqawwi-i-dandanwalitha* - Tonic for gums and teeth, *Mufattehsudad*–Deobstruent, *Qateakhlateghaleeza*, *Qatesafra*–Antibilious, *Mubarrid*– Refrigerant, *Mulattif*– Demulcent, *Mujaffif*– Dessicant, *Habis*– Styptic, *Qabid*– Astringent, *Musakkin-i-alam*– Analgesic, *Muhallil-i-warm* –Antinflammatory, *Muhallil-i-dam-i-munjamid*– Anticoagulant, *Manaynazf-ud-dam* –Hemostatic, *Jali*– Detergent, *Dafi-i- taffun*– Antiseptic, *Mundij*– Concoctive.^{[2],[7],[12]}

ISTE'MAL: (USES ACCORDING TO UNANI MEDICINE)

1. It can be used in *qay* and *ghisyan*^[1]
2. Due to antiphlegmatic action it liquefies the sticky morbid phlegmatic humours and removes them from the body.^{[2],[6],[8]}
3. It quenches thirst when consumed with plain water in sips.^{[2],[6]}
4. It is helpful in indigestion by promoting digestion and strengthening digestive system. It acts as appetizer, hence used in pickles and other dishes.^{[2],[6],[8]}
5. Consumption of *sirka* regularly in diet helps to reduce obesity.
6. Ingestion of *sirka* helps to remove intestinal infestation of worms.^[2]
7. Oxymel, a popular ancient medicine composed of honey and vinegar, was prescribed for persistent coughs.^[13]
8. The external application of *sirka* along with *roghane gulor roghane zaitoon* is indicated in *dared sar harr* and in *sarsame harr*.^{[2],[6],[8],[9]}

9. It is used as eardrops to relieve pain in otalgia.^{[2],[6]}
10. Fumigations of *sirka* is helpful in hard of hearing, tinnitus and vertigo. ^[2]
11. Inhalation of *sirka* helps to remove nasal block.^{[2],[9]}
12. Inhalation of *sirka*, strengthens the brain.^{[2],[6]}
13. It acts as moisturiser in case of dryness of skin.^{[2],[8]}
14. It removes *bahaq wa baras* when applied locally on affected area.^{[2],[6]}
15. Local application of *sirka* with *shahed*(honey) heal the wound, clean the impurity and hence used in gangrene, *humra*(erysipelas) and other inflammatory conditions.^{[2],[6]}
16. *Sirka* is applied on scorpion bite or on other insect bites as an antidote. Grape vinegar with salt is used in dog bite. It also used as an antidote in opium and hemlock poisoning.^{[6],[11]}
17. *Sirka* is useful in gout patients when used with sulphur as a douche.^[11]
18. It acts as a catalyst when used with other drugs for fast absorption and penetration of drugs into the tissue.^{[2],[6]}

ETHNO BOTANICAL DESCRIPTION

The word —Vinegar is derived from an old french word “*Vin aigre*” means —Sour wine^{[1],[14]} It is produced from raw materials containing starch or sugar via sequential ethanol and acetic acid fermentations. Grape, apple, and other fruit juices are the primary starting materials used for vinegar production although rice vinegar, malt vinegar, and beer vinegar are also produced in some countries. The production of vinegar typically involves a first fermentation where simple sugars in raw material are converted to alcohol by yeasts.^{[2],[15]}

Cane vinegar is obtained by the fermentation of sugarcane juice.^[16]

MACROSCOPIC CHARACTERISTICS:

Colour- Clear, colourless liquid

Odour- Pungent, characteristic odour when diluted

Taste- Acidic taste^[17]

ACTIONS: (ACCORDING TO CONVENTIONAL MEDICINE)

Anticancerous, Antibacterial^[13], Antihypertensive^[18], Antiobesity^{[13],[15]}, Antinfection^[13], Antiglycemic, Antioxidation^{[13],[15]}

USES: (ACCORDING TO CONVENTIONAL MEDICINE)

1. Vinegar is used with water for sponging the body in high fevers.^[19]
2. Vinegar has been used for cleaning and treating nail fungus, head lice, warts, and ear infections.
3. Natural preservative methods for inhibiting the growth of food borne pathogenic microorganisms in food.
4. Vinegar could be used to inhibit pathogenic bacteria on fresh fruits and vegetables.
5. Vinegar has been demonstrated to have a therapeutic effect on burns due to antibacterial properties.^[15]
6. Diluted vinegar is useful in lead colic after a free purge.
7. In uterine haemorrhage it is very useful.
8. It can be used as a disinfectant or antiseptic.^[19]
9. Local application of woolen pack soaked in vinegar is used to stop the swelling of wounds.
10. It is also useful in creeping ulcers, scabies, ring worms and heals the burn more quickly than any other drug.
11. A mouthwash or gargling with addition of common salt or alum is useful in case of throat pain, tooth ache, bleeding gums etc.
12. Vinegar is smeared with honey to prevent dark circles but its constant use weakens the eye sight.^[6]
13. Local application of *sirka* gives relief in local inflammatory pains as from scorpion & bee bites and irritation produced by limestone It is used in various liniments and oils which are readily used for massage as it rapidly absorbs in tissues and relieve muscular stiffness and pain In can be used in nervous headache as already described in Unani.

CHEMICAL CONSTITUENTS:

Natural vinegar contains acetic acid, smaller amounts of non volatile oils, organic acids, malic acid, tartaric acid, citric acid and other acids. Other constituents of vinegar include vitamins, mineral salts, amino acids, polyphenolic compounds (e.g. gallic acid, catechin, caffeic acid, ferulic acid), ligustrazine.^[13]

PHARMACOLOGICAL ACTIVITY:

1. **Anti-infective activity:** Vinegar had a bactericidal effect on food-born pathogenic bacteria including EHEC O157:H7. The bactericidal activity of vinegar increased with the temperature. The use of vinegar with use of an appropriate treatment temperature was found to be markedly effective for the prevention of bacterial food poisoning.^[14]

Mechanism of the antibacterial effects of organic acids. Organic acids in vinegars inhibit the growth of bacteria through the following ways:

- i. Destroying the outer membrane of bacteria
- ii. Inhibiting macromolecular synthesis
- iii. Consuming the energy of bacteria
- iv. Increasing intracellular osmotic pressure and
- v. Promoting the generation of antibacterial peptides in host cells.

Mechanism of the antibacterial effects of polyphenols: The antibacterial activities of the polyphenols present in vinegars are primarily achieved by:

- i. Destroying the integrity of the cell membrane.
- ii. Interfering with the activities of enzymes present in bacteria^[13]

2. **Antihypertensive activity:** A significant reduction in systolic blood pressure (approximately 7 mm Hg) in SHR rats fed a standard laboratory diet mixed with either vinegar or an acetic acid solution (approximately 0.86 mmol acetic acid/day for 6 weeks) was observed when compared with SHR rats fed with the same diet mixed with deionized water. These observed reductions in systolic blood pressure were associated with reductions in both plasma renin activity and plasma aldosterone concentrations (35% to 40% and 15% to 25% reductions in renin activity and aldosterone concentrations, respectively, in the experimental vs control SHR rats). Others have reported that vinegar administration (approximately 0.57 mmol acetic acid, orally) inhibited the renin-angiotensin system in nonhypertensive Sprague-Dawley rats.
3. **Cardio-protective activity:** In another study, a significantly lower risk for fatal ischemic heart disease has been reported among participants in the nurses' health study, who consumed oil-and-vinegar salad dressings frequently (5-6 times or more per week) compared with those who rarely consumed them. This happens because oil and vinegar dressings are a major dietary source of dietary alpha-linolenic acid, an antiarrhythmic agent.^[14]
4. **Lipid metabolism regulation:** Animal experiments have shown that the long-term consumption of a specific amount of acetic acid, grain vinegars, and fruit vinegars can significantly reduce the concentration of total cholesterol, triglycerides, and LDL and increase the concentration of HDL. Moreover, the regulation of lipid metabolism by vinegars was also observed in mice with type 2 diabetes and obese. Experiments on humans (8 wk) have revealed that the consumption of 30 ml apple vinegar 2 times per day can significantly reduce total cholesterol, triglycerides, and LDL levels of patients with hyperlipidemia and increase the content of HDL in a non significant manner. In another study on the effects of vinegar on lipids, triglyceride levels significantly decreased in obese people consuming 15 ml apple vinegar every day. Although reports on the regulation of human lipid metabolism due to grain vinegar consumption have not been published, the long-term intake of grain vinegars may have positive effects, according to previous animal experiments.

Mechanism of the regulation of lipid metabolism by acetic acid: Acetic acid in vinegar also decreases the synthesis of lipids and increases the excretion and decomposition of lipids by activating the AMPK pathway *in vivo*. During the conversion of acetic acid into acetyl-CoA, the activation of the AMPK pathway leads to a reduction in the concentration of cholesterol, triglycerides, and LDL by down regulating the expression of the *srebp-1* gene. Besides, activated AMPK also inhibits the expression of a series of genes related to fatty acid synthesis through the phosphorylation of ChREBP, which reduces the synthesis of fatty acids. In addition, acetic acid reduces the blood lipid content of rats by promoting the oxygenolysis of fatty acids and the secretion of bile; however, further research is required to determine whether these functional properties are prevalent in humans^[13]

5. **Antitumor activity:** The induction of apoptosis in human leukemia cell HL-60 was investigated with sugar cane vinegar, for the elucidation of food factor for cancer prevention contained in naturally fermented vinegar. Fraction eluted by 40% methanol from AmberliteXAD 2 chromatography of sugar cane vinegar showed potent radical scavenging activity and also the activity repressing growth of typical human leukemia cells such as HL-60, THP-1, Molt-4, U-937 and Jurkat.1 In vitro, sugar cane vinegar induced apoptosis in human leukemia cells.

In the human colonic adenocarcinoma cell line Caco-2, acetate treatment, as well as treatment with the other SCFA n-butyrate and propionate, significantly prolonged cell doubling time, promoted cell differentiation, and inhibited cell motility. Because bacterial fermentation of dietary fiber in the colon yields the SCFA, the investigators concluded that the antineoplastic effects of dietary fiber may relate in part to the formation of SCFA. Others have also documented the antineoplastic effects of the SCFA in the colon, particularly n-butyrate. Thus, because acetic acid in vinegar deprotonates in the stomach to form acetate ions, it may possess antitumor effects.

Vinegars are also a dietary source of polyphenols, compounds synthesized by plants to defend against oxidative stress. Ingestion of polyphenols in humans enhances *in vivo* antioxidant protection and reduces cancer risk.

A case-control study conducted in demonstrated that vinegar ingestion was associated with a decreased risk for esophageal cancer^[14]

6. **Antiglycemic activity:** A study demonstrated that in normoglycemic subjects 7 ml white vinegar (5% acetic acid) as a salad dressing ingredient reduced the glycemic response to a mixed meal (lettuce salad and white bread containing 50 g carbohydrate) by over 30% ($P < .05$).

Mechanism of the acetic acid-induced control of blood glucose levels: The acetic acid in vinegars regulates the concentration of blood glucose in the following ways:

- i. Delaying gastric emptying.
- ii. Inhibiting disaccharidase activity.

- iii. Improving insulin sensitivity.
- iv. Promoting the production of glycogen.

Vinegar ingestion at bedtime can help patients with type 2 diabetes to moderate their waking glucose concentration in the next day.

- 7. Antioxidant activity:** *In-vitro* antioxidative activities of various kinds of vinegar were investigated by using a linoleic acid autoxidation model detected by TBA method and the 1, 1-diphenyl-2-picrylhydrazyl radical system.

Antioxidation mechanism of polyphenols: The antioxidant activities of polyphenols in vinegar include the abilities to scavenge free radicals, chelate transition metal ions, and reduce oxidants.^[13]

- 8. Antitubercular activity:** Efficiency of vinegar was tested against *Mycobacterium tuberculosis*. It was found that exposure to 6% solution of vinegar for 30 min successfully killed the bacteria. It was concluded that vinegar is an effective mycobactericidal disinfectant.^{[1], [13], [15], [18]}

- 9. Weight loss:** Obese animal model experiments have proven that the long-term consumption of a specific amount of acetic acid, grain vinegars, or fruit vinegars can significantly reduce the body weight, lipid content, and total cholesterol and triglyceride contents of animals. Human experiments have proven that the long-term intake of fruit vinegars can also significantly reduce the body weight, body mass index, and total cholesterol and triglyceride levels of healthy people with obesity and obese people with high blood pressure.^[13]

Mechanism of weight loss due to acetic acid: Acetic acid in vinegar affects weight loss through the following mechanisms:

- i. Decreasing the synthesis of lipids.
- ii. Increasing the oxygenolysis and secretion of lipids.
- iii. Increasing postprandial satiety.
- iv. Increasing energy consumption.

Acetic acid increases postprandial satiety by stabilizing postprandial blood glucose levels, thereby reducing dietary intake. In addition, acetic acid also increases biological energy consumption by increasing myoglobin levels and upregulating the expression of genes related to the synthesis of fatty acids.

- 10. Improvement in circulation:** Ligustrazine effectively improves blood circulation by inhibiting platelet aggregation and expanding blood vessels *in vivo*. Studies have shown that ligustrazine is a good calcium channel blocker, which can inhibit the aggregation of platelets and the contraction of muscle cells on blood vessels by reducing the internal flow of calcium ion in cells, which improves blood circulation. In addition, ligustrazine can pass the blood– brain barrier, so it is also used in the treatment of cerebrovascular diseases as well as cardiovascular diseases.^[13]

CONCLUSION

The traditional use of medicines implies to ample historical usage and this is perhaps true for almost all traditional medicines. In many developing countries, like India, a major population relies on traditional medicines for healthcare and the trend is now gradually shifting to developed countries as well. WHO has developed separate guidelines for assessment of traditional medicines. Sirka (Vinegar) has a long historical background and besides its usage as a potent medicinal substance, it has been extensively exploited as a common condiment, food ingredient, preservative, flavoring and culinary agent. This review provides significant information regarding the actions and therapeutic uses of Sirka mentioned in traditional Unani Medicine. It also provides substantial information regarding various recent pharmacological and clinical researches validating the already mentioned clinical indications of Sirka. The review also provides a new ray for research. More pharmacological and clinical researches may be designed to search and revalidate the unexplored aspects of Sirka that are already mentioned in Unani classics.

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CONFLICT OF INTEREST

There is no conflict of interest to declare.

REFERENCES

- [1]. Saleem MN, Idrees M. Sirka (Vinegar): From traditional use to scientific approach. JHMR. 2016. 716; 1(02): 32-26.
- [2]. Ghani HN. Khazainuladviya. New Delhi: Idarakitab-us-shifa; YNM. 162, 163, 987, 171-173.
- [3]. Sani T. Qarabadeenesarkari. New Delhi. CCRUM. Institutional area. Janakpuri. 2002:83
- [4]. Khan MA. MuheeteAzam. New Delhi CCRUM. Institutional area. Janakpuri. 2014:69-74

- [5].Hk.ASaleem .Minhajul-saidlawa al kimia.Aligarh.Idarakitabushshifa. 2000:121-122
- [6].Kouser H, Ahmed K, Jahan N, Bano H, Husain S, Shamim M. Sirka (vinegar): A potent unani drug. Am. J. PharmTech Res. 72; 4(6): 12-7.
- [7].Kabeeruddin GM. Makhzanulmufradatbamanikitabuladvia. New Delhi: Idarakitab-us- shifa; 707. 121, 256, 23, 371, 372.
- [8].Kabiruddin H. IlmuladviaNafeesi. New Delhi: Ejaz publishing house. 122, 123, 76, 77, 333, 334.
- [9].Khan MA. Muheet-e-Azam (Persian). Vol 3. Part 2. Kanpur: Matba Nizami; 1892. 23-25.
- [10].Vikanes AV. Causes of hyperemesis gravidarum. Division of epidemiology, Norwegian institute of public health. University of Oslo. 710: 08.
- [11].Sina I. Al Qanoon fit tib (English translation). Vol. 2. New Delhi: JamiaHamdard; 1998. 197, 266, 267.
- [12].Kabeeruddin MH. Bayaz e Kabeer. Vol I-III. New Delhi: Idarakitab-us-shifa; 710. Vol - I: 240, 23, Vol - II: 221, Vol - III: 70.
- [13].Chen H, Chen T, Giudici P, Chen P. Vinegar functions on health: constituents, sources, and formation mechanisms. Comprehensive Reviews in Food Science and Food Safety. 716; 15: 1124-1135.
- [14]. Carol S, Jhonston, Clindy A. Vinegar: medicinal uses and antiglycaemic effect. Med Gen Med. 706: 8(2): 61-74.
- [15].Budak NH, Aykin E, Seydim AC, Greene AK, Seydim ZBG. Functional properties of vinegar. Journal of Food Science. 72; 6 (5): R757-R762.
- [16].Tan S C. Vinegar fermentation. B.S. Mechanical Engineering, University of Louisiana at Lafayette. 705: 10.
- [17]. Kluwer W. Remington. The science and practice of pharmacy. Vol I. 21st ed. Lippinkot: Williams and Wilkins; YNM. 126-128, 143.
- [18].Pazuch C M, Siepmann FB, Canan C, Cola E. Vinegar: functional aspects. Jaboticabal. 715; 43 (4): 302-308.
- [19].Nadkarni KM. Indian materiamedica. Vol- I. Mumbai: Popular prakashan (P) Ltd; 710. 346-348, 144-146.

