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QUERCUS (OAK) TREES OF ISRAEL AND PALESTINE UPDATED REVIEW

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ABSTRACT

Quercus (oak) trees are of the most prominent species that comprise the landscape between the Jordan River and the Mediterranean Sea. They are unmistakable. Humans used them since ancient times for various objectives, and this review article will focus mainly on ethnomedicinal and activities-properties that modern research found. Among those, antimicrobial activity is the most published. Other activities such as anticancer, anti-inflammatory, wound healing and antimalarial were also published multiple times. Interestingly, and maybe strangely, the chemical compositions of these plant were very partially published, and unique natural products from these trees are scarcely known. Most of the research so far focused on acorns, which are also the edible parts for humans, in most cases. Leaves and other parts of these trees, that can reach impressive size, were not significantly studied. Some researchers addressed the concerns about the toxicity of some parts of these trees and this topic will be presented and discussed as well.

KEYWORDS: *Quercus*, *Quercus infectoria*, antibacterial, anticancer, anti-inflammatory, antimalarial, ethnomedicine, chemical composition, food source, wound healing.

Abbreviations: ABTS 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid), ahc and her/his colleagues, AChE acetylcholine esterase, BuChE butyrylcholine esterase, CNS central nervous system, COX cyclooxygenase, CUPRAC cupric reducing antioxidant capacity, DEE diethyl ether, DPPH 2,2-Diphenyl-1-picrylhydrazyl, DCM dichloromethane, DEE diethyl ether, DMSO dimethyl sulfoxide, EDTA ethylenediaminetetraacetic acid, EO essential oil, FRAP ferric reducing activity power, GCC general chemical composition, GC-MS gas chromatography mass spectrometry, HPLC high performance liquid chromatography, IR

infrared (spectroscopy), LC-MS liquid chromatography mass spectrometry, LOX lipoxygenase, MDA malondialdehyde, MPO myeloperoxidase, NDGA nordihydroguaiaretic acid, NMR nuclear magnetic resonance (spectroscopy), PE petroleum ether, ROS reactive oxygen species, SOD superoxide dismutase, STZ streptozotocin, TAC total antioxidant capacity, TBARS thiobarbituric acid reactive substances, TEAC Trolox equivalent antioxidant capacity, TFC total flavonoid content, TPC total phenolic content, TRPA total reducing power ability, TTC total tannins content.

1) Introduction: Taxonomy, Archeology and Published Review Article

The *Quercus* genus (Oak) is part of the Fagaceae family, which consists of 8-10 genera and around 1000 species.[1] Even though these numbers are debated, most researchers accept them, especially the numbers of species.[2] In the reviewed region, the Fagaceae family includes a single genus, *Quercus*, and it includes five species of Oak: *Quercus boissieri* syn. *infectoria*, *Quercus calliprinos* syn. *coccifera*, *Quercus cerris*, *Quercus ithaburensis* and *Quercus look*.[3] As for *Quercus boissieri*, there is a notable debate about its relations with *Quercus infectoria*. Some researchers tend to consider *Q. boissieri* a subspecies of *Q. infectoria*[4], while others see it the other way round. According to "Flora of Israel and adjacent areas"[3], one of the best botanical websites of the reviewed region plants, *Quercus boissieri* and *Quercus infectoria* are synonym botanical names, and practically, it is the same species. In this review article, we will accept this classification. In addition to that, we will accept the botanical taxonomy of *Quercus calliprinos* syn. *coccifera*.[3,5]

Generally, *Quercus* trees are robust with relatively hard wood. For this reason, they have been used by humans since early times for construction and firewood. One of the earliest known uses was reported by M. Rybnicek ahc that reported an archaeological study that found oldest construction wood, where most of it was produced from *Quercus* ssp.[6] T. Engel and W. Frey found that *Q. calliprinos* was used by ancient populations of Wadi Arabah, Jordan, as firewood in the copper smelting process.[7]

In our literature search we found around 18 published review articles about the *Quercus* tree family. And after carefully examining them, we found that ten of them have real significance to our review article. The major characteristics of these articles are listed in **Table 1**.

Table 1: Selected published review articles about *Quercus* trees of Israel and Palestine.

Author(s) [Reference]	Pages/ References	Major focus	Traditional Uses	Medicinal Activities	Chemical Composition
M. Taib ahc[8]	20/120	General *Quercus*	Yes	Yes	Very extensive
H. Migaskó and K. Ecseri[9]	6/38	General *Quercus*	Yes Nutrition Extensive	No	No
E. Burlacu ahc[10]	24/133	General *Quercus*	No	Yes	Very extensive
R. Banc ahc[11]	48/134	General *Quercus*	Partial	Extensive (galls)	Extensive (galls)
W. Ahmad ahc[12]	6/27	*Q. boissieri* General	Yes	Partial	Very partial No structures
N.N. Zin ahc[13]	17/57	*Q. boissieri* Antiparasitic	Partial	Partial	No
M. Jain ahc[14]	6/43	*Q. boissieri* Oral health	Partial	Partial Mechanisms	No
S.F. Askari ahc[15]	9/85	*Q. boissieri* General	Yes	Partial	No
W. Amilah ahc[16]	8/63	*Q. boissieri* General	Partial	Yes	No
A. Alam ahc[17]	8/79	*Q. boissieri* General	Yes Extensive	Yes Detailed	No
H. Hapidin ahc[132]	7/71	*Q. boissieri* Osteoblast	Partial	Partial	Very partial No structures

2) Ethnobotany and Ethnomedicine of *Quercus* Trees of Israel and Palestine

As mentioned in the **Introduction**, the major traditional uses of the *Quercus* trees are for construction and firewood, although some medicinal uses were also known and documented. A summary of these published uses is presented in **Table 2**.

Table 2: Ethnobotany and Ethnomedicine of *Quercus* Trees of Israel and Palestine.

Species	Country/Region, Uses, Reference
Q. boissieri syn. *infectoria*	Palestine, Bark, decoction (detailed); treat diarrhea[18] Turkey, Aerial parts, extract; dyes for textiles (rugs)[19] Turkey, fruits; animal food[25] Jordan, fruits, decoction; astringent[27]
Q. calliprinos syn. *coccifera*	Greece, Rhizomes, topically applied decoction; treat wounds, eczema, psoriasis[20] Israel, fruits/bark, decoction; anticancer[21] Syria, fruits/bark, decoction; antibleeding, pain reliever, promote digestion, blood purification, cough, eczema[22] Jordan, fruits/bark, decoction; anticancer[23] Syria, fruits/leaves, decoction; antidiabetic, intestinal infections, wounds and burns, hemorrhoids, tonic[24] Jordan, fruits, decoction; treat constipation[27] Turkey, galls, decoction; anti-diarrhea[29]
Q. cerris	Greece, Rhizomes, topically applied decoction, treat eczema, psoriasis[20] Turkey, fruits, decoction; infections, hemorrhoids, skin disorders, eczema[25]

Q. ithaburensis	Syria, stem/bark, decoction; cancer, fever, bed wetting, high blood pressure, ulcer[22] Turkey, fruit cupula, aqueous extract; colors[25] Israel and Palestine, bark/fruits/stem, decoction (detailed); cancer, fever, bed wetting, high blood pressure, ulcer[26] Jordan, fruits, decoction; anti-inflammatory[27] Turkey, fruits, decoction; stomachic, anti-diarrhea[28] Turkey, galls, eaten; anti-diarrhea[29]
Q. look	None, None

3) Published Activities-Properties of *Quercus* Trees of Israel and Palestine

The published activities-properties of *Quercus* trees are diverse but reveal two important and surprising facts. First, most published properties activities are of *Quercus boissieri* syn. *infectoria*. Second, the antimicrobial activity tops the list. A summary of these activities-properties is presented in **Table 3**.

Table 3: Published Activities-Properties of *Quercus* Trees of Israel and Palestine.

Activity-Property, Testing Method(s), Result(s), Reference
Quercus boissieri syn. ***infectoria***
Galls methanolic extract was purified several times (fraction A) and partitioned with water (fraction B), *n*-butanol (fraction C) and with ethyl acetate (fraction D). Mice were used for *in vivo* tests. Fraction A was tested for analgesic (tail flick) and antidiabetic (blood sugar) activities. Fraction B was tested for sedative-hypnotic (spontaneous motor activity), barbiturate potentiation, anti-tremorine and analgesic activities.[30]
A follow-up of previous study: galls methanolic extract was fractionized with several solvents and solvent mixtures, the chromatographed affording syringic acid (**Figure 1A**), which was active in three tests (*in vivo*, mice) anti-contraction induced by tremorine, potentiation of pentobarbital sodium and anaesthetic.[31]
Fruits ethanolic extract was prepared and analyzed for GCC. It tested for antimicrobial (four bacteria species and *Candida albicans*), antioxidant (*in vitro*, enzymes), anti-inflammatory (carrageenan-induced paw edema in rats) and antiparasitic (earth worm) activities.[32]
Galls methanolic extract showed weak (21.4%) AChE inhibition.[33]
Galls methanolic extract had antihyperlipidemic activity and inhibition of atherosclerotic plaque formation, in rabbits.[34]
Galls methanolic extract had very strong (100%) dihydrofolate reductase inhibition activity. Kinetic study is presented.[35]
Galls were successively extracted with *n*-hexane, ethyl acetate and methanol, and the GCC of each extract was analyzed. Extracts were tested against human cancer cell lines (HeLa, MDA-MB-231, Hep G2) using L929 cell line as reference. Effect was weak.[36]
Galls ethyl acetate extract was strongly active against HeLa (human cervical cancer cells) and weakly active against Vero (African green monkey kidney cells).[37]
Galls aqueous extract was active against CCND1, TP53, BCL2 and BAX cancer cells. The extract was partially and qualitatively analyzed by GC-MS yielding nine compounds.[38]
Galls were separately extracted with 80% aqueous ethanol*, ethyl acetate and PE. The extracts were analyzed for GCCs and found active against MCF-7 cancer cells.[39]
Galls aqueous extract was eluted for gallotannin-rich fraction which was obtained by using 50% aqueous methanol (71.15%). This fraction had high antioxidant activity (DPPH and FRAP methods) and strong anticancer activity (DBTRG-05MG cells) with Tamoxifen and Temozolomide as standard drugs, and crude extract and synthetic gallotannin as other two references. The gallotannin-rich fraction was active as the

standard drugs.[40]
Galls ethanolic extract had nephroprotective activity against Fe-NTA (ferric nitrilotriacetate) induced renal oxidative stress, hyperproliferative response and renal carcinogenesis in rats. Effect was measured by using more that fifteen biomarkers.[41]
Galls methanolic extract had activity against isoniazide-induced clonic convulsion using rat model, with diazepam as reference.[42]
Aqueous and methanolic galls extracts were active against STZ-induced diabetes in rats, with acarbose as reference. Effect was observed by blood glucose decrease and α-glucosidase inhibition.[43]
Galls methanolic extract increased insulin secretion in BRIN BD-11 cells.[44]
Galls 90% aqueous ethanolic extract was active against castor oil or magnesium sulfate-induced diarrhea in mice, with loperamide as positive control. Effect was measured by diarrheal faeces and gastrointestinal motility.[45]
Galls ethanolic extract was defatted with PE and used against paw/ear edema in rats (*in vivo*), separately induced by several chemicals. It had also against LPS-induced inflammation in microphages (*in vitro*). Indomethacin and dexamethasone were reference drugs.[46]
Galls powder was dissolved in DMSO and was used to treat two inflammation conditions: IL-β1-induced in human gingival fibroblast cells, and aphthous in rabbit ears. Effect was measured with several biomarkers. Prednisolone and COX-2 inhibitor (NS398) were used as standard drugs, respectively.[47]
Galls were extracted with 50% aqueous methanol yielding tannin-rich extract, which was used to prepare a hydrogel that was active against xylene-induced ear edema in rats. Effect was measured by several biomarkers and several reference drugs were used.[48]
Galls 90% aqueous ethanolic extract was used to treat N-ethylmaleimide-induced inflammation in rats. Effect was measured with concentrations of: MDA, nitric oxide, MPO and SOD.[49]
Fruit hulls methanolic extract treated formalin-induced paw edema in rats and had analgesic effect, compared with diclofenac as standard drug.[50]
Galls acetone extract was active against *Plasmodium falciparum* (malaria parasite). Effect was measured with parasite mortality (caused by pH alteration) ratio.[51]
Another research published by the same group using similar methods but, in this case, acetone, aqueous, methanolic and ethanolic extracts were applied. Acetone and methanolic extracts were most active. In addition, the toxicities of the extracts were tested using brine shrimp method.[52]
Galls aqueous and ethanolic extracts were separately active against 15 bacterial strains with seven standard antibiotics used as references.[53]
Galls 95% aqueous ethanolic extract was fractionized and chromatographed affording gallic and tannic acids (**Figure 1A**). Crude extract, ethyl acetate faction and both acids were active against *S. aureus*, compared to three standard drugs.[54]
Galls were separately extracted with PE, chloroform, methanol and water, and all extracts were tested against five dental bacterial species (*S. aureus*, *S. salivarius*, *S. mutans*, *L. acidophilus*, *S. sanguis*). Aqueous and methanolic extracts were most active.[55]
Galls 50% aqueous ethanolic extract had activity against four *E. coli* subspecies.[56]
Seeds methanolic extract had weak to moderate activity against seven bacterial strains compared to ampicillin as standard drug.[57]
Galls 50 and 90% aqueous ethanolic extracts and one of their fractions had activity against seven *E. coli* subspecies.[58]
Galls aqueous, ethanolic and methanolic extracts were tested against eight bacterial strains isolated from wounds, compared with fifteen standard antibiotics.[59]
Galls aqueous and 95% aqueous ethanolic extracts were active against two *Candida* subspecies (*C. albicans*, *C. glabrata*) isolated from vaginal swabs.[60]
Follow up of previous studies[53,54,56,58] where galls 95% aqueous ethanolic extract, its fractions and active components (syringic, gallic, tannic and ellagic acids, **Figure 1A**) were active against *S. aureus*. Vancomycin was reference drug.[61]

Galls were separately extracted with *n*-hexane, chloroform, ethanol and water, and the extracts were tested against three bacterial strains (*E. coli*, *B. subtilis*, *S. aureus*). Aqueous and ethanolic extracts were most active compared to tetracycline and kanamycin as standard drugs.[62]

Galls were separately extracted with acetone/methanol/aqueous-ethanol and the extracts showed significant activities against *S. aureus*, with vancomycin as reference.[63,64,67,68]

Galls aqueous extract was active against *P. aeruginosa*, *C. albicans* and *S. aureus*.[65]

Galls methanolic and extracts were active against *S. mutans*, *S. salivarius*, *P. gingivalis* and *F. nucleatum*, with chloramphenicol as positive control.[66]

Galls methanolic extract had significant activity against *Enterococcus faecalis* with chlorhexidine as reference drug.[69]

A follow up of the work cited in reference 56 but in this case, the effect of ellagitannin isolated from the extract (**Figure 1A**), was tested, in rats.[70]

Galls 96% aqueous ethanolic extract was active against *Saprolegnia*, with malachite green as reference antifungal agent.[71]

Commercial extract (not specified) was added to films prepared from polysaccharides of seeds of *Cassia fistula* and *Delonix regia*, had activities against *B. subtilis*, *S. aureus*) and *E. coli*. Films with no extract (no antibacterial activity) were control in this study.[72]

Extract (unspecified) was analyzed for pigments and these had activity against five bacterial and two fungal species.[73]

Fruits were separately extracted with water and ethanol and these extracts were active against mixed dental bacteria (unspecified).[74]

Galls were extracted with acetic acid and TPC of the extract was determined as well as single phenolic compounds were identified (tannic acid was major compound, 52.85%). The extract was tested and found active against *S. aureus*, *P. aeruginosa*, *E. coli*, *S. typhimurium* and *B. subtilis*.[75]

Galls aqueous and 84% aqueous-ethanol extracts were active against six bacterial strains. Positive control was bacterial suspensions in Mueller Hinton Broth.[76]

Galls aqueous extract was analyzed for GCC and formulated with Carbopol 940 and triethanolamine. The formulation was active against *Psedomonas aeruginosa* spp.[77]

Galls 70% aqueous ethanolic extract was active against chicken egg microbial species: *S. aureus*, *E. coli*, *P. aeruginosa*, *S. typhimurium* and *C. albicans*. Extract was chromatographed for chemical composition and the three major components were (%): 4-hydroxybenzoic acid 7.4, pyrogallol 7.2 and catechol 6.7 (**Figure 1A**).[78]

A follow-up of the research cited in reference 76: against *Leptospira interrogans*.[79]

Galls methanolic extract was active against *S. aureus*, *P. aeruginosa* and *E. coli*. Analysis of the extract (HPLC) yielded chlorogenic acid, caffeic acid and quercetin (**Figure 1A**) as major compounds.[80]

Galls were separately extracted with *n*-butanol, ethanol, ethyl acetate and water, and the extracts found active against *Pseudomonas aeruginosa* recovered from burns wounds. Mechanism of action is presented based on the effect of extracts on gene (las, hl, and exotoxin A) genes.[81]

Galls were extracted with 80% aqueous ethanol affording phenolics-rich (especially free gallic acid, 8.68 g in 100 g dry extract) extract. This extract was active against vaginal pathogens: *E. coli*, *S. aureus*, *S. agalactiae*, *C. albicans*, *C. krusei*, *E. faecium*, *L. acidophilus*, *G. vaginalis* and *T. vaginalis*. Metronidazole was standard drug reference.[82]

Bark ethanolic extract had activity against *S. aureus*, *E. coli* and *K. pneumonia*. Amoxicillin was standard antibiotics, and for *E. coli*, the extract was more active than the drug.[83]

Galls aqueous extract was analyzed for GCC and found active against *Rothia dentocariosa* isolated from oral cavity.[84]

Galls were separately extracted with ethanol, methanol and water, and the three extracts were active against *Salmonella typhi* and *Salmonella enteritidis* in a time and dose dependant manner. Ciprofloxacin was standard antibiotics. GC-MS analysis of the methanolic extract afforded 1,2,3-benzenetriol (**Figure 1A**) as major component.[85]

Galls were separately extracted with ethanol, methanol and water, and the methanolic extract was dissolved in

methanol-ethyl acetate in four ratios. These solutions were tested against *Pseudomonas aeruginosa* and *Escherichia coli*, separately or in combination with ceftazidime (standard antibiotic). The combination proved to have synergistic effect.[86]

Galls were separately extracted with acetone, ethanol and water. The extracts solutions were combined and evaporated yielding an oily mixture. This mixture was analyzed for GCC and chromatographed to determine tannic acid content. The oily extract was found active against five bacterial strains.[87]

A handwash containing galls 70% ethanolic extract had activity against *S. aureus*.[88]

A gel containing ethanolic extract was active against *S. aureus* and *P. aeruginosa*. The extract was chromatographed (HPLC) to determine the content of gallic and tannic acids.[89]

A gel containing ethanolic extract was active against *S. aureus* and *P. aeruginosa*, *E. coli* and *C. albicans*.[90]

A gel containing ethanolic extract was active against oral *C. albicans*.[91]

Hand sanitized containing galls ethanolic extract was active against ten bacterial strains and *C. albicans*.[92]

A follow up of the research cited in [88]. Galls 50% aqueous ethanolic extract was analyzed for GCC and the content of gallic and tannic acids was determined. The extract was used to prepare a formulation that was active against *S. aureus*, *P. aeruginosa* and *E. coli*.[93]

Galls 80% ethanolic extract was fractionized with 15% aqueous ethanol yielding water soluble material. This material was active against *S. mutans*, *S. sobrinus*, and *C. albicans*. It was also used to prepare mouthwash, separately and in combination with *Scrophularia striata* aerial parts extract, and the products were tested against the same microbes.[94]

Bark aqueous and ethanolic extracts were active against 50 *S. aureus* subspecies.[95]

Galls 70% aqueous ethanolic extracts was analyzed for GCC and partially chromatographed for phenolic compounds, where gallic acid had highest concentration, 12.75 g/g dried matter. The extract was active against nine bacterial strains, with tetracycline, gentamicin and ampicillin as standard drugs. It also had antioxidant activity tested with DPPH method[96]

Galls ethanolic extract was analyzed for TFC, TPC, soluble tannic contents, fatty acids composition (oleic acid had highest, 43.2% of fatty acid content) and its phenolic content was analyzed (28 g/1 kg dry matter). It had antidiabetic (α-amylase and α-glucosidase inhibition), antioxidant (ABTS, CUPRAC, DPPH and FRAP methods) and antimicrobial (14 bacterial and microbial species) activities. Authors conclude that the antimicrobial activity can be utilized for milk preservation.[97]

Bark methanolic extract was tested for antibacterial (ten species), antiulcer (ethanol induced in rats), anti-inflammatory (carrageenan-induced and formalin-induced paw edema, in rats) and antidiabetic, antihyperlipidemic (in extract-pre-treated rats) activities. The last effect was measured by nine biomarkers.[98]

Galls were separately extracted with acetone, ethanol and water, and the three extracts were analyzed for GCC. The extracts were tested against dermatophytes infections in rats.[99]

Tannins-rich gall extracts were prepared by fractionation of crude aqueous extract with 70% aqueous acetone and 95% aqueous ethanol. These fractions were active against *Trichophyton mentagrophytes* fungus.[100]

Galls were separately extracted with water and 95% aqueous ethanol, and both extracts were active against eight fungal strains: *A. flavus*, *A. fumigates*, *A. ochraceous*, *C. cladosporioides*, *P. citrinum*, *S. chartarum*, *M. gypseum* and *T. rubrum*.[101]

Galls ethanolic extracts was analyzed for TPC, TRPA and for content of gallic and tannic acids (8.75 and 19.93%, respectively). Its antioxidant activity was measured with the following methods: ABTS, DPPH, FRAP, hydroxyl radical scavenging, hydrogen peroxide reduction, lipid peroxidation, metal (Fe^{+2}) chelating and ROS quenching (*t*BuOOH).[102]

Galls methanolic extract was analyzed for TPC and was active against $NaAsO_2$ -induced oxidative stress in rats. Effect was measured with FRAP, TAC and lipid peroxidation (measurement of MDA) methods.[103]

Galls methanolic extract was separately extracted with methanol and water. Both extracts were analyzed for compound families: phenolics, tannins, alkaloids, flavonoids, saponins, terpenoids, quinines, triterpenes and cardiac glycosides. The contents of gallotannin (tannic acid) and phlobatannin (phlobaphene, **Figure 1A**) were also determined. Results indicated clear differences between the two solvents.[104]

Fruits methanolic extract had antioxidant (DPPH, L-dopa oxidation methods) and tyrosinase inhibition

activities.[105]
Galls 50% aqueous ethanolic extract was analyzed for TPC and tested against *Naja naja* venom, *in vivo* (rats, local tissue necrosis). It was also tested *in vitro*: phospholipase A2, proteases, hyaluronidase and L-amino acid oxidase. Tannic acid was reference phenolic compound.[106]
Fruits aqueous extract was supplemented to pregnant female rats and overall results indicated some toxicity. In details: there was no increase of animals mortality nor significant behavior changes, but abortion and early parturition with lower weight of the pups were observed. In addition, notable increases in eight blood parameters were observed.[107]
Fruits were separately extracted with 80% aqueous methanol and water, and both extracts were analyzed for TPC and tested for antioxidant activity (ABTS, DPPH methods). In this research, many plants were used and they were selected due to their reputation in Jordanian traditional medicine as antidiabetic.[108]
Some nutritional ingredients and condensed tannins content (15.5 g/kg in dry matter) were determined in fruits.[109]
Leaves were analyzed for five macro (Ca, K, Mg, Na, K) and four micro (Cu, Fe, Mn, Zn) elements compositions, in order to compare six species for sheep food.[110]
An earlier study by the same group of the research cited in reference 110, in order to compare five species for sheep food. Leaves were analyzed for gas production and GCC.[111]
Galls methanolic extract was chromatographed affording ellagic and gallic acids.[112]
Galls aqueous and methanolic extracts were analyzed for TFC and TPC.[113]
Monthly changes in leaves macro elements (Ca, K, Mg, N, K, P) composition.[114]
Galls EO (solid phase microextraction) was analyzed for TFC and TPC. It was tested for antimicrobial (ten bacterial and three fungal strains) and antioxidant (CUPRAC and FRAP methods) activities. It was also analyzed for chemical composition where the four major components (%) were: *Z*-anethol 28.55, pentadecanolide 26.44, diethyl phthalate 6.46 and acetoin 5.66 (**Figure 1A**).[115]
Analysis of galls super-critical-CO_2 extract yielded three major compounds (%): tannic acid 67.18, quinic acid 7.99 (**Figure 1A**) and gallic acid 2.57.[116]
Analysis of galls methanolic extract yielded twelve compounds (**Figure 1B**) where some are new. The IR and the GC-MS spectra are presented in detail. For each one of previously known compounds, a reported pharmacological activity is indicated.[117] a
Fruits were analyzed for GCC and qualitatively for chemical composition (GC-MS, 24 previously known compounds), in order to determine the usability of these fruits as feed additive for lactating ewes. Milk amount increased.[118]
Galls 80% aqueous methanolic extract had gastroprotective activity against ethanol-induced ulcer in rats. Effect was measured by gastric acidity and six stomach histological parameters. Healthy animals were control group is this study.[119]
Galls powder, topically applied twice by female patients with gingivitis had ameliorating effect. In addition to gingivitis measurement, oral pH was improved.[120]
An earlier study by the previous group where they topically tested the effect of galls powder on gingivitis and plaque in human patients. Alleviating effects were recoded.[121]
Galls 50% aqueous ethanolic extract was analyzed for TPC and had hepatoprotective activity against carbon tetrachloride-induced damage in rat liver. It was tested for anti-inflammatory activity by 5-LOX inhibition (with NDGA as a reference). Extract antioxidant activity was tested by DPPH, hydroxyl radical scavenging and Fe^{+2} chelating methods; with ascorbic acid, D-mannitol and EDTA as references, respectively.[122]
Galls 70% aqueous ethanolic extract had hepatoprotective activity against carbon tetrachloride-induced damage in rat liver. Effect was measured with eight antioxidant and anti-inflammatory biomarkers. Silymarin was reference compound.[123]
Leaves were analyzed for animal food parameters: TPC, TTC, gas production and digestibility. Results show that these leaves can be used as feed for small ruminants.[124]
Leaves and their DEE extract were analyzed for nutritional components.[125]
Galls 80% aqueous ethanolic extract was analyzed for partial nutritional composition and supplemented to

mice, resulting immunomodulatory effect (leukocytes count).[126]
Galls aqueous extract decreased NO production and had immunomodulatory effect (leucocytes count and analysis: six biomarkers) in macrophages.[127]
Galls were successively extracted with chloroform, methanol and water, and separately with acetone to obtain tannin-rich extract. Also, ethyl acetated and *n*-butanol extracts were separately prepared. Except chloroform extract (not tested) all other five extracts showed significant insecticidal activity against mosquito (*Anopheles stephensi*) larvae.[128]
Leaves ethanolic extract was separately and in combination with cypermethrin, against Khapra beetle (*Trogoderma granarium*).[129]
Galls aqueous extract had positive effects on basic contractility, frequency and strength of isolated virgin female rats uterus smooth muscle.[130]
Galls were defatted with PE and extracted with ethanol, and the extract was analyzed by GC-MS, where the three major components were (%): gallic and ellagic acids (46.8 and 35.5, respectively, **Figure 1A**) and lup-20(29)-ene-3,28-diol (15, **Figure 1B**). The extract was supplemented high-fat, STZ-induced diabetic rats resulting clear protective effects that were measured with: blood glucose concentration, serum lipid profile, glycated haemoglobin, insulin resistance, oxidative stress and the expression of transforming growth factor-β.[131]
Galls aqueous extract increased the proliferation of human fetal osteoblast cells 1.19 and the level of alkaline phosphatase.[133]
A follow-up of previous study. Galls aqueous extract was fractionized with four solution mixtures of ethyl acetate-methanol-acetonitrile-water in four different ratios. These four fractions were partially analyzed for phenolics composition (gallic acid was major component, and in one fraction, phaseolic acid, **Figure 1B**, was detected). All fractions enhanced bone biomarkers in human fetal osteoblast cells 1.19.[134]
Fruits were partially analyzed for GCC to use them in the future to treat skin diseases.[135]
Galls methanolic extract was analyzed for TFC and TPC; and tested for antioxidant activity using DPPH method. The extract was used to prepare an emulsion for skin protection, and it was tested *in vitro* (several tests) and *in vivo* (human female volunteers) , resulting notable activities.[136]
A gel prepared with galls powder was found safe in brine shrimp test and for rats with aphthous ulcer.[137]
Feeding lambs with leaves, stems and fruits (150 g/day, 10-13 days) caused the death of some of these animals, mainly these with a history of anorexia and recumbency. Testing several biomarkers and body changes indicated that toxicity occurred in many ways.[138]
Galls aqueous extract caused no mucosal irritation and no toxicity in mice.[139]
Kinetic study of tyrosinase inhibition by galls methanolic extract is reported.[140,141]
Galls were extracted with a mixture (no ratio) of DEE-ethanol-water, and the extract was partitioned with PE and ethyl acetate, resulting four fractions: PE, DEE ethyl acetate and aqueous. These fractions had wound healing activity in rats, tested by incision, excision and dead space
(granulation) wound models. Aqueous fraction was most active, and authors relate this result with higher content of flavonoids, tannins and other compounds.[142]
Galls 70% aqueous ethanolic extract was used to prepare two ointments: 2 and 4%. These had wound healing activity (wound closure of excision wound model) in rats, where the 4% content was more efficient.[143]
Galls ethanolic extract had wound healing (excision/incision wound models) in rats. Effect was also detected by concentrations increase of antioxidant enzymes: SOD and catalase. The dose of 800 mg/kg of body weigh was more effective than 400 mg/kg.[144]
Galls aqueous extract ointment (5%, 21 days) had better wound healing activity than phenytoin cream, in rats. In addition to wound closure, several histological parameters were tested and proved the effectiveness of the extract.[145]
Galls 95% aqueous extract was analyzed for TFC, TPC, and tested for antioxidant (ABTS, DPPH methods). Twenty formulations that contained this extract were prepared and based on their antibacterial (*S. aureus*) the most active was selected. This formulation had very high wound healing activity in STZ-induced diabetic rats.[146]

Fruits thin shell (pair) used to prepare a cream that had ameliorating effect in women nulliparous with episiotomy (wound).[147]
A follow-up of the work cited in reference 146, and it was analyzed for tannic acid content. In this case antioxidant activity was tested with ABTS, DPPH and FRAP methods. Wound healing activity was tested in L929 murine fibroblast cell line (H_2O_2 model).[148]
Galls were separately extracted with water and 40% aqueous acetone, and both extracts were analyzed for TTC and tested for antioxidant activity with DPPH method. Molecular docking was performed for wound healing potential of 13 compounds contained in the extracts.[149]
Peeled fruits were PE affording oil that was analyzed with several methods according to the compounds to be detected. Oleic acid was major fatty acid, γ-tocopherol was major tocopherol and β-sitosterol was major phytosterol.[165]
Oil was prepared from fruits by extraction with *n*-hexane/*iso*-propanol (3:2), and the oil was analyzed (GC-MS) for fatty acids: oleic acid was major component.[187]
a) Strangely, the NMR data of the new compounds is not presented.

Quercus calliprinos syn. ***coccifera***
Fruits were separately extracted with 80% aqueous methanol and water, and both extracts were analyzed for TPC and tested for antioxidant activity (ABTS, DPPH methods).[108]
Some nutritional ingredients and condensed tannins content (26.7 g/kg in dry matter) were determined in fruits.[109]
Leaves were analyzed for five macro (Ca, K, Mg, Na, K) and four micro (Cu, Fe, Mn, Zn) elements compositions, in order to compare six species for sheep food.[110]
An earlier study by the same group of the research cited in reference 110, in order to compare five species for sheep food. Leaves were analyzed for gas production and GCC.[111]
Leaves 70% aqueous acetone extract was analyzed for TPC, TTC and condensed tannins, and was tested against *B. subtilis*, *S. aureus* and *P. mirabilis* bacteria strains. The antimutagenic activity was tested on *Allium cepa* (onion) root tip cells.[150]
Leaves were extracted with *n*-hexane, chloroform, methanol, boiled water (soaking) and water (microwave-assisted). The five extracts were analyzed for partial GCCs, tested for antioxidant (DPPH method) and anticancer (NCI-H2126 lung cancer, BT-20 breast cancer, DU-145 prostate cancer) activities. In both tests, methanolic and aqueous (soaking) extracts were most potent.[151]
Aqueous and ethanolic extracts were prepared from each part of the fruit (3 parts, six extracts), and these extracts were tested for anticancer (A549, MCF-7, HeLa cancer cells) and lactate dehydrogenase release activities. Ethanolic extracts were most active.[152]
Follow-up research of the study cited in reference 151, using same extraction method. In the present study, α-amylase inhibition of the extracts was evaluated. Extracts were profiled using NMR and LC-MS methods.[153]
Stems and bark methanolic extract was analyzed for active compounds yielding six compounds with potential of inhibiting α-glucosidase and tyrosinase. For tyrosinase inhibition, activity (IC_{50}, μg/mL) order was: polydatin (**Figure 2**) > (-)-8-chlorocatechin (**Figure 2**) > extract (kojic acid was reference), and for α-glucosidase (acarbose was reference), extract > (-)-8-chlorocatechin > cocciferoside (**Figure 2**). Molecular docking was performed.[154]
Fruits aqueous extract had moderate α-amylase inhibition. It was analyzed for TPC and phenolic composition where the major component was chlorogenic acid, 41.2%,[155]
Similar methods as in the study cited in reference 151 (Plant material, extraction, GCC, TPC and antioxidant activity). Extracts were tested for antibacterial activity against *S. aureus*, *S. pneumoniae*, *P. aeruginosa*, *E. coli* and *B. melitensis*.[156]
Leaves 70% aqueous ethanolic extract had notable porcine pancreatic lipase inhibition, and its antioxidant activity was tested with DPPH) and TRPA methods.[157]
Stems aqueous and methanolic extracts were analyzed for TPC and tested for antioxidant activity using DPPH, NO scavenging and SO (sulfur monoxide radical) methods.[158]
Fruits and leaves were separately extracted ultrasound-assisted methanol. The extracts were analyzed for TFC,

TPC and semiquantitative-analysis for chemical compositions. The antioxidant activities of the extracts were tested using ABTS and DPPH methods. Fruits had much higher TPC and was more active in both antioxidant assays.[159]
Leaves 70% aqueous ethanolic extract was analyzed for TPC and was active against *Heterorhabditis bacteriophora* (nematode).[160]
The effect of seasonality on leaves/fruits nutritional compositions is reported.[161,162]
Peeled fruits were analyzed for GCC, TFC and TPC. The ethanolic extract was analyzed for single amino acids (aspartic acid was highest, 0.2 g/kg) and minerals (potassium, 8.2 g/kg). Analysis of fatty acids in oil of these fruits showed that oleic acid composed 50% of totals acids of this oil, and β-sitosterol (**Figure 2**) composed 94% of total sterols content of this oil.[163]
Nutritional values of DEE extract of aerial parts were determined. These plant parts were also analyzed for the same purpose and their digestibility in goats is reported.[164]
Peeled fruits were PE affording oil that was analyzed with several methods according to the compounds to be detected. Oleic acid was major fatty acid, γ-tocopherol was major tocopherol and β-sitosterol was major phytosterol.[165]
Partial general nutritional composition is reported.[166]
Coffee was prepared from peeled dried fruits, with or without roasting. The coffees and the fruits were also extracted with 80% aqueous ethanol. All extracts had moderate to notable inhibition of AChE, BuChE and tyrosinase.[167]
Follow-up of previous study. The three parts of the fruit, shell, cup and peeled acorns, were separately extracted with 70% aqueous ethanol (6 extracts), and each extract was analyzed for TFC and TPC. Their antioxidant activity was tested with DPPH and FRAP methods. Their neuroprotective activity was tested by inhibition of AChE, BuChE. [168]
Stem and bark aqueous extract was used to prepare and ointment (1% extract) that had wound healing effect in rats.[169]
Consumption of leaves and buds caused toxicosis (death) of cattle.[170]
Follow-up of the research cited in reference 169. Stems aqueous and methanolic extracts had wound healing activity, tested *in vitro* (two cell lines). Extracts were analyzed for TPC and tested for antioxidant activity with DPPH method. The antibacterial activity of the extrcts was tested against nine bacterial strains. The effect of extracts on collagen was tested with hydroxyproline assay, and anti-inflammatory effect was measured by tumour necrosis factor-alpha (TNF-α) method.[171]
Peeled fruits were defatted with *n*-hexane and extracted with slightly basic water to obtain (after acidification) protein hydrolysates. These fractions were tested for the following activities: antidiabetic (dipeptidyl peptidase-4 method), angiotensin I-converting enzyme inhibition (antihypertension) and antioxidant (superoxide anion retention).[173]
Oil was prepared from fruits by extraction with *n*-hexane/*iso*-propanol (3:2), and the oil was analyzed (GC-MS) for fatty acids: oleic acid was major component.[187]

Quercus cerris

Some nutritional ingredients and condensed tannins content (10.5 g/kg in dry matter) were determined in fruits. [109]
Leaves were analyzed for five macro (Ca, K, Mg, Na, K) and four micro (Cu, Fe, Mn, Zn) elements compositions, in order to compare six species for sheep food.[110]
An earlier study by the same group of the research cited in reference 110, in order to compare five species for sheep food. Leaves were analyzed for gas production and GCC.[111]
Bark 80% aqueous ethanolic extract was analyzed for TPC and qualitatively and partially for single phenolics. Significant results were recorded in each of the following activity tests: antioxidant (DPPH, oxidative hemolysis), inhibition of NO production, antiproliferative (three human cancer cell lines) and antimicrobial (ten bacterial and two fungal strains).[172]
Peeled fruits were defatted with *n*-hexane and extracted with slightly basic water to obtain (after acidification) protein hydrolysates. These fractions were tested for the following activities: antidiabetic (dipeptidyl

peptidase-4 method), angiotensin I-converting enzyme inhibition (antihypertension) and antioxidant (superoxide anion retention).[173]

Follow-up study of the research cited in reference 172. The two differences are: TBRAS instead of DPPH for testing antioxidant activity, and phloem (outermost layer of the stem beneath the skin) instead of bark. Similar results.[174]

Two extracts were prepared with 95% aqueous ethanol: leaves and fruits-stems. Each extract was very partially and qualitatively analyzed for chemical composition: no compounds assigned. Both extracts were active against *S. aureus* bacterial strain.[175]

Leaves aqueous and 95% aqueous ethanolic extracts were active against *S. intermedius*, *E. faecium*, *E. coli* and *S. maltophilia* bacteria species in a dose dependant manner.[176]

Leaves were extracted with microwave-assisted 70% aqueous ethanol, and this extract was analyzed for TPC and TTC. Extract was tested for antibacterial (against five species) and antioxidant (ABTS and DPPH methods) activities.[177]

Fruits 95% aqueous ethanolic extract inhibited lipid peroxidation, with thiobarbiturate as a reference. Kinetic study is presented.[178]

Leaves were extracted with ultrasonic assisted 80% aqueous methanol, and this extract was analyzed for TFC, TPC and total flavan-3-ol (TF3L) content. Testing the extract for antioxidant activity (ABTS, DPPH, FRAP methods) showed clear seasonality effect.[179]

Wood was extracted with 70% aqueous ethanol, raw (dry) or thermos-vacuum treated (two procedures), The three extracts were analyzed for TFC, TPC and tested for antioxidant activities using DPPH, FRAP and β-carotene bleaching methods. GC-MS analysis showed that the major component (%) of the extract of untreated wood was 4-((1*E*)-3- hydroxy-1-propenyl)-2-methoxyphenol 9.92, while in the extract of the treated wood was 3-(4- hydroxy-3-methoxyphenyl)- 2-propenal 17.04 (both compounds, **Figure 3**).[180]

Fruits were extracted with ethanol either raw (dry) or after thermal treatment (200 °C, 15 min). The TTC of both materials and antioxidant activity with thiobarbiturate as a reference, were clearly different. Kinetic study is presented.[181]

One of the follow-ups of previous study.[b] In this research, TFC, TPC, TTC, gallic acid content, were determined. The antioxidant activity was determined with DPPH and FRAP methods, with thiobarbiturate as a reference.[182]

Bark (periderm) and internal trunk wood (rhytidome) were separately extracted with 44% aqueous ethanol. Both extracts were analyzed for TPC, tested for antioxidant activity (ABTS, DPPH methods), and for tyrosinase inhibition (L-dopa was reference).[183]

Peeled fruits were roasted and prepared as "coffee" powder, and its nutritional composition was determined. The powder was extracted with PE and the tocopherols (α-tocopherol was major component) content was determined. Aqueous extract of the powder was analyzed for TFC, TPC, and tested for antioxidant activity (DPPH, FRAP methods). It was tested against ROS scavenging: superoxide radical, hydrogen peroxide, hypochlorous acid, nitric oxide and peroxyl radical. The extract was partially and qualitatively analyzed with NMR and LC-MS mainly to detect phenolic compounds.[184]

From peeled fruits "coffee" powder was prepared, raw ("native", dry) and after roasting and both powders were tested for sensory assessment. EO (hydrodistillation) and DCM extracts of the powders were prepared and analyzed with GC-MS. Clear differences were recorded between native and roasted powders.[185]

Polycyclic hydrocarbons (acenaphthene, fluorene, phenanthrene, anthracene) were successfully removed from aqueous solutions (5-50 µg/L) by this tree. No release of these compounds was observed after sorption.[186]

Oil was prepared from fruits by extraction with *n*-hexane/*iso*-propanol (3:2), and the oil was analyzed (GC-MS) for fatty acids: oleic acid was major component.[187]

Kinetics study of the pyrolysis of bark and GCC before and after this process.[188]

Earlier research by the same group cited in reference 174: GCC, TFC, TPC, TTC and antioxidant activity (DPPH, FRAP, TEAC methods), of aqueous, ethanolic and DCM extracts. The kinetics of the use of wood as fuel is presented.[189]

Wood was tested for hardness and termite resistance. It was extracted with 50% aqueous ethanol and the

extract was analyzed for TFC and TPC.[190]
b) Another follow-ups investigated *Quercus* species that are not native to the reviewed region. In this research, *Q. robur* was reported as well.

Quercus ithaburensis syn. ***aegilops***
Partial general nutritional composition is reported.[166]
Aqueous solution of fruits commercial extract was orally supplemented to STZ-nicotinamide-induced diabetic rats, resulting positive effect. This effect was measured with body weigh (no change), blood glucose (decrease), serum insulin (increase), total cholesterol (decrease) and total triglycerides (slight decrease). Positive effect was also recorded in the functions of oxidant (decrease)/antioxidant (increase) enzymes.[191]
Commercial dry fruits powder was extracted with 80% aqueous ethanol, and was tested for antioxidant activity with Fenton reagent, DPPH and TBRAS methods. In addition, production of unsaturated acids was decreased in radical-induced oxidations. TFC of the extract was determined.[192]
Fruits aqueous extract had protective antioxidant effect on fresh-cut potatoes. The effect was measured with colour parameters, polyphenol oxidase, peroxidase, phenylalanine ammonia-lyase activities; MDA and hydrogen peroxide content and ABTS method.[193]
Peeled fruits 80% aqueous ethanolic extract protected meat burgers against oxidation and improved their quality and taste. Antioxidant effect was tested with TBRAS method.[194]
Follow-up of previous study: raw and cooked meatballs.[195]
Leaves aqueous and ethanolic extracts were active against four bacterial strains (*E. coli*, *P. aeruginosa*, *C. tetani*, *S. aureus* and a fungus *C. albicans*, in dose dependant manner. Reference drugs were ciprofloxacine and clotrimazole, respectively.[196]
Fruits aqueous extract was chromatographed affording gallic, ellagic (**Figure 1A),** flavogallonic and nonahydroxytriphnoic acids (**Figure 4**).[197]
Fruits aqueous extract was prepared for the purpose of producing adhesives. Analysing this extract yielded several compounds like these mentioned in previous research, and vescalagin, castalagin, vescalin and castalin (**Figure 4**, copied from this reference with stereochemistry indications).[198]
Fruits were separately extracted with methanol and water by maceration, ultrasonically-assisted and microwave-assisted. The six extracts were analyzed for TPC, mineral contents, fatty acids content (oleic acid was major component) and tested for antioxidant activity (DPPH, FRAP methods). It was also analyzed for proteins using electrophoresis.[199]
Root bark 80% ethanolic extract was chromatographed yielding several phenolic compounds, including *n*-propyl gallate, ferulic and *p*-coumaric acids (**Figure 4**).[200]

Quercus look
No published activities-properties.

* Unless indicated otherwise, solvent mixtures are volume/volume, v/v.

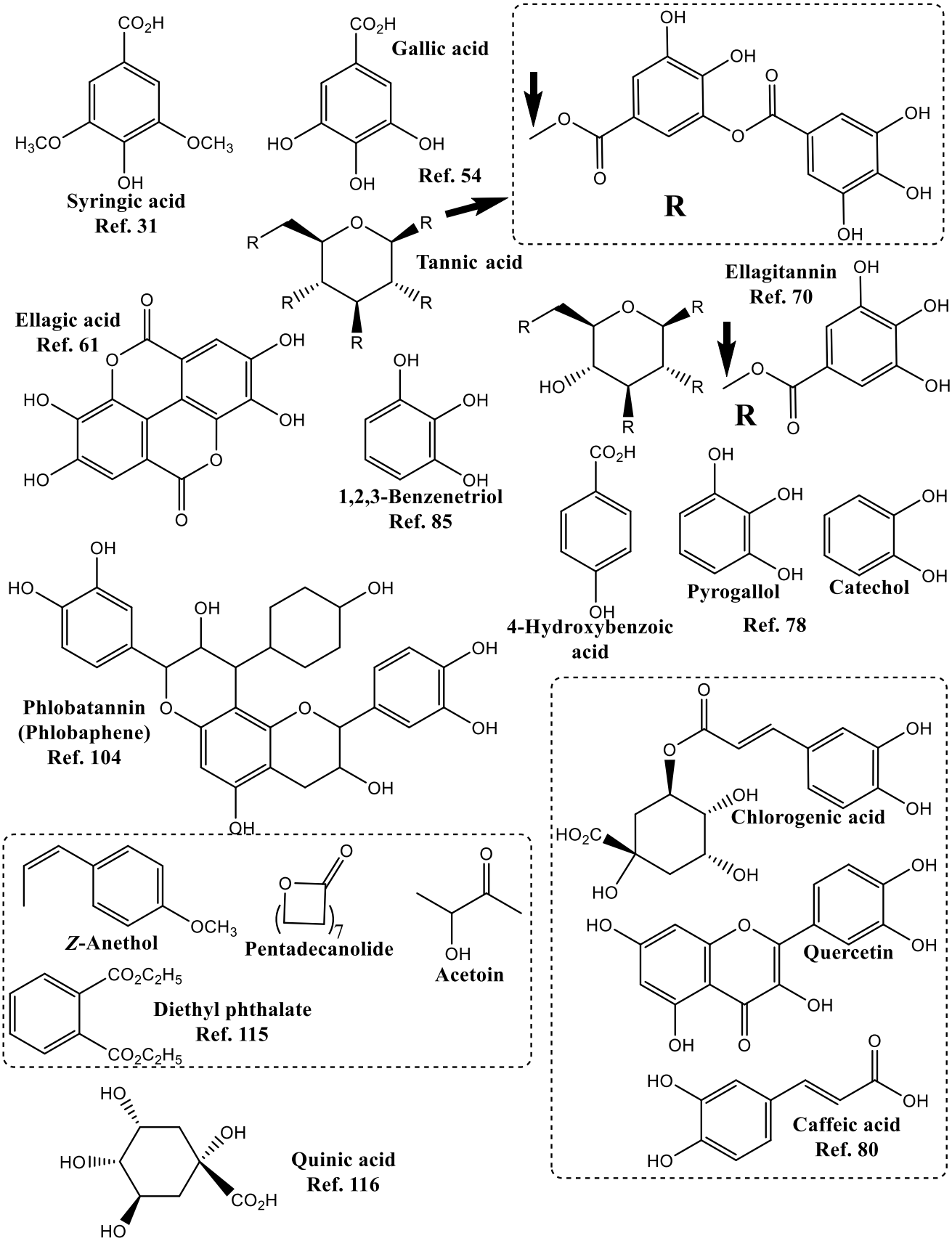

Figure 1A: Natural products isolated from *Quercus boissieri* syn. *Infectoria.*

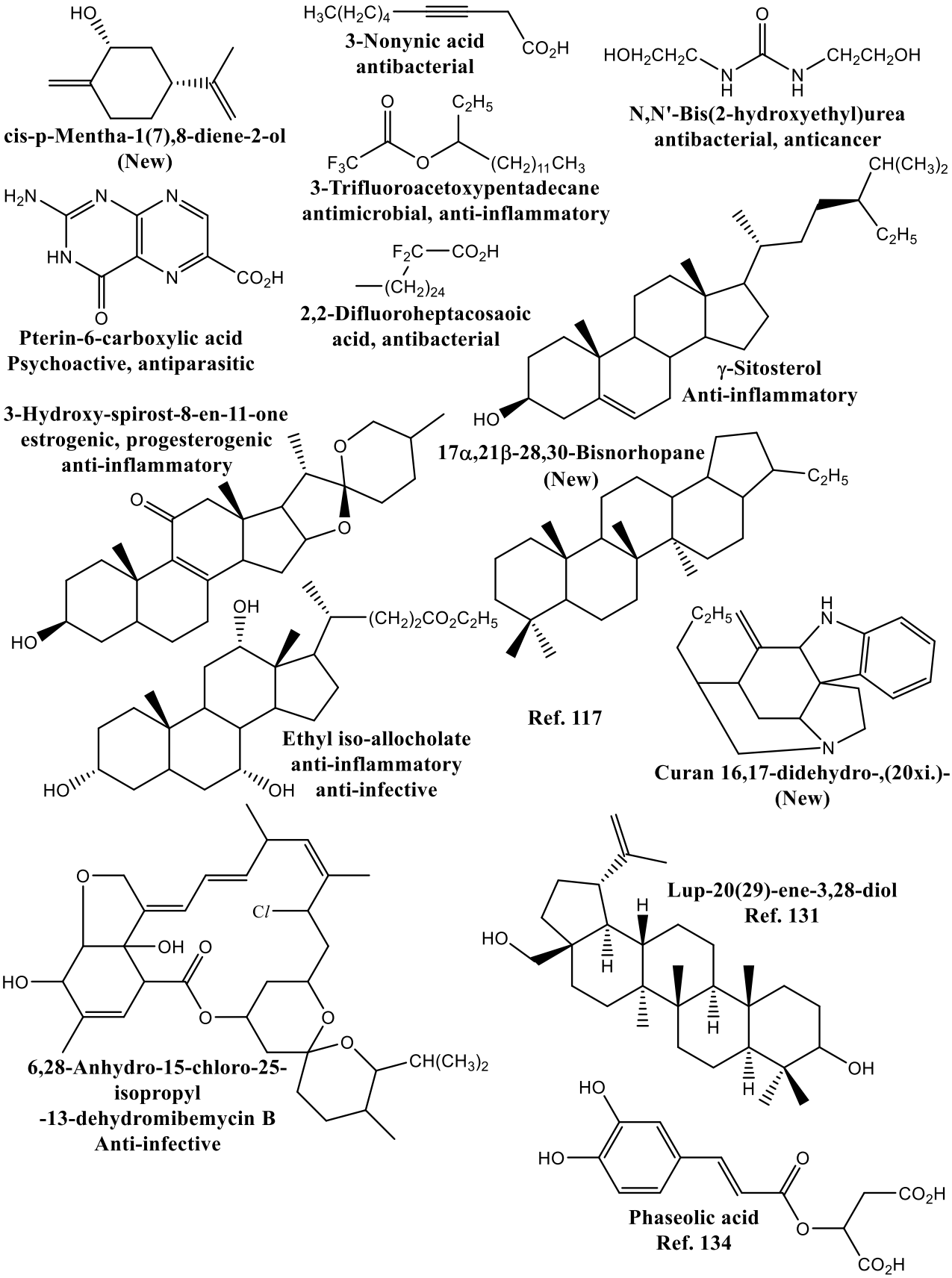

Figure 1B: Natural products isolated from *Quercus boissieri* syn. *Infectoria.*

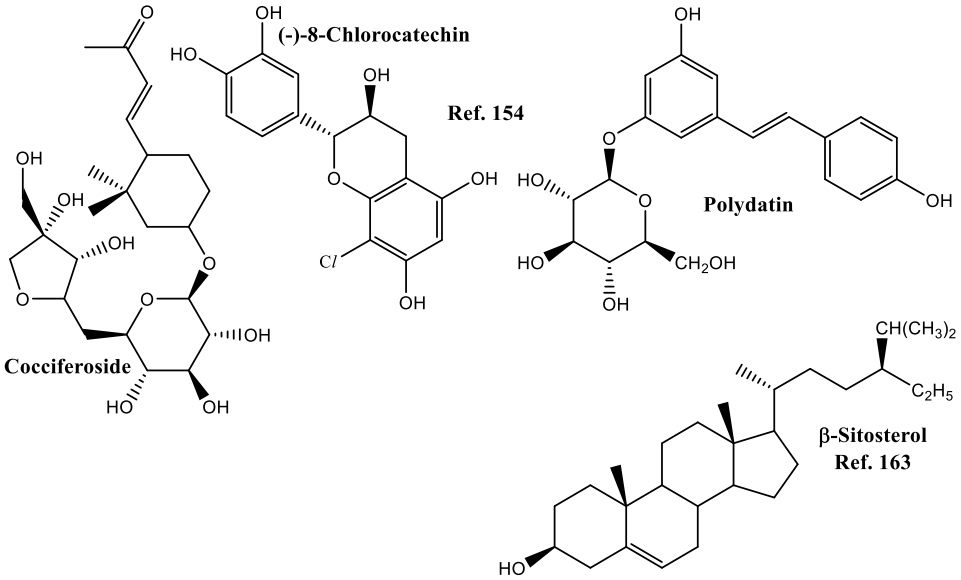

Figure 2: Natural products isolated from *Quercus calliprinos* syn. *Coccifera.*

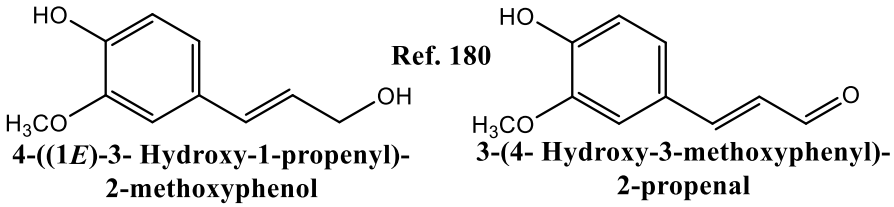

Figure 3: Natural products isolated from *Quercus cerris.*

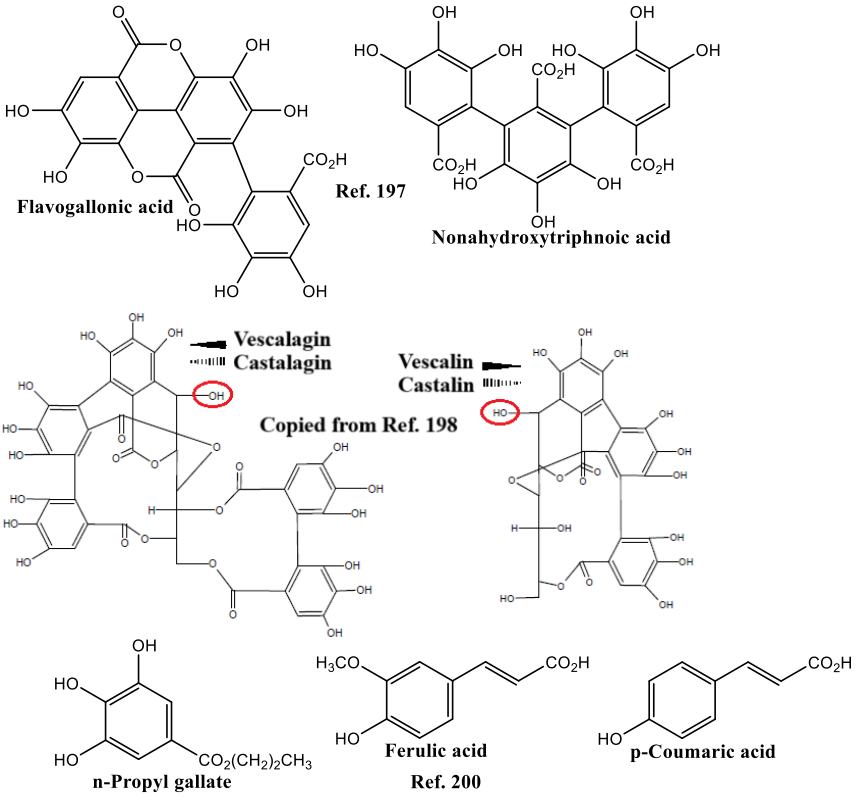

Figure 4: Natural products isolated from *Quercus ithaburensis* syn. *Aegilops.*

4) DISCUSSION

Writing this review article is an interesting yet challenging task. There are at least three reasons for this. First, there are several publications that we found while surveying the literature that information that they include was almost or is identical to the information in articles that we cited, so these omitted publications have no real contribution to the readers of this article. Second, most of the activities-properties listed in **Table 3** refer to *Quercus boissieri* syn. *infectoria*. In fact, in many of the cited articles, authors named the tree *Quercus infectoria* only. Third, researchers like E. Shachar ahc (Israeli) and many others, include *Quercus libani* in the *Quercus* trees of Israel and Palestine.[201] We chose not to include it based on the very reliable website that we presented as reference 3 (Israeli). It is very important to mention that this debate is pure scientific since some Palestinian researchers like J.M. Ighbareyeh ahc include it in the flora Palestine[202], while others (Ali-Shtayeh ahc) don't.[203] In addition to that, most of *Quercus* species have many scientific names, and consequently, finding published articles about them becomes not easy. For example, *Quercus ithaburensis* has several botanical names including *Quercus aegilops*.[204]

As we have mentioned above, *Quercus boissieri* syn. *infectoria* is the major species in this review article, according to the number of publications that we cited about its properties-activities. On the top of these, antimicrobial activity. In this context and others, there seems some safety concerns, and some differences between galls and leaves. While galls are reported safe, leaves were toxic to livestock, especially when extensively consumed as food. Contrary to this, M.S. Dar and M., Ikram[31], reported that galls methanolic extract was chromatographed affording syringic acid (**Figure 1A**), which had CNS-related activities. This is the only mention of this property in relation to *Quercus* species of the reviewed region. But this is a well-known property of this acid.[205]

Performing efficient extraction of plant material is always valid research topic. R. Purbowati ahc published an interesting method, were they used supercritical fluid extraction of CO_2 with co-solvent methanol.[206] Authors reported higher extract yields, higher phenolic content and lower toxicity, compared with classical extraction methods. In an earlier study, M. Asif ahc investigated the standardization of galls extract.[207] This is an important work since this and other extracts, might contain contamination, and it is also important for the determination of the extract toxicity, since it can be used in food of pharma industry. Similar and more detailed work was published after six years by F.F. Magbool ahc[208], that we presented their work

preparing formulations of *Quercus boissieri* syn. *infectoria* against candidiasis.[91] The importance of these standardization studies is crucial when the plant products for food animals or humans, such as in the works of M.Y. Elahi ahc.[124,209] In the second research, they investigated the effects of phenolic compounds three *Quercus* species on the health of Iranian goats, where they came up with interesting conclusions. To conclude this part of the discussion about *Quercus boissieri* syn. *infectoria* modern technologies of use, S. Tugce Aydin ahc have loaded 3D-printed patches with 96% aqueous ethanol galls extract for wound healing.[210]

Even though not the largest among *Quercus* species of the reviewed region, *Quercus calliprinos* syn. *coccifera* is the most widespread, and it was relatively studied and published extensively. As in the case of *Quercus boissieri* syn. *infectoria*[206], E. Hayouni ahc investigated the effect of extraction solvents and extraction methods, on TPC of the fruit extracts, and consequently, on their biological activities.[211] In the first method, a single solvent was used, and in the second, mixtures of three or four solvents. Clear differences were recorded in extraction yield, TPC, phenolic compositions, antimicrobial and antioxidant activities.

The leaves of *Quercus boissieri* syn. *infectoria* are one of the food choices of livestock, especially during the summer, the dry season, after the spring greens are not available. N. Silanikove studied the effect of adding polyethylene glycol (PEG) on goats fed with *Quercus boissieri* syn. *infectoria* leaves (and *Pistacia lentiscus* and *Ceratonia siliqua*).[212] This successful research was done due to relatively high TTC in the leaves of these trees, which make their digestibility relatively hard.[213] In this context of dry habitats and drought and PEG, two published studies are strongly related. First, *Quercus boissieri* syn. *infectoria* can tolerate drought and dryness.[214] Second, for cultivated *Quercus boissieri* syn. *infectoria*, addition of PEG to irrigation water can retard the growth of the tree and alter its chemical composition.[215]

An interesting *Quercus boissieri* syn. *infectoria* related study was conducted by L.O. Hanus ahc, where they investigated the chemical compositions of epiphytic lichenized ascomycete *Ramalina lacera* that grows on this tree and others.[216] They reported very detailed fatty and aromatic acids compositions, where the major five components (µg/100 g dry matter, ethanol-water-HC*l*, 90-9-1) of the second group were: Protocetric acid 41.2, Diffractaic acid 38.9, Usnic acid 29.4, Norstictic acid 22.8 and Lecanoric acid 21.7 (**Figure 5**).

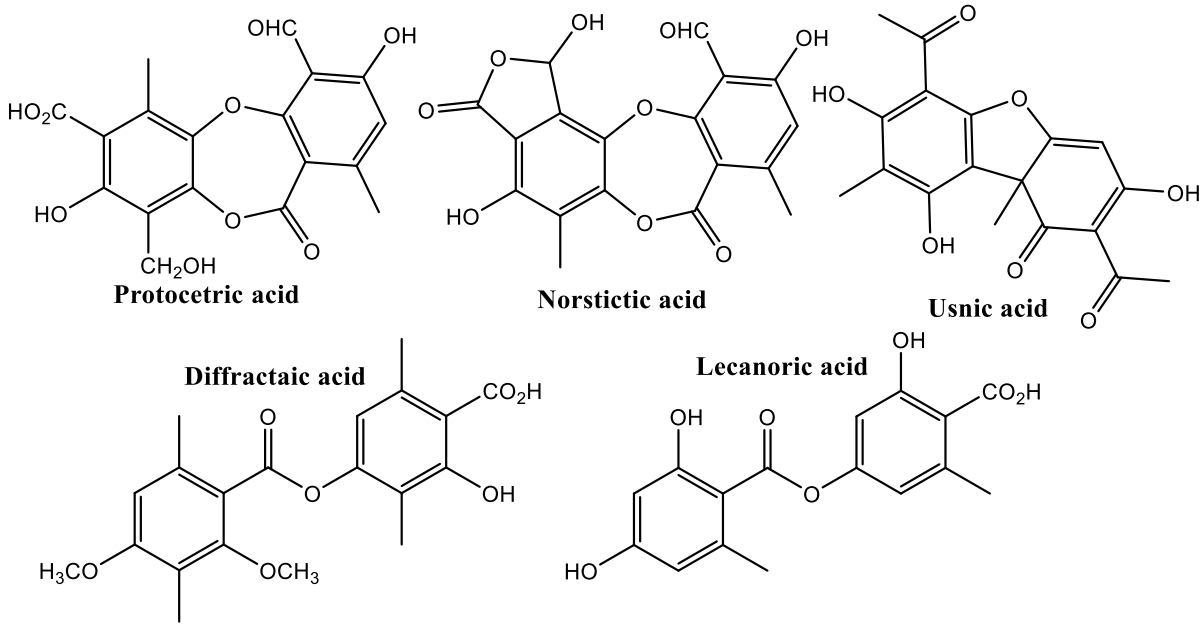

Figure 5: Natural products isolated from *Quercus calliprinos* syn. *Coccifera.*

Even though *Quercus* species are a good source of polyphenols, we found it strange that this source was not utilized for green synthesis of nanoparticles (NPs), except the report of E. Kocadag Kocazorbaz ahc.[217] Using leaves aqueous extract, they prepared AgNPs that were active antimicrobial, antioxidant and had deglycation activity.

The search for active plant products for therapeutic purposes was developed by I. Koç ahc to obtaining wood vinegar of several *Quercus* species waste.[218] This vinegar had notable antioxidant (CUPRAC method) and anticancer (HT29 and U2OS human cancer cell lines) activities. A major achievement of this method is that it allowed the researchers avoiding the extraction step, which can be challenging. U. Sen ahc published interesting results of using polar solvent mixture in maceration extraction of *Quercus cerris*.[219] Using either pure water, pure acetone of five binary mixtures for extraction of tree waste, yielded extracts with high TPC, significant antimicrobial (eight bacterial strains and *C. albicans*) and antioxidant (DPPH and FRAP methods) activities. And in their attempts of developing successful extraction method, M. Ponticelli ahc changed three variables.[220] Temperature (20, 50 and 80 °C), solvents ratio ethanol/water (0, 20 and 40%) and time (3, 6 and 24 h), resulting in 27 different extracts. This method resulted high TPC and antioxidant activity (DPPH method.

As for all plants, the chemical compositions and their activities are influenced by many environmental factors such as water stress (excess or drought) and seasonality. M. Kebert ahc cultivated *Quercus cerris* under water deficit and/or high temperature conditions.[221] They

reported that the young trees developed defence mechanisms of increasing the production of antioxidants against oxidative stress. S.V. Wolkerstorfer ahc found clear effect of seasonality on gas exchange, photosynthetic pigments and antioxidants, in trees of different ages, where some were notably old, 140 y.[222] For example, the α-tocopherol concentrations in leaves were much higher on September 23rd than on May 16th. This seasonality effect was studied by R. Najib ahc who sampled the leaves of *Quercus cerris* and tested several activities and compositions, but their research focuses of the capacity of this species as phytoremediator.[223] For example, cadmium concentration in the tree leaves had minimal values in June and maximal values in October, 0.02 and 0.3 ppm, respectively.

Cr(VI) is considered one of the worst pollutants, and dozens of studies were published about its removal, mainly from water, and so, many review articles about this issue were published as well [for example,[224]]. Recently, there is a developing approach of treating Cr(VI) with industrial-agricultural, especially plant waste.[225] Accordingly, E. Malkoc and Y. Nuhoglu used acorns waste of *Quercus ithaburensis* syn. *aegilops* to remove this pollutant from wastewater.[226] Significant kinetic study is provided.

Another interesting use of *Quercus ithaburensis* syn. *aegilops* was published by P. Erdem ahc, who prepared a complex of Fe^{+3}-Tannin by mixing $FeCl_3$ aqueous solution with aqueous solution of tannin-rich fruit aqueous extract.[227] The stoichiometry of the complex is reported as FeL_2 but the formulas of the ligand and/or the complex are not reported. It has notable antioxidant activity tested with DPPH method. And a final citation for this species, M.B. Ozdemir and R. Karadag proved the great general importance for this tree in Turkey.[228] They highlighted its practical (numbers, graphs and tables) usefulness in economy, sustainability, but focused on “the potential to serve as a bio-mordant, natural dye for textiles and leather”.

Oak (*Quercus*) trees are very beautiful and have impressive, large shapes. In many places in the world, this greatness went beyond human and animal food, medicinal uses and construction uses. This greatness has emotional aspects: oak trees became holy and sacred. *Quercus calliprinos* syn. *coccifera* reached this status in Morocco[229], and in Palestine.[230,231]

5) CONCLUSIONS

1) *Quercus* (oak) trees of Israel and Palestine have medicinal, economic, sustainability and emotional-religious values.

2) The medicinal activities-properties of some these trees are either non-existent or partial, and research effort is needed.

3) Most of the species have many botanical names and this is confusing. These multiple names must be unified to one or two names for each species.

4) The debates over the inclusion/exclusion of some species in Israel and Palestine is also confusing. It should be reconsidered and concluded.

5) There is an immediate need for more documentation of the traditional uses of these species.

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