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Evaluating the therapeutic potential of amygdalin: Cytotoxic and antimicrobial properties

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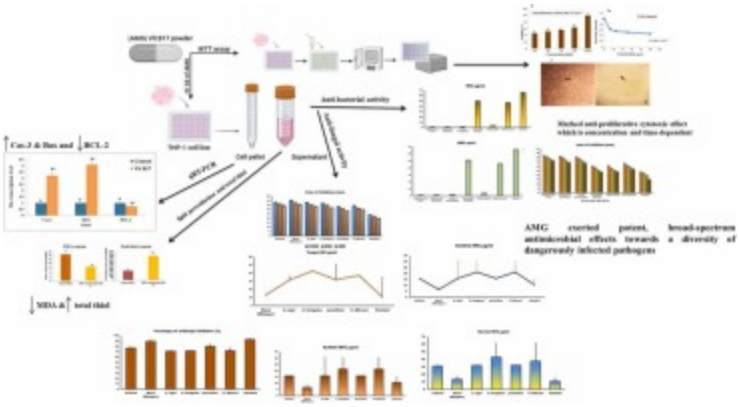
Highlights

- Leukemia is an incurable disease represents the most common childhood cancer.
- Human monocytic leukemia has been exposed to amygdalin.
- Amygdalin has marked anti-proliferative cytotoxic effects against leukemia.
- Amygdalin exerted potent, broad-spectrum antimicrobial effects.

Abstract

Leukemia is an incurable disease; it exhibits strong resistance to chemotherapy and other therapies, and it represents the most common childhood cancer and mortality. The cytotoxic of amygdalin (AMG) against the cell line of human monocytic leukemia (THP-1) was recorded, before determining other pharmacological effects. The cells were exposed to AMG for 24 hr at 37°C at different concentrations, the cytotoxic effect was determined *via* the MTT assay. The cells and the supernatant were collected for analyzing the oxidant/antioxidant status, apoptotic markers, and anti-microbial activity. Results showed a marked anti-proliferative cytotoxic effect of AMG which is concentration and time-dependent, the lipid peroxidation content was significantly decreased while the total thiol was increased in the treated cell line, significant up-regulation of Caspase-3 (Cas-3) and Bcl-2-associated X protein (BAX) and down-regulation of B-cell lymphoma 2 (Bcl-2). Furthermore, The bacterial activity was detected *via* Minimum Inhibitory Concentration (MIC), Minimum Bactericidal Concentration (MBC), and Disc Diffusion assays, while the antifungal evaluation was done by the Minimum Fungicidal Concentration (MFC). Antimicrobial experiments revealed that AMG exerted potent, broad-spectrum antimicrobial effects toward a diversity of dangerously infecting pathogens. In conclusion; the prevailing research suggests that AMG is an effective anticarcinogenic and antimicrobial substance. The utilization of AMG subsequently in masks or wound dressings to prevent bacterial & fungal infections, including mucormycosis following COVID-19, as well as infections caused by penicillium and aspergillus, is a highly effective strategy in combating resistant microorganisms.

Graphical Abstract



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Introduction

The term "cancer" indicates a cluster of diseases with uncontrolled growth properties and the spreading of malignant cells throughout the body parts (Saleem et al., 2018). Throughout the 20^{th} and 21^{st} centuries, cancer has represented a remarkable cause of mortality (Kumar et al., 2018). Acute myeloid leukemia (AML) is a heterogeneous cancerous type affecting the bone marrow, especially the myeloid cells, once becomes evident it spreads and leads to hematopoiesis impairment. AML incidence surges with age and is linked to a dismal prognosis. Multiple cytogenetic and genetic abnormalities manifest in myeloid precursors to produce AML, a hematologic heterogeneous disorder (O'Donnell et al., 2017). Poorly differentiated myeloid cells can accumulate at their site of production in the bone marrow (BM) and spread to adjacent blood vessels, resulting in impaired hematopoiesis and a variety of symptoms, such as bleeding, bruising, infections, fatigue, and bone pain (American CancerSociety. 2020).

Many strategies have been used in the fight against cancer, including stem cell transplantation, chemotherapy, radiotherapy, and targeted biological treatments. The results of these strategies are variable and may be hampered by underlying health conditions, particularly in elderly ones, also, the rates of relapse are extreme (Koenig et al., 2020).

Numerous cancer treatment options have been established, including radiation, chemotherapy, and surgery (Vutakuri and Somara, 2018). On the other hand, using natural plants as cancer therapy is viewed as the upcoming cancer therapy they have low adverse effects and cost with great pharmacological efficiency (El-Masry et al., 2020). Herbal medicine is considered a main resource for the establishment of both chemo-preventive and therapeutic drugs (Shanmugam et al., 2016). Approximately 80% of all FDA-approved medications over the past three decades were derived from natural sources (Bishayee and Sethi, 2016). The kernel of apricot seed could be used as a source for botanical remedies (Akhone et al., 2022). Several investigations have demonstrated its effectiveness in cancer remedies. These investigations suggest that the antiproliferative properties of apricot kernels are due to the presence of AMG. AMG triggers apoptosis, which in turn suppresses the growth and survival of the malignant cells (El-Masry et al., 2020). It contains glycosides termed cyanogenic glycoside; under the effect of beta-glucosidase enzyme converted into HCN and benzaldehyde, that cause cellular destruction and eradication for the cancerous cells in a synergistic manner (Enculescu, 2018). Moreover, It's antioxidant properties reduce the oxidative stress of the cancer cells (El-Masry et al., 2019). Multiple researches have recorded the cytotoxic and apoptotic of AMG in cancer cell lines of human origin (Shi et al.,

2019). To our knowledge, however, no studies have been done on human leukemic cell lines to demonstrate AMG efficacy and cytotoxicity.

The apricot (*Prunus armeniaca L.*) is a globally valuable commercial crop. Numerous flavonoids and carotenoids are believed to confer antioxidant properties to apricots (Ozturk et al., 2009). In several nations, these seeds are used extensively in their diets (Gezer et al., 2011). Due to its putative anti-cancer properties, AMG is found in the seeds of apricots and other fruits (Salama et al., 2019). The Egyptian papyri used derivatives of bitter almonds in the treatment of cutaneous tumors around 5000 years ago. They are represented to be one of the finest sources of AMG, Vitamin B17, and laetrile (Lv et al., 2017).

Public health has great global threats that are represented in developing the resistance towards drugs used as a therapy for cancer and microbial infections, which require urgent development of effective solutions. Following this, we require a more effective natural material with potent antimicrobial and anticancer activity in addition to the evolutionary processes that result in the emergence of adaptive phenotypes as a reply to the selective burden of the therapeutic compounds. Many similarities have been shared between the previously emerged accelerated drug resistances; involving the mode of action and topoisomerase II; the molecules' availability with both antineoplastic and antimicrobial activity (e.g., antineoplastic antibiotics); the same resistance mechanism; shared selective causes for resistance; and dual resistance, intrinsic (failure to get a primary response to drugs) and acquired (commitment of the immune system in the progress of resistance) (Lambert et al., 2011).

The aim of this work is to address the toxicity and efficacy of AMG as a herbal remedy for cancer *in vitro* against human leukemic cell lines, as well as to design an AMG concentration as an efficient therapy. In addition to their antileukemic action as a strong anticancer drug, AMG's antibacterial and antifungal activities against a range of illnesses that impair human and animal health were also reported in this work.

Section snippets

Amygdalin (Vit B17)

Was achieved by Nature's Only Choice Company (Tbilisi, GA, USA) in the form of pure capsules each of 150 mg concentration. …

Cell line

THP-1 cell line (VACSERA, Cairo, Egypt) was used for analyzing the anti-proliferative cytotoxic effect of AMG, THP-1 cells were cultured in DMEM medium provided with (10%) FBS, (100 mg/mL) streptomycin, and (100 units/mL) penicillin and a humidified atmosphere (5% CO_2 & 37 °C). …

Samples

A stock solution of AMG was pre-solubilized in dimethylsulphoxide (DMSO) at 37 °C. Serial …

Anti-proliferative activity

A great anti-proliferative cytotoxic effect was recorded following the treatment of the cancerous cells with different concentrations of AMG in which the viability was significantly inhibited with increasing the concentration as shown in (Fig. 1a), in which the lowest viability % (46%) was recorded at the highest concentration (100 µg/mL) of AMG. The IC50 value was determined for the tested substance at about (64 µg/mL) (Fig. 1.b). …

Morphological effects

The cells lose their brightness and become opaque and shrunk (…

Discussion

Disorders of a malignant and infectious nature are considered the most prevalent and problematic ones with marked negative impacts on the general population's health. According to the World Health Organization (WHO), cancer is one of the primary causes of death worldwide in 2020, accounting for nearly 10 million deaths. Antimicrobial resistance (AMR) is one of the top ten global hazards, not only to human health but also to the health of the environment, and is a typical example of a One Health …

Conclusion

Overall, the anti-proliferative cytotoxic effect of AMG against THP-1 cells appears to be mediated by the modulation of the expression rates of the genes involved in the regulation of cellular proliferation, metastasis, and apoptosis. Moreover, it's anti-oxidant and anti-microbial effects. About the antimicrobial investigations; AMG has shown great antimicrobial activity against Gram-positive, Gram-negative, and various fungal isolates which indicated their broad spectrum antimicrobial …

Ethical approval

The standards set forth guidelines for the care and use of experimental animals by the Institutional Animal Care and Use Committee of Vet. CU. IACUC, Cairo University was followed in the present study (Vet CU 03162023695). …

Authors contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Doaa R.I. Abdel-Gawad], [Marwa A Ibrahim], [Hossny A. El-Banna], [Walid H. Hassan], and [Fatma I. Abo El-Ela]. The first draft of the manuscript was written by [Doaa R.I. Abdel-Gawad] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. …

Consent for publication

All authors are agree to publish the work. …

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Author statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request. …

CRediT authorship contribution statement

Fatma I. Abo El-Ela: Writing – review & editing, Methodology. **Walid H. Hassan:** Supervision, Methodology. **Hossny A. El-Banna:** Writing – review & editing, Supervision. **Marwa A Ibrahim:** Writing – review & editing, Methodology. **Doaa R. I. Abdel-Gawad:** Writing – review & editing, Writing – original draft, Investigation. …

Declaration of Competing Interest

The authors have no relevant financial or non-financial interests to disclose. …

Recommended articles

References (76)

A.M. Alwan *et al.*
Onco-immunity and therapeutic application of amygdalin: a review
J. Oral. Biol. Craniofacial Res. (2023)

A. Bishayee *et al.*
Bioactive natural products in cancer prevention and therapy: Progress and promise
Semin. Cancer Biol. (2016)

G. Coelho De Souza *et al.*
Ethnopharmacological studies of antimicrobial remedies in the south of Brazil
J. Ethnopharmacol. (2004)

M. Friedman *et al.*
Antibacterial activities of phenolic benzaldehydes and benzoic acids against campylobacter jejuni, escherichia coli, listeria monocytogenes, and salmonella enterica
J. Food Prot. (2003)

T. Isozaki *et al.*
Quantitative determination of amygdalin epimers by cyclodextrin-modified micellar electrokinetic chromatography

J. Chromatogr. A (2001)

J.H. Ko *et al.*
Cloning of large-conductance Ca2+-activated K+ channel α-subunits in mouse cardiomyocytes
Biochem. Biophys. Res. Commun. (2009)

J.F. Koster *et al.*
Intra-cellular and extracellular sulphydryl levels in rheumatoid arthritis.
Ann. Rheum. Dis. (1986)

H.M. Lee *et al.*
Amygdalin regulates apoptosis and adhesion in Hs578T triple-negative breast cancer cells
Biomol. Ther. (2016)

K.J. Livak *et al.*
Analysis of relative gene expression data using real-time quantitative PCR and the 2−ΔΔCT Method
Methods (2001)

J. Makarević *et al.*
Amygdalin delays cell cycle progression and blocks growth of prostate cancer cells in vitro
Life Sci. (2016)

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Cited by (3)

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