The Role of Amygdalin in Treating Cancer *In Vitro*

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Abstract

This study researches the effects amygdalin, a compound found in the pits and seeds of several fruits, has on cancerous cells through *in vitro* tests on lung, breast, prostate, and cervical cancer cell lines. Data was collected from previous studies treating cells in mediums with concentrations of 2.5, 5, 10, and 20 mg/ml of amygdalin for 24 hours. The results showed that with an increase in the concentration of amygdalin, there was a decrease in cell viability. These results were found to be significant from *p*-values, which further support the original hypothesis that amygdalin is effective in treating the previously stated cancer types *in vitro.*

Introduction

According to the National Cancer Institute, 39.6% of men and women from the United States will be diagnosed with cancer in their lifetime (NCI, 2017). In 2018, it is predicted that there will be 154,050 deaths from lung cancer (83,550 men and 70,500 women), 40,920 deaths from breast cancer in women, 4,170 deaths from cervical cancer in women, and 29,430 deaths from prostate cancer in men. Currently, common treatments include chemotherapy, radiation, surgery, and other therapy options (American Cancer Society, 2018). Although these treatments are most frequently used, doctors sometimes turn to alternative medicine. The objective of alternative methods is to provide a non-harmful approach to treating cancer while maintaining the overall health of the body. Alternative treatment forms are often pushed aside by doctors as they are not considered the safest and not proven to work by clinical trials, but patients may be inclined to choose an alternative form of treatment based on the cost of the treatment, personal lifestyle, acceptance of side effects, or the possibility of living longer (American Cancer Society, 2018). Alternative methods provide a different and more natural approach than normal treatment methods. Examples of alternative medicine include acupuncture, aromatherapy, and homeopathic

remedies. Another form of alternative treatment is amygdalin. Doctors tend to overlook amygdalin as an option, however, as it is not well known and is believed to be an ineffective treatment due to the lack of use and unclear results of treatment. In addition, amygdalin is not regulated by the Food and Drug Administration (FDA), contributing to its lack of use in the United States (PDQ, 2017).

Amygdalin is a naturally occurring chemical compound found in the pits and seeds of apricots, plums, apples, peaches, and bitter almonds. First isolated by French chemists in 1830, amygdalin was later used as a cancer treatment in Russia in 1845 (Dang, Nguyen, & Tran, 2017). Ernst T. Krebs, a biochemist from the United States, was the first to give amygdalin the name B-17. In medical terminology, amygdalin is synonymous with laetrile and vitamin B-17 (PDQ, 2017). The compound's chemical formula, $C_{20}H_{27}NO_{11}$, is composed of glucose, benzaldehyde, and hydrocyanic acid (Figure 1). Each amygdalin compound contains a nitrile group which is released as a toxic cyanide anion to target cancerous cells, causing cell death (Song & Xiaohong, 2014). This destruction of cells can be accomplished through oral or intravenous administration (Ames, Moyer, Kovach, Moertel, & Rubin, 1981).

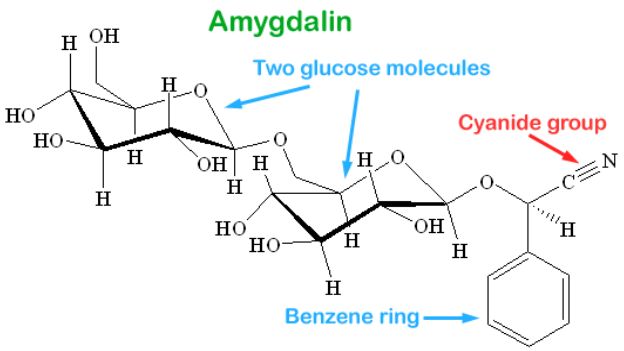

Figure 1. Structural model of amygdalin (Ahmed, 2015).

As stated previously, amygdalin is a natural alternative to the more common forms of cancer treatment. To most effectively use amygdalin as a treatment, it is advantageous to understand where it comes from, how it develops within the plant itself, and how amygdalin is able to carry out its functions (Sánchez-Pérez et al., 2017). Seeing that it is a secondary metabolite, or an organic compound found in plants that is not necessary to the development of the plant itself, plants dispose of the cyanogenic glycoside allowing humans the ability to

harvest make use of it (Yashunsky et al., 2015). Although not commonly used by many doctors, due to the belief it is ineffective or could cause cyanide poisoning, amygdalin has shown promising results in experiments and trials. Cyanide poisoning occurs when the body is unable to detoxify the concentration of cyanide present, which leads to the inhibition of oxygen use for the body (Bromley, Hughes, Leong, & Buckley, 2005). While amygdalin was first used by Russian physicians as a cancer treatment starting in 1845, clinical trials were not started in the United States until 1980. These U.S. trials with the goal of verifying the anticancer effects of amygdalin. Yet, researchers concluded that amygdalin did not have anticancer effects (Rubin et al., 1981). Nevertheless, recent *in vitro* studies have revealed that amygdalin does have anticancer properties giving hope that it could offer potential treatment for the myriad of cases of untreatable cancers (Jeon et al., 2015).

After looking at the effect of amygdalin on non-cancerous cells, it was found that granulosa cells, which display phenotypes depending on location, were able to survive an amygdalin treatment. Healthy cells are able to remain unharmed by the treatment process and not be targeted (Halenár, Medveďová, Maruniaková, & Kolesárová, 2015). It can then be hypothesized that amygdalin can successfully target cancerous cells and not affect the healthy cells in the body. Research has established amygdalin fights cancer by targeting cancerous cells, while leaving the immune system intact. The makeup of the compound has led scientists to believe the benzaldehyde within the compound is primarily responsible for the killing of cancer cells (Kolesárová et al., 2015).

A clinical trial carried out in 1981 treated patients with malignant tumors using varying treatments of amygdalin. In order to test the effectiveness of amygdalin in the treatment of cancer, it needed to be used in these clinical trials, rather than *in vitro* (Rubin et al., 1981). In one study, amygdalin was used to treat tumors in mice. The results varied from clinical trials in humans since the cellular makeup of mice is different than that of humans

(Stock et al., 1978). Although the results show amygdalin as a non-effective therapy, this study acts as a prediction for the effect amygdalin would have on humans but does not fully indicate a human response (J. Greek, R. Greek, & Shanks, 2009). Results of amygdalin as treatment on humans can reveal its effectiveness, as well as how the treatment must be administered and the potential side effects. One study produced results indicating that intravenous (IV) administration was the ideal form of administration based on the favorable outcomes after treatment (Rubin et al., 1981).

Information on the efficacy and pharmacological properties and composition of amygdalin as an anticancer treatment has been further investigated elevating researchers understanding of how amygdalin is able to target and kill cancerous cells (Song & Xiaohong, 2014). Amygdalin contains hydrocyanic acid and when released, it leads to the death of cancerous cells after β-glucosidase activation. This is the process carried out when the body is administered amygdalin with the goal of treating cancer (Yun-long, Qiao-xing, Rui-jiang, & Xiang-qian, 2015).

A study on healthy bladder cells found amygdalin decreased proliferation and growth in bladder cancer cells with consistent treatment administered over a period of 24 hours. By reducing cell proliferation, the body is not producing as many of the cancerous cells and therefore causes less growth of the cells overall. With a decrease in the production of these cells and less growth, the cancer will not be able to spread throughout the body and become worse. Although the amygdalin may not have completely cleared the body of the cancerous cells, it was able to prevent the cancer from developing further and getting worse (Blaheta et al., 2014a).

While use of amygdalin may be a viable option currently, most cancer treatment methods use chemotherapeutic approaches. Chemotherapeutic drugs target cells at different points during the cell cycle, whereas amygdalin targets proteins that help carry out the cell

cycle and slow down the process and overall decreasing cell growth and development. Research demonstrates that the use of amygdalin in cancer treatments works in a similar manner by targeting cancerous cells that cannot fight off the cyanide anion (Blaheta et al., 2014b).

Additional research found that amygdalin inhibited cancerous cell growth and down regulated the telomerase activity. When treated with amygdalin, human cancer cell lines showed a decrease in growth. Telomerase activity is the event in which a DNA sequence is added to a chromosome to make it longer. Through down-regulation, this process is stopped and does not allow the cell to grow. The hydrogen cyanide released from the amygdalin compound is able to prevent further growth and even the spread of the cancerous cells and cancer itself (Jeon et al., 2015).

Background

Previous research revealed that there is pharmacological activity within amygdalin prompting research to create anti-tumor drugs (Timmerman et al., 1982). Healthy cells contain rhodanese (Figure 2), an enzyme that is able to detoxify cyanide and turn it into thiocyanate. Thyocyanate is a compound stored in the liver and helps to regulate blood pressure. However, cancerous cells do not have rhodanese, which allows the benzaldehyde to attack the cell (Rubin et al., 1981). The β-glucosidase, which is responsible for catalyzing the hydrolysis of bonds, breaks down the cyanide and benzaldehyde

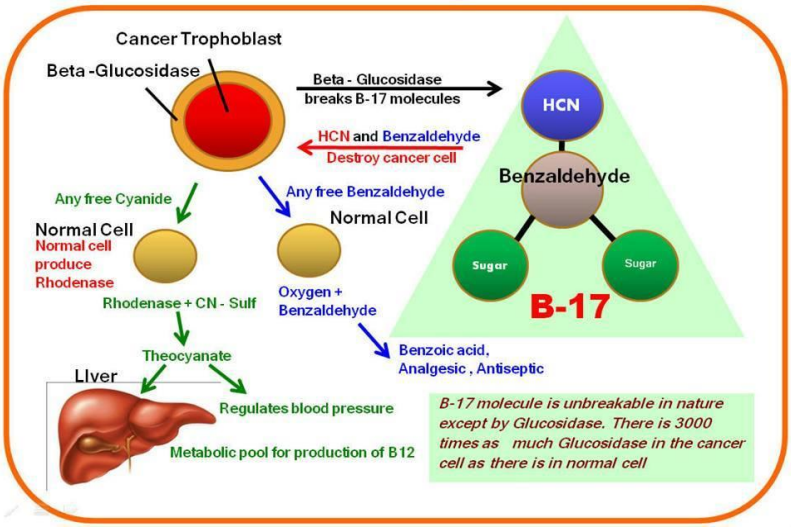

Figure 2. Shows the process in which amygdalin is able to target and attack cancerous cells (n.d.).

group, creating a toxic poison that enters the cell. Once inside the cell, the cyanide inhibits oxygen from entering the cell which causes the mitochondria to shut down and stop producing energy. With no energy production, the cell dies ("Laetrile / Vitamin B-17 Treatment," 2017). More research on amygdalin as a form of treatment for cancer can widen the options previously known. Though many of the current cancer treatments available effectively treat cancer for some patients, there remains a copious number of patients who do not experience favorable results from the treatment they receive. As it becomes apparent that a traditional or more common treatment is not working, doctors can turn to other options, such as amygdalin because it approaches killing cancerous cells more naturally and shows promising results for many patients.

A study in which breast cancer cells were treated in a medium with concentrations amygdalin *in vitro,* found that amygdalin was able to act as an anti-tumor drug with cell inhibition properties. The results in this study showed that amygdalin has the ability to inhibit cancerous cells (Moon & Lee, 2016). This opens the opportunity for amygdalin to be considered as a possible option for treatment. Being an effective form of treatment, doctors with doubts regarding the ability of amygdalin to treat cancer can be reassured based on scientific evidence. In similar studies, the effects of treating cancerous cells with amygdalin were tested. The results indicated that amygdalin is able to inhibit cell proliferation as well as induce apoptosis in cancerous cells (Qian, Xie, & Wang, 2015; Kim et al., 2006). Furthermore, amygdalin has the ability to induce HSC-T6 cell proliferation and fibrosis. After testing cells with amygdalin, it has been found that amygdalin could be considered as a therapeutic agent for liver fibrosis. Although this study did not specifically investigate cancerous cells, the study demonstrates that amygdalin can be used for beneficial effects in the body (Wang et al., 2016).

Many current cancer treatments attack cancerous cells in the body and come with several side effects. Amygdalin is able to do the same thing, but with minimal side effects. There are reports of cyanide poisoning after the administration of amygdalin, most of which are linked to the oral administration of these compounds (Meyer et al., 2015; Dang, Nguyen, & Tran, 2017). Although considered toxic, previous research has shown that amygdalin has the ability to reduce the growth of cancerous cells and plays a significant role in treating cancer (Qian et al., 2015). The National Cancer Institute sponsored clinical trials in the 1980s to further investigate amygdalin. Based on previous knowledge of the possible pharmacological properties, or properties displaying similarities to medical drugs, researchers conducted trials to understand the properties in more depth. In one study, patients with malignant disease were used in a clinical trial. Within this trial, varying administration, concentration, and quantity of amygdalin were used to treat the patients' cancer. Some were given treatment intravenously and some were given treatment orally. The results of this specific trial, however, produced unclear results and left scientists with more research to do in order to draw conclusions on the ability of amygdalin to treat cancer (Rubin et al., 1981).

Studies have indicated that amygdalin does not have pharmacological properties because there is insufficient evidence that amygdalin does have pharmacological effects. Yet, test results point in both directions: the treatment having success and not having success with using amygdalin in treating cancer ("Unproven methods of cancer management", 1991). Since amygdalin contains cyanide, it has toxic properties that come along with it. In one particular case, it was discussed that a patient was prescribed B-17 tablets for pancreatic cancer treatment. However, it led to cyanide poisoning and organ failure due to oral administration and perhaps an overdose. Although many cases of treatment with amygdalin are successful, there are some cases linked to oral administration that prove fatal and life threatening to the patient (Dang, Nguyen, & Tran, 2017: "Laetrile / Vitamin B-17

Treatment", 2017). In one case concerning a patient with a malignant brain disease, the oral administration of amygdalin resulted in a similar catastrophic situation. However, the patient was able to be treated and continued with a standard oncology treatment (Meyer et al., 2015). In the future, this can be avoided by more careful administration and closer monitoring of the dosage being prescribed.

Additional research shows amygdalin can be further implemented as a type of treatment or be considered as an alternative if another treatment has failed. This treatment acts as another possible option while keeping the rest of the body from being broken down by the amygdalin. Many cancer treatments can affect the rest of the body with sometimes severe symptoms including fatigue, pain, nausea, and more. According to the Physician Data Query (PDQ) cancer database, amygdalin causes similar side effects like nausea and headaches, but are caused due to cyanide poisoning (PDQ, 2017). However, Dr. Jimenez, who has been using amygdalin in his institute, Hope4Cancer, for almost 30 years, has reported only two cases of cyanide poisoning while using the substance ("Laetrile / Vitamin B-17 Treatment", 2017). Despite the common belief that amygdalin is toxic, it rarely becomes a problem if administered in the correct dosage.

Researching the overall effectiveness of amygdalin in treating cancer can reveal whether or not it should be used more frequently in treatments. If found to be an effective form of treatment, its implementation can prove beneficial to patients. Amygdalin offers an alternative cancer treatment which does not attack healthy cells and has fewer harsh side effects. Each year, 12.7 million people globally are diagnosed with cancer and 7.6 million people die from cancer (Neal, 2011). Although patients are diagnosed and given treatment, the treatment methods are often unsuccessful and do not cure the cancer. As treatment options become more difficult to discover for some patients due to how serious their cancer is or which treatments their body responds to, amygdalin could be a solution for them.

Understanding amygdalin as a treatment option allows doctors to have an alternative treatment method in their list of possible choices when treating a patient. Further researching on the effectiveness of amygdalin in killing cancerous cells, specifically those of lung, breast, prostate, and cervical cancer, will better determine if amygdalin is a plausible treatment option that can be implemented into more treatment plans.

Purpose

The purpose of this study is to investigate the effectiveness of amygdalin in treating lung, breast, prostate, and cervical cancer *in vitro*. Researching the overall success of amygdalin in treating these cancers *in vitro* can lead to the next step in the process of determining if amygdalin is safe and effective in the human body. If found to be an effective form of therapy, the implementation of this treatment method to *in vivo* studies and clinical trials can be beneficial to patients in the future. Although there are already numerous treatments available to cancer patients, some patients decide to turn to alternative treatments. Moreover, amygdalin does not attack other parts of the body, namely the immune system, leaving the patient feeling better overall with less side effects while going through treatment. Furthermore, additional research regarding the efficacy of amygdalin will provide a better understanding on the treatment itself and how effective it is in treating lung, breast, prostate, and cervical cancers specifically.

Hypothesis

The research question addressed in this study is as follows:

What is the role of amygdalin in treating lung, breast, prostate, and cervical cancer *in vitro*?

Alternative hypothesis:

Amygdalin is effective in decreasing cell viability in multiple forms of cancer *in vitro.*

Null hypothesis:

Amygdalin is not effective in decreasing cell viability in multiple forms of cancer *in vitro*.

Materials

Data in this study was collected through systematic data analysis. Data sources include articles retrieved from PLOS Medicine, NCBI, EBSCOhost, Science Archive, BIOSIS Preview, MEDLINE, Open Science Directory, ScienceDirect, and Springer Library, Wiley Online Library, and PubMed. These databases were used based on availability and accessibility. The date range of the papers used begins with 1981 and ends with current research dating 2017. Data was found through other scientists' previous research. The older articles are valid as the more recent studies show similar findings. The articles were read, and data was obtained from July 2017-March 2018. Methods, materials, and results were observed and synthesized to finalize one result for this study. This research design was the most effective as the project was all theoretical. Meta-analysis was not applicable as the four main types of cancer viewed for this study would not have had the proper amount of data sets necessary for meta-analysis. Surveys were also not able to be used since the data needed was from *in vitro* studies. Data collected from personal lab work was not necessary. Information and data was gathered from other journals and articles found through the websites listed above.

Methods

Data Collection

Data collection was completed through reading articles and synthesizing results of different studies to create a data set. This was done through systematic review. The data collected was recorded in tables and graphs. All data collected was from articles that tested amygdalin on cells and cell lines *in vitro*. *In vitro* means that a procedure is performed within a controlled environment outside of an organism. After comparing several studies,

synthesized data was used to determine how effective amygdalin is in treating specific cancers by comparing test groups against the control.

Data collected from published research papers included sources with studies using amygdalin in the concentration of 2.5 mg/ml, 5 mg/ml, 10 mg/ml, and 20 mg/ml for treatment in the time span of 24 hours. The only timespan viewed in this study was 24 hours as it was seen that it was most commonly used throughout papers. The use of tables and graphs helped to organize and compare the data.

In Vitro

Cell lines of lung, breast, prostate, and cervical cancers were treated with amygdalin. Amygdalin from apricot kernels was dissolved in cell culture mediums with concentrations of 2.5, 5, 10, and 20 mg/ml for 24 hours. After 24 hours of treatment, cell numbers were counted to determine the cell viability within the sample.

In a separate part of this study, a control group (which did not receive any treatment) was compared to a treatment group using 10 mg/ml concentration of amygdalin. Cells were left in the medium for 24 hours, then cell viability was observed. Data was plotted to show the comparison of no treatment (control group) with the standard amygdalin treatment of 10 mg/ml.

Analysis of Data

After data was collected, programs including JMP and Excel were used for analysis. Numbers taken from the studies were averaged, then standard deviation measurements were run. After graphs were created to display the results of the data collection, *p*-values were tested through unpaired t-tests and analysis of variance (ANOVA) tests. The unpaired t-tests were conducted comparing the data of the control group to the other concentrations. ANOVA tests were performed in the same manner. If the *p*-values were less than 0.05, the data was considered significant. If the *p*-values were greater than 0.05, the data was either deemed as

marginally significant or insignificant, depending on the number value. Values below 0.05 indicate a higher percentage of support toward the hypothesis and a lesser support of the null hypothesis.

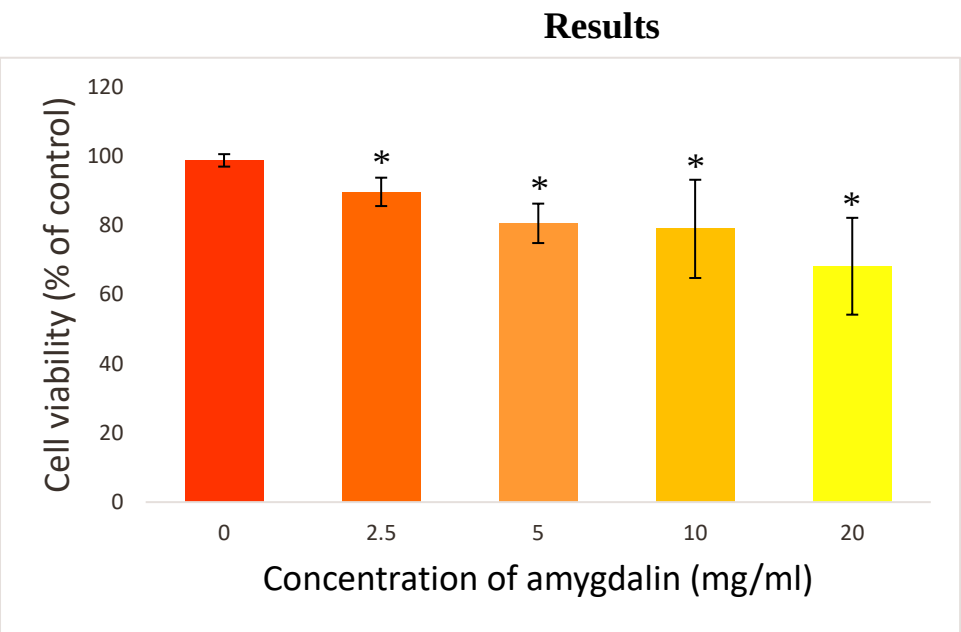

Figure 3. The Effectiveness of Amygdalin in Treating Cancer Cells. This graph shows amygdalin concentrations and cell viability (%) of an *in vitro* cell treatment study. The cell viability presented indicates the percentage of cancer cells remaining after treatment as well as number of dead cancerous cells counted. *indicates significant difference to control ($p < 0.05$) (Chen et al., 2012; Moon et al., 2016; Qian, Xie, & Wang, 2015)

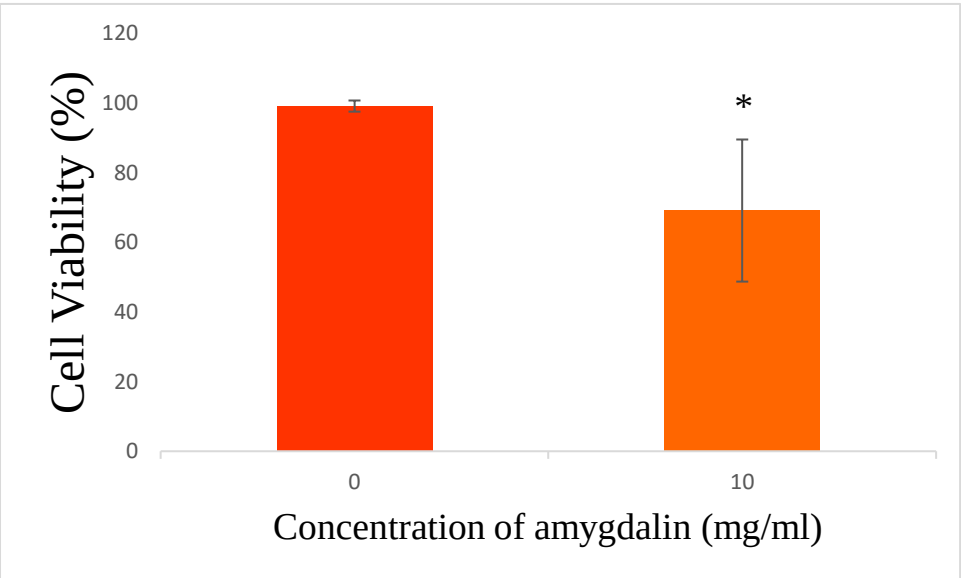

Figure 4. Cell viability after 10 mg/ml treatment. Cell viability percentages were taken from studies involving mediums with a concentration of 10 mg/ml. Results were compared to a control group which did not receive treatment. *indicates significant difference to control ($p < 0.05$) (Chen et al., 2012; Kim et al., 2006; Moon et al., 2016; Qian, Xie, & Wang, 2015).

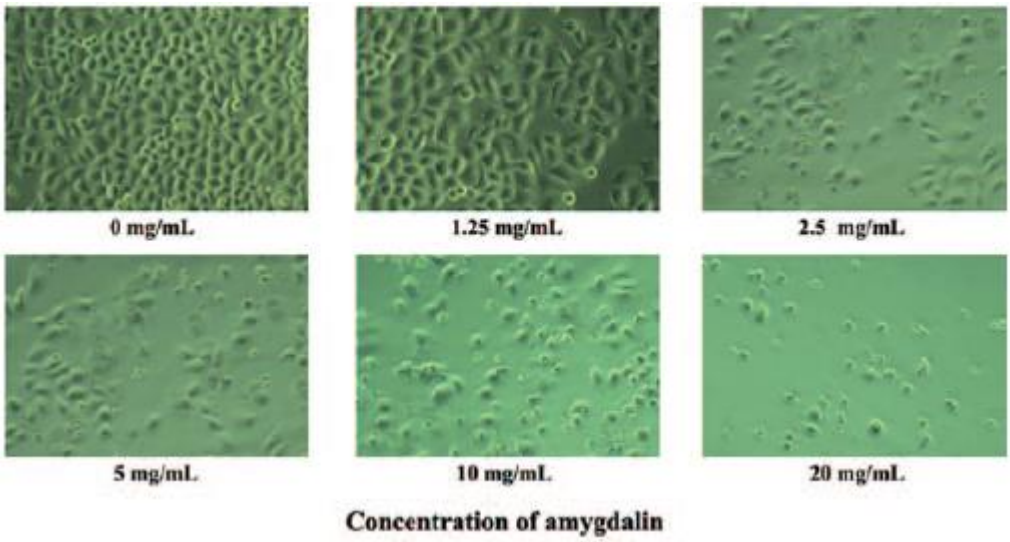

Figure 5. HeLa cells under a microscope after being treated with amygdalin for 24 hours (Chen et al., 2012).

Effect of Amygdalin on Viability of Cancerous Cells

The viability of cells treated with amygdalin decreased in a dose-dependent manner. The data includes tests on breast, cervical, prostate, and non-small cell lung cancer cells. After 24 hours of treatment, the number of cells were counted and compared to the starting number of cells. The control group, or the group that was put in a medium with 0 mg/ml of amygdalin, displayed a cell viability of 98.8 ± 1.8%. At concentration of 2.5, 5, 10, and 20 mg/ml, the viability of cells was 89.68 ± 4.14% ($p < 0.001$), 80.58 ± 5.71% ($p < 0.01$), 79.00 ± 14.20% ($p < 0.05$), 68.20 ± 14.01% ($p < 0.01$) of the control value (Fig 3). Overall, the data as a whole produced a *p*-value greater than 0.05.

In Vitro Cell Analysis After Treatment

HeLa cells were observed under a microscope after 24 hours of treatment. Each image displays cells in an *in vitro* environment. As the concentration increases, the number of HeLa cells decreases. The shape of the cell also became rounder (Fig. 5).

Cell Viability After 10 mg/ml Treatment

Breast, prostate, cervical, and non-small cell lung cancer cell lines were treated in the

medium for 24 hours (Fig 4). After 24 hours, the cell viability was determined and compared to the control group, indicating the 10 mg/ml concentration showed a lower cell viability after the treatment. The control group exhibited a slightly lowered cell viability level of 99.1 ± 1.6%, while the test group of 10 mg/ml displayed a cell viability of 69.1 ± 20.44% ($p < 0.01$).

Sources of Error

The data collected from this study was synthesized from several papers on breast, prostate, lung, and cervical cancer. Although there was sufficient data present from other papers to provide viable results, the outcome of this study would be more significant if there had been a greater number of papers to synthesize. Meta-analysis would have been able to be performed with more papers, which would have then provided stronger results.

Discussion

This research study reports anti-cancer effects of amygdalin, a compound extracted from almonds and the seeds and pits of apples, peaches, apricots, and plums. Secondary plant metabolites have had reported anti-cancer effects on the human body. *In vitro* studies further prove the compound's ability to work against and kill cancerous cells.

The goal of the present study was to test the effectiveness of amygdalin in treating cancerous cells *in vitro*. Two experiments were conducted to test concentrations of amygdalin to determine the effect of amygdalin on cell viability. After reviewing the results, it can be seen that amygdalin did have an impact on cell viability. As the concentration increased, the cell viability decreased, indicating that more cancer cells died.

In Figure 3, data collected from studies using concentrations of 2.5, 5, 10, and 20 mg/ml of amygdalin were averaged, and the results indicate that as the concentration increased, the cell viability decreased. The control group did not display a change in the number of cells after 24 hours. The viability did decrease slightly but was a result of natural cell death rather than from an outside acting factor. When comparing the change in cell

viability from control to test groups, all groups displayed significant results based on *p*-value. The four different concentrations were all values less than 0.05 or 5%. As a whole, the data's *p*-value was 0.06 as indicated from an analysis of variance (ANOVA) test. Although the value was not below 0.05, the results are still considered marginally significant. Therefore, the null hypothesis is not accepted and the hypothesis that amygdalin is effective in treating multiple types of cancer *in vitro* can be accepted.

To further the significance of these results, an additional test was conducted to demonstrate the effectiveness of the 10 mg/ml concentration using results from additional studies. Even with more data to synthesize, the results still indicated that cell viability decreased. This test also produced significant results as the *p*-value was <0.01. After these results, the null hypothesis can once again be rejected.

The images displayed in Figure 5 depict only HeLa cells, which are related to cervical cancer, but they also represent how other cancerous cells lines would appear under the microscope. These images give a visualization of the results from Figure 3 and 4. As the concentration of amygdalin increased, the volume of cells decreased. It can be seen that the cells were less dense, there are fewer present, and the shape of the remaining cells became more oval shaped than the previous circular shape. The change in shape indicates that the amygdalin was able to target the cancerous cells and did have an impact on the physical make up of the cell. Even thought the cell was not killed by the treatment, it was still affected by it.

Conclusion

Through viewing the results of the treatment of cancerous cells *in vitro*, conclusions can be drawn about the effectiveness of amygdalin. The data presented in these studies indicates that the null hypothesis is not accepted, and the hypothesis is accepted. Therefore, amygdalin is effective in treating multiple types of cancer including lung, breast, prostate, and cervical cancers *in vitro.* The results after 24 hours reveal that the higher concentration of

amygdalin allow for lower cell viability. As the concentration of amygdalin increased, the cell viability decreased, supporting the idea that higher concentrations have a larger effect on cell viability.

The results indicate the efficacy of amygdalin as a treatment, but in order to implement it in the future, further studies need to be done. These studies include *in vivo* and eventually clinical trials. Although the results from the *in vitro* studies point towards the idea that amygdalin can treat cancer effectively, further investigation on how the human body will tolerate the treatment need to be done.

Further Work

Clinical trials involving amygdalin have not been conducted in the United States since 1981. At this time, there had been two clinical trials conducted, but the results showed several cases of cyanide poisoning and fewer cases with success. Based on the results of these trials, the FDA decided not to approve amygdalin as a treatment. It is generally thought that amygdalin is unsuccessful in treating cancer or has no effect on the cancer. Many doctors believe rather, that amygdalin causes cyanide poisoning or other harmful results. After viewing the results of this study as well as other previous research, the effectiveness of amygdalin treating cancer *in vitro* can help lead to the consideration of clinical trials involving humans.

Ample research involving amygdalin and cancerous cells *in vitro* has been conducted recently providing updated results and therefore a need to re-test amygdalin in the human body. More knowledge on the properties of amygdalin as well as the effects of amygdalin on cancerous cells is present and the trials may produce different results than before.

The process building up to clinical trials involves further research, more *in vitro* studies, *in vivo* studies, and tests on animals. *In vitro* studies are useful to understand how the treatment works on a cellular level, but in order to see how the body responds to the

treatment, *in vivo* studies serve as the next step. Rats are used in these *in vivo* studies as they are typically analogous to humans and can help in the predictions of how the human body will react. Once these stages in the research process are complete, it is then that clinical trials can begin and be used to prove the safety and efficacy of amygdalin as a treatment for cancer.

In addition to further work needed to investigate the effects of amygdalin on the treatment of cancer, researchers should consider work being done in other countries. Hope4Cancer, an institute in Mexico specializing in alternative treatment for cancer, uses amygdalin as a treatment option for patients. This clinic has reported favorable outcomes from their treatment. If amygdalin use in the United States reaches a point of clinical trials, doctors may consider contacting this clinic to receive assistance to keep their trials safe and effective.

Table 1. The dosages for each form of administration is based on the maximum quantity of amygdalin administered to patients per day, through both oral and intravenous administration. In comparison, the two doses vary because oral administration must be given in smaller doses to prevent possible cyanide poisoning. Although intravenous administration has a higher dosage, it is diluted and administered over a longer period time.

Administration form	Concentration of amygdalin (g) administered daily
Oral	2
Intravenous	9

Using the information in Table 1 in future clinical trials can lead to safer results and avoid the risk of cyanide poisoning. In past clinical trials, there was a lack of knowledge about the correct dosing of amygdalin. This lack of knowledge led to unfortunate outcomes

for patients, which can now be prevented. With knowledge from *in vitro* studies of the effect of amygdalin concentration on cell viability, dosing can be better adapted to maintain the health of the body while killing cancerous cells and not lead to cyanide poisoning in the process.

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