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Effects of Arachidin-1 and Arachidin-3 on Human Colon Cancer Cells

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by

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Abstract

Cancer remains a leading cause of death in the state of Arkansas and across the United States. Recent research found that peanuts consumption has been correlated with a decreased risk of cancer. Although limited research has been conducted, phenolic antioxidant compounds found in peanuts, arachidin-1 and arachidin-3, are correlated to a decrease in human leukemia and lung cancer cell growth. The objective of this study was to evaluate the anti-colon cancer effects of these compounds. Experiments were conducted to examine the effects of purified arachidin-1 and arachidin-3 on Caco-2 cell proliferation. Treatment of cells with arachidin-1 (0, 1, 5, 10μM) and arachidin-3 (0, 5, 10, 20μM) were measured at time points 0, 24, and 48 hours. There was cell reduction for 10 and 20μM treatments of arachidin-3 at time point 24 hours, but no other significant reduction was found. The findings suggest that arachidin-1 and arachidin-3 did not inhibit the growth of human colon cancer cells. Further research needs to be conducted to examine the effects of peanuts stilbenoids, arachidin-1 and archidin-3, as potential anticarcinogenic agents.

Chapter I. Introduction

Globally, each year about 14 million individuals learn they have cancer while 8 million people die from the disease (CDC, 2014). Cancer is the second leading cause of mortality in the United States. Colorectal cancer is the third leading cause of cancer death and approximately 5%, or every 1 in 20 Americans, will be diagnosed with cancer of the rectum or colon in their lifetime (ACS, 2014). In the state of Arkansas, there is a rate of 41.7 per 100, 000 men and women per year compared to the national rate (42.4 per 100, 000). But Arkansas has a higher death rate (17.9 per 100,000) than the national rate (15.5 per 100,000) (Holt et al., 2011).

Epidemiologic studies have identified an inverse association between diet rich in fruits and vegetables and cancer (Chen et al., 2015). A variety of fruits and vegetables contain bioactive components, antioxidants, which have been linked to chemoprevention of colon cancer (Amin et al., 2009).

Peanuts (*Arachis hypogaea L.*) contain high concentrations of polyphenolic antioxidants. Of the bioactive compounds in peanuts much attention has been on the phenolic antioxidant, resveratrol (trans-3,5,49- trihydroxystilbene), a family of stilbenoids. Previous research on resveratrol and polydatin (resveratrol-3-O-b-mono- D-glucoside) has indicated that stilbenoid compound polydatin alone or with resveratrol caused the Caco-2 cell (a human epithelial colorectal adenocarcinoma cell) death by apoptosis (De Maria et al., 2013). Arachidin-1 [trans-4-(3-methyl-1-butenyl)-3,5,3',4'-tetrahydroxysilbene)], and arachidin-3 [(Arachidin-3, trans-4-(3-methyl-1-butenyl)-3,5,4'-trihydroxystilbene)] also belong to a family of stilbenoids derived from the root of

a peanut plant. However, there is limited information available on health-promoting activities of arachidin-1 and arachidin-3.

The goal of this study is to determine the effects of arachidin-1 and arachidin-3 on human colon cancer cells. The objectives of this study were to: 1) determine if arachidin-1 and arachidin-3 can inhibit colon cancer cell growth and 2) determine what concentrations of arachidin-1 and arachidin-3 are effective at inhibiting cell proliferation.

Chapter II: Literature Review

Colon Cancer

Colorectal cancer is the third most common cancer diagnosed in both men and women in the United States (NIH, 2016). CRC is cancer that starts in the colon or rectum. The colon and the rectum are parts of the large intestine, which is the lower part of the body's digestive system (CDC, 2014). The function of the colon is to absorb water and salt from the food matter and to serve as a storage place for waste matter. It is composed of four different sections: ascending colon, transverse colon, descending colon, and sigmoid colon (NIH, 2016).

Colorectal cancer incident and mortality rates are dependent on sex, race, age, and ethnicity (Figure 1). From 2002 to 2011 in the United States the incident rate of colorectal decreased significantly by 3.6% per year among men and by 3.2% per year among women. While in the same years, the death rate decreased significantly by 3.1% per year among men and by 2.9% per year among women (CDC, 2014). Although there is a decrease, in the United States for 2015 the number of CRC cases was projected to be 132,700 new cases of colon and rectum cancer and 49,700 deaths (NIH, 2016).

Risk factors of colorectal cancer include age, race, sex, heredity, preexisting conditions and lifestyle factors such as: physical activity, diet, overweight, alcohol consumption, and tobacco use (CDC, 2014). There is much evidence linking the 'Western' diet (high fat and low fiber content) to increased risk of CRC. Diets are under review as there is a correlation to a higher risk of CRC if a diet consists of a large amount of red meat or processed meats, but a lower risk of CRC if the diet is high in fruits and vegetables (NIH, 2016).

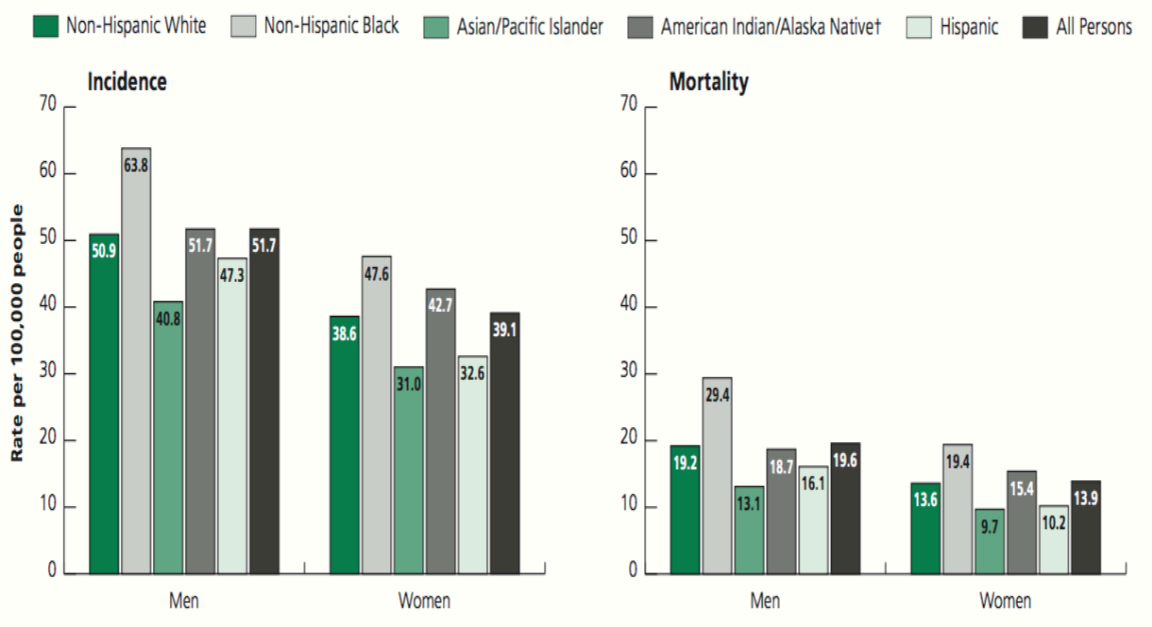

Figure 1: Colorectal Cancer Incident and Mortality Rates* by Race/Ethnicity and Sex, 2006-2010 (ACS, 2014). *Rate are per 100,000

Since diet is a risk factor linked to colorectal cancer, researchers have investigated whether consuming dietary antioxidants can help lower the risk of developing cancer in humans. An antioxidant is a chemical substance that slows down or prevents the damage that oxygen does to organisms or food. Currently research is being conducted looking at specific antioxidants and the effects on cancer, heart disease, stroke, and other diseases associated with aging.

General Information about Peanuts

Nutrients in Peanuts

Peanuts (*Arachis hypogaea* L.), a type of legume, are known for their source of protein and energy. For every 100 grams of peanuts there is approximately 585 kilocalories, 21.51 grams of carbohydrates, 8.0g of fiber, and 49.66g of fats, and 23.68g of proteins. With the exception of meat, legumes, such as peas, beans, and peanuts contain a large amount of protein, more than any other nuts (Settaluri et al., 2012). Peanuts are composed of nutrients, minerals, and vitamins that are essential for optimum health.

Table 1. Composition by weight* of biomolecules in peanuts (Adapted from Settaluri et al., 2012)

Amino acids		**Vitamins**	
Type	Weight (g)*	Type	Weight (g)*
Tryptophan	0.230	Thiamin	0.438×10^{-3}
Threonine	0.811	Riboflavin	0.098×10^{-3}
Isoleucine	0.833	Niacin	13.525×10^{-3}
Leucine	1.535	Pantothenic acid	1.395×10^{-3}
Lysine	0.850	B6	0.256×10^{-3}
Methionine	0.291	Folate	1450×10^{-6}
Cysteine	0.304	E**	6.93×10^{-3}
Phenylalanine	1.227	Choline	55.3×10^{-3}
Tyrosine	0.963		
Valine	0.993	**Minerals**	
Arginine	2.832	Calcium	54×10^{-3}
Histidine	0.599	Iron	2.26×10^{-3}
Alanine	0.941	Magnesium	176×10^{-3}
Aspartic acid	2.888	Phosphorous	358×10^{-3}
Glutamic acid	4.949	Potassium	658×10^{-3}
Glycine	1.427	Sodium	6×10^{-3}
Proline	1.045	Zinc	3.31×10^{-3}
Serine	1.167	Manganese	2.083×10^{-3}
Lipids		**Others**	
Total saturated fatty acid	6.893	Carbohydrates (total)	21.51
Total monounsaturated	24.640	Dietary fiber	8.0
Total polyunsaturated	15.694	Sugar (total)	4.18

*Quantities expressed are per 100g of dry-roasted peanuts, all types, and without salt. **This is a fat soluble vitamin and the rest are water soluble vitamins

Peanuts dietary protein contains amino acids essential for growth and development. Additionally, they are great sources of folate, manganese, niacin – which contributes to brain health and blood flow to brain, and vitamin E – a powerful lipid solvent antioxidant.

Health Benefits of Peanuts

Peanuts are one of the widely cultivated oil-seed and established prime commercial crops in the world. The health benefits of peanuts are becoming a rising topic for researchers as well as nutritionists. In recent years, research has shown that peanuts could be linked to reduced weight gain and especially correlated with different functions in the digestive system (Bes-Rastrollo et al., 2007). Women age 30-55 years had no history of gallstone disease was studied in a 20-year cohort study. Women who consumed at least one ounce of peanuts and/or other nuts each week had a significantly lower risk of cholecystectomy than women who did not eat nuts (Tsai et al., 2004). In a different cohort study of 8,866 individuals, it was found that those who ate nuts—walnuts, almonds, hazelnuts, and peanuts— at least twice a week were much less likely to gain weight of 5 kilograms or more than those who almost never ate nuts (Bes-Rastrollo et al., 2007). In another 10-year cohort study beginning in 1990, the consumption of peanuts and a reduced risk of colorectal cancer were correlated. 12,026 men and 11,917 women aged 30 to 65 years, who were residents in 7 townships in Taiwan, were annually followed by evaluating weekly food measures. Their findings suggest that women who consumed peanuts had a much lower risk of colorectal cancer. It is indicated that some specific components in peanuts inhibit the carcinogenic mechanisms of colorectal cancer, but other studies must be conducted in order to rule out other factors that might have been

present (Yeh et al., 2006). A following step could be to determine what specific component(s) do peanuts possess that could be linked to one or more of these advancements in human health mentioned above. Recent discovery of bioactive components in naturally occurring food has allowed research to continue to conduct more specific studies by researching one or more of the components in food directly. The ability to test only certain bioactive components are crucial for both the research of food industries as well as research regarding human biological processes and diseases. As mentioned above, there are many studies correlating health benefits and peanuts. With increased research with certain bioactive components experimenters can see more specific correlations and possibly extend information to other areas especially for human health.

Bioactive Components in Peanuts

Bioactive compounds are extra nutritional constituents that typically occur in small quantities in foods (Kris-Etherton et al., 2002). Currently bioactive components (which are varied by the number of hydroxyl groups and isopentenyl moiety) in peanuts are on the forefront of research as they are able to prevent or slow the growth of cancers, contain antioxidants, and even extend lifespans (Chang et al., 2006). Polyphenols, antioxidants, are abundant in fruits and vegetables, and evidence for their role in the prevention of degenerative diseases such as cancer and cardiovascular diseases is emerging (Manach et al., 2004). The health effects of polyphenols depend on the amount consumed and on their bioavailability (Manach et al., 2004). Not only do polyphenols have antioxidant properties, but also they have other have a variety of biological activities that are yet to be understood (Manach et al., 2004). Polyphenols are composed of a

subcategory named natural stilbenoids, which are a family of polyphenols known for their diverse biological activities. Recently, it was found that the stilbenoid antioxidants and resveratrol (trans-3,5,4'- trihydroxystilbene), found in peanuts seeds and red grapes has been determined to improve blood flow in the brain by as much as 30%, thus greatly reducing the risk of stroke (Peanuts, 2015). Previous research on polydatin, (resveratrol-3-O-b-mono- D-glucoside, Product Origin: Root of *Polygonum cuspidatum*), a natural precursor of resveratrol, reported that polydatin alone or with resveratrol caused the Caco-2 cell (a human epithelial colorectal adenocarcinoma cell) death by induction of apoptosis (De Maria et al., 2013). Although resveratrol (trans-3,5,4'- trihydroxystilbene) has received considerable attention as a putative anticancer agent, a study found that other peanuts prenylated stilbenoids, arachidin-1 and archidin-3, may be preferable alternatives due to increased bioavailability via slowed metabolism (Brents et al., 2012). Due to the similar chemical structures of resveratrol, arachidin-1 (trans-4-(3-methyl-1-butenyl)-3,5,3',4'-tetrahydroxysilbene), and arachidin-3 (Arachidin-3, trans-4-(3-methyl-1-butenyl)-3,5,4'-trihydroxystilbene) are now specifically being studied. Arachidin-1 and arachidin-3 belong to a family of stilbenoids derived from the root of a peanuts plant. Current research is limited due to the recent discovery of these bioactive components.

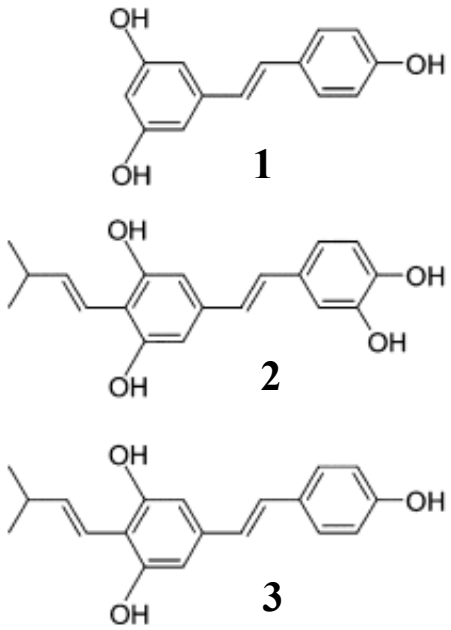

Figure 2. Chemical Structures of 1. Resveratrol (trans-3,5,4'- trihydroxystilbene) 2. Arachidin-1 trans-4-(3-methyl-1-butenyl)-3,5,3',4'-tetrahydroxysilbene; 3. Arachidin-3, trans-4-(3-methyl-1-butenyl)-3,5,4'-trihydroxystilbene (Adapted from Soboley 2013).

Biological Activities of Arachidin-1 and Arachidin-3

Prenylated stilbene compounds in peanuts such as arachidin-1 (Ara-1) and arachidin-3 (Ara-3) are beginning to be studied *in vitro* experiments in order to understand these compounds and the functions that they possess. It was found that both of these compounds possess a defense mechanism against physical injuries and fungal contamination when challenged by a fungal strain (Liu et al., 2013). Prenylated Ara-1 and Ara-3 improved glucuronidation profiles (Brents et al., 2012). In addition, both Ara-1 and Ara-3 showed a significant decrease in Rotavirus Gastroenteritis viral replication when applied (Ball et al., 2015). This study found that the effects of the compounds, Ara-1 and Ara-3, were dose- and time- dependent to decrease viral progeny when they were applied to both the Rotavirus within human intestinal cells. It is indicated that the prenylated side

chain of Ara-1 and Ara-3 promotes invasion through cell membranes more than resveratrol due to the increased lipophilicity to the attached molecules (Ball et al., 2015). Compounds, Ara-1 and Ara-3, are being used in a variety of experiments with viruses, fungal strains, and possible therapeutic values for chronic disease, but they are commonly used in exposure to cancer cells. (Liu et al., 2013). In recent studies Ara-1 had the highest efficacy in inducing programed cell death in Human Leukemia cells HL-60 with an approximately 4-fold lower EC_{50} than resveratrol. Specifically Ara-1 caused mitochondrial membrane damage, released apoptosis-inducing factor, and activation of caspases (Huang et al., 2010). Ko and colleagues in 2013, reported that arachidin-1 decreased thymidine phosphorylase (TP) and Excision repair cross-complementation 1 (ERCC1), both with high amounts in cancer cells are associated with poor prognosis. In addition, arachidin-1 combined with Metformin, a type two diabetic drug, significantly decreased TP and ERCC1 in human lung cancer (NSCLC) cell lines (Ko et al., 2013).

Table 2. Summary of anticarcinogenic activities of arachidin-1 arachidin-3, and resveratrol (*in vitro* studies)**.**

Phenolic Compound	**Cell Line**	**Concentration**	**Effect**	**Time**
Resveratrol, Polydatin (De Maria et al., 2013)	Caco-2 cells, differentiated and undifferentiated	Different concentrations: 0 to 500μM of each or combination (50:50, 75:25 molar ratio)	IC50: 190μM Pol and 373μM Res in differentiated polydatin alone has a stronger cytotoxicity, antiproliferative effect poly:res 3:1	24 hours

Phenolic Compound	Cell Line	Concentration	Effect	Time
Arachidin-1, Arachidin-3, Resveratrol (Cheng-Po et al., 2010)	Human leukemia HL-60	0 to 20 μM treating with Ara-1 and Ara-3	EC_{50} values of 4.2 μM Ara-1, 18.9 μM Ara-3, and 17.6 μM resveratrol	0-72 hours
Metformin (diabetic drug), Arachidin-1 (Ko et al., 2013)	A549 and H1975 Lung cancer cells	0.5, 1, 5 and 10 μM Ara-1 and 25 μM metformin 5, 10, 25 and 50 μM metformin and 0.5μM Ara-1 Ara-1 (0.5 μM) were added for 24 hr	Greater loss of cell viability with both metformin and Ara-1	Treated with metformin, Ara-1 or both for 24hr
Arachidin-1 Arachidin-3 Resveratrol Piceatannol (Ball et al., 2015)	Rotavirus Gastroenteritis HT29 (Human intestinal line infected with Rotavirus)	10, 20 μM Ara-1, 10, 20 μM Ara-3	Ara-1 10 μM tenfold decrease, 20 μM twenty-fivefold decrease Ara-3 10 μM ninefold decrease, 20 μM ninety-eightfold decrease in virus infectivity titer	12 and 24 hours postinfection

*IC50: the dose that causes half-maximal inhibition by antagonist

** EC_{50}: the concentration resulting in a 50% decrease in cell viability (Cheng-Po et al., 2010)

Chapter III: Materials and Methods

Materials

Arachidin-1 (Ara-1) and arachidin-3 (Ara-3) compounds were generously donated by Dr. Medina-Bolivar (Arkansas State University, Jonesboro, AR). All media components and reagents were obtained from Gibco® through ThermoFisher (Waltham, MA).

Methods

HPLC Analysis

A System Gold high performance liquid chromatograph (Beckman-Coulter, Fullerton, CA, USA) with autosampler (model 508), dual pump (model 126), photodiode array detector (model 168) with Beckman-Coulter System 32 Karat software (version 8, 2006) was used to analyze the arachidin-1 and arachidin-3. The compounds were separated using an adapted method of Abbott et al (2010). Separation was performed using a Phenomenex (Torrance, CA) Aqua 5µm C18 (250 × 4.6 mm) column using a binary gradient of 2% formic acid for mobile phase A and 99:1 (v/v) acetonitrile/mobile phase A. The initial conditions of the gradient were 10% B, then increased linearly from 10-18% for 8 min, and was held at 18% B for 2 minutes. Next, B increased linearly to 18-25% over 5 min, 25-35% B for 3 min, and held isocratically for 20 min, then %B increased 35-60% linearly for 60 min before returning to the initial 10%B. Peaks were monitored at 340 nm refer to Figure 3.

Cell Culture

A human epithelial colorectal adenocarcinoma cell line (Caco-2 cells) was purchased from the American Type Culture Collection (ATCC, Rockville, MD). The cells were at passage number 18 (passage number refers to the number of times the cell line has been re-plated) and cultured in Working Media (W-MEM). W-MEM is composed of 10% fetal bovine serum (FBS), 2% antibiotic-antimicotic solution, 1% Non-essential amino acids, and Dulbecco's modified eagle's medium (DMEM). Cell cultures were maintained under strict sterile conditions incubated at 37°C, 70% humidity, and 5% CO_2 in the incubator (VWR® symphony ™, VWR® International LLC, Radnor, PA).

Cell Proliferation Assay

Cells, passage number 22-25, were used for the proliferation assays. The effects of Ara-1 and Ara-3 on the cellular proliferation and viability of Caco-2 cells were measured using CellTiter 96® Aqueous One Solution Proliferation Assay (Promega Cor. Madison, WI). CellTiter 96® contains tetrazolium compound [3-(4,5-dimethyl-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-sulfophenyl)-2H-tetrazolium, inner salt; **MTS**] and an electron coupling reagent (phenazine ethosulfate; PES). This assay is a colorimetric method to determine the number of viable cells in proliferation or cytotoxicity assays. The tetrazolium compound becomes reduced by living cells into a colored formazan product, which is soluble in culture media. The amount of reduced tetrazolium is measured by a plate reader resulting in a directly proportional number of living cells in the culture.

To conduct this MTS assay, Caco-2 cells (2×10^3) in 200µl of W-MEM were seeded in the wells of a 96 well plate. Cells were incubated at 37°C, 70% humidity, and

5% CO_2 for 24 hours to allow attachment of the cells to the bottom of the wells. After 24 hours, the media was aspirated and replaced with different concentrations of a compound (either Ara-1 or Ara-3) and control. Treatment media containing Ara-1 at concentrations of 1, 5, and 10μM and Ara-3 at concentrations of 5, 10, and 10μM. A negative control of 0.1% DMSO in 10% FBS W-MEM was used to measure the viability of Caco-2 cells in the absence of compounds. Treatments and negative controls were done in triplicate. Viability measurements were made at time 0hr, 24hr, and 48hr after the addition of the compounds or control. Time 0hr refers to the time of applying treatment.

CellTiter reagent was directly added to the cells, 40μl per well. The reagent was added to all wells (including wells with cells and to wells only with compounds where no cells are present, a sample control). Microplates were incubated for 2 hours after the addition of the reagent, before measuring the absorbance at 490nm with the plate reader (Synergy HT Multi-Mode Microplate Reader, BioTek Instruments, Inc. Winooski, VT). Once the absorbance readings were made, data was corrected for the background absorbance of the wells with negative control media or with wells with compounds without cells. Corrected absorbance numbers were converted into cell numbers using an equation from the Caco-2 cell standard curve.

A standard curve was composed of serial dilution of cells prepared in triplicate in a 96 well plate ranging from 32000 cells to 0 cells with W-MEM. The standard curve was created by seeding cells in the actual experiment adding CellTiter reagent directly to the wells, and then measuring the absorbance of these cells. The results of standard curve of the 0hr plate were plotted to compare the change in absorbance as the total cell number increased. Each experiment conducted used the equation given from data plotted to

calculate the cell numbers to plot cell growth curves. Cell viability was checked at time points of 24hr and 48hr with cell counts ranging from 32000 to 2000.

Statistical Analysis

Values were expressed means ± standard error of the mean (SEM). Data was analyzed using Statistical Analysis System (Version 9.4; SAS Institute Inc., Cary, NC). A one-way analysis of variance was used to show significant differences from the control cells at each time point. An alpha level of 0.05 was used to determine statistically significant differences. Fisher's least significant difference (LSD) test was used to analyze the data.

Chapter IV: Results

HPLC Results

The High Performance Liquid Chromatogram (HPLC) analysis confirmed the identity of compounds used for this experiment: arachidin-1 and arachidin-3. The results are summarized in Figure 3.

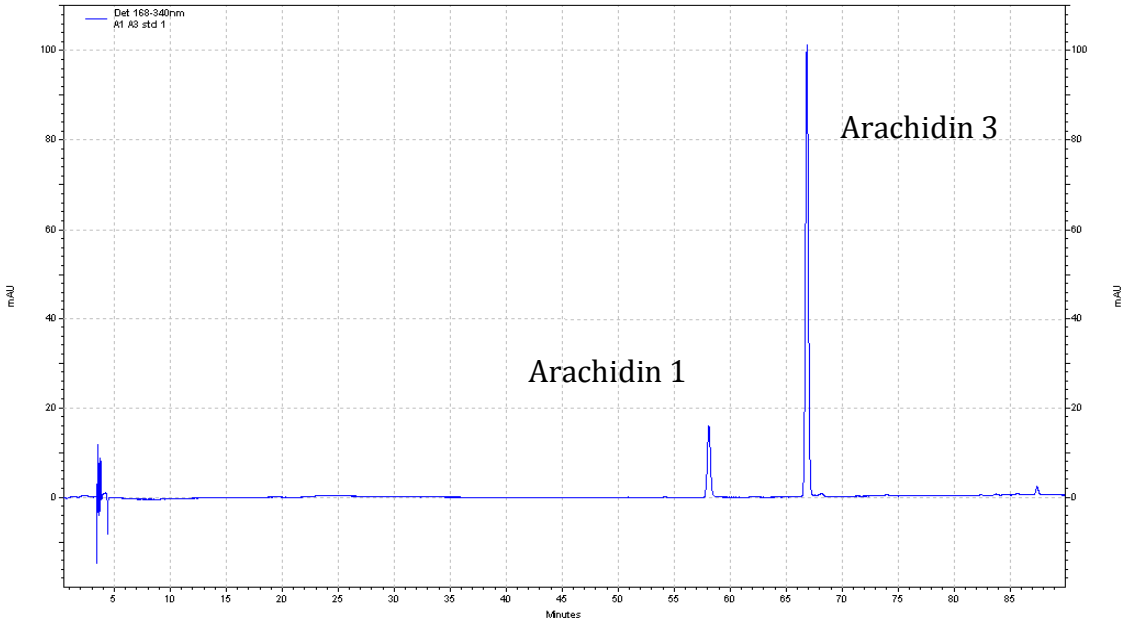

Figure 3. High Performance Liquid Chromatogram of arachidin-1 and arachindin-3 at 340nm.

Cell Standard Curve

In order to differentiate outside factors from treatment cells, a standard curve was used as a control on every plate. This was used as a reference for cell growth and conditions on each cell plate throughout the experiment. Figure 4 shows the standard curve of Caco-2 cells.

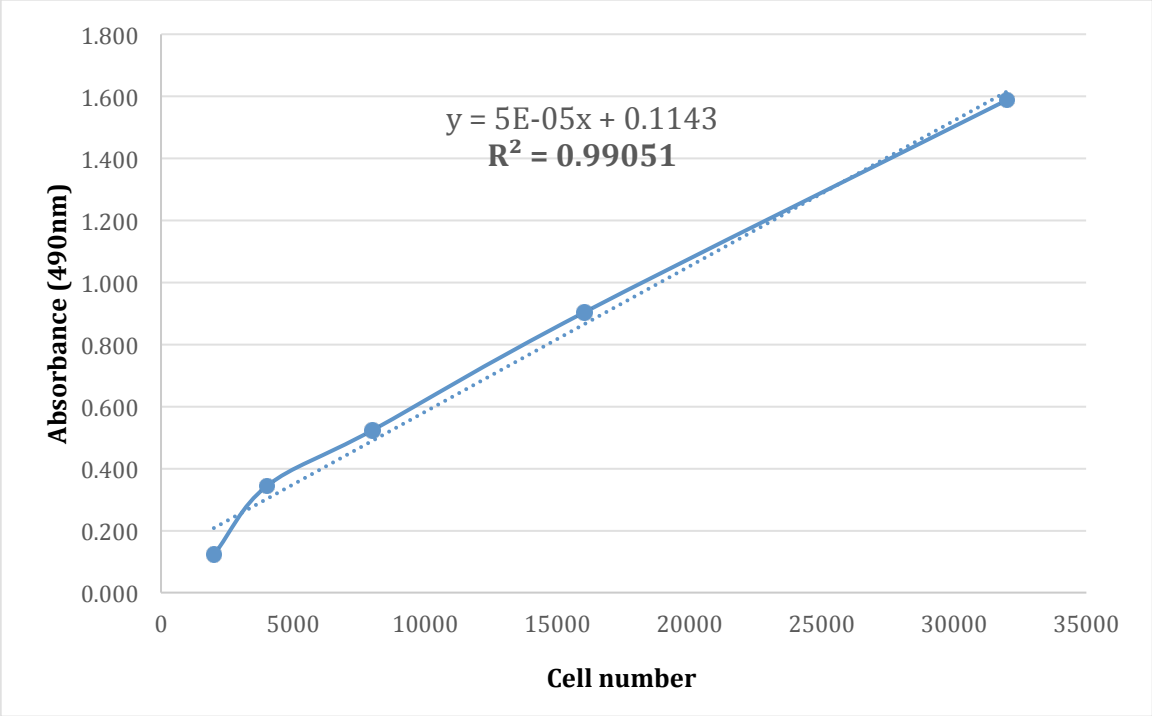

Figure 4. Caco-2 cell standard curve

Cell Proliferation

Treatment of Caco-2 Cells with arachidin-1 did not decrease cell proliferation compared to control (Figure 5). There is a difference between 10mM cell growth compared to the control (0μM), 1μM, and 5μM. At both time points of 24 and 48 hours for arachidin-1, 10μM treatment seemed to promote cell growth compared to the control, treatment of 1μM and 5μM. The effectiveness of reduced cell proliferation for arachin-1 was not correlated with concentration at time points 24 and 48 hours.

Figure 6 shows the effects of arachidin-3 on the survival of Caco-2 cells. Compared with the control and 5μM of arachidin-3, treatments of 10μM and 20μM of arachidin-3 resulted in a significant reduction of cell number at time point 24 hours ($P<0.05$). At time point 48 hours there was not a significant difference between the any of the treatments of arachidin-3.

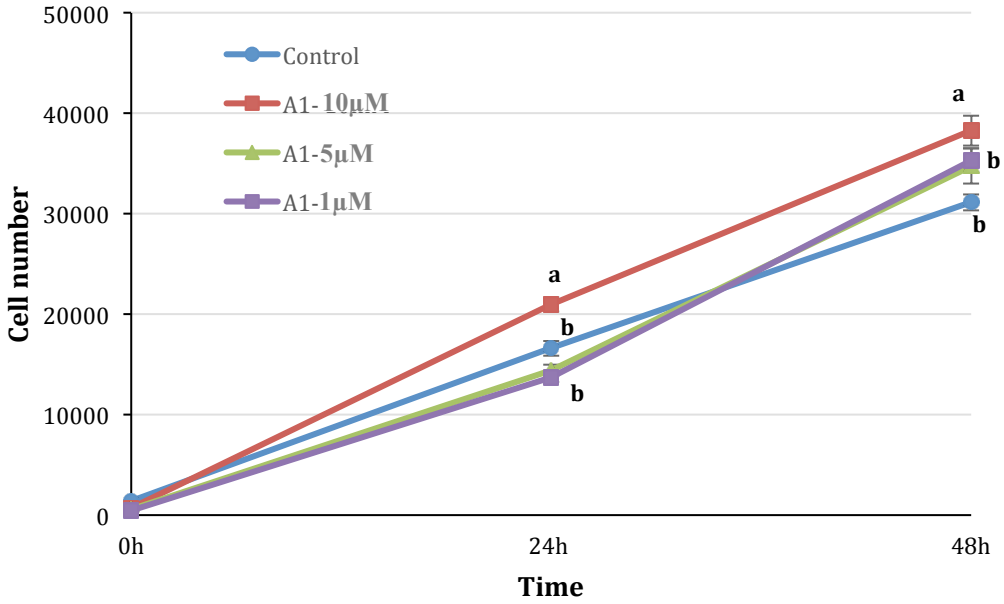

Figure 5. Effect of arachidin-1 on the survival of Caco-2 cells. Values are mean ± standard error of the mean (SEM). Values with different letters at the same incubation time are significantly different (P<0.05).

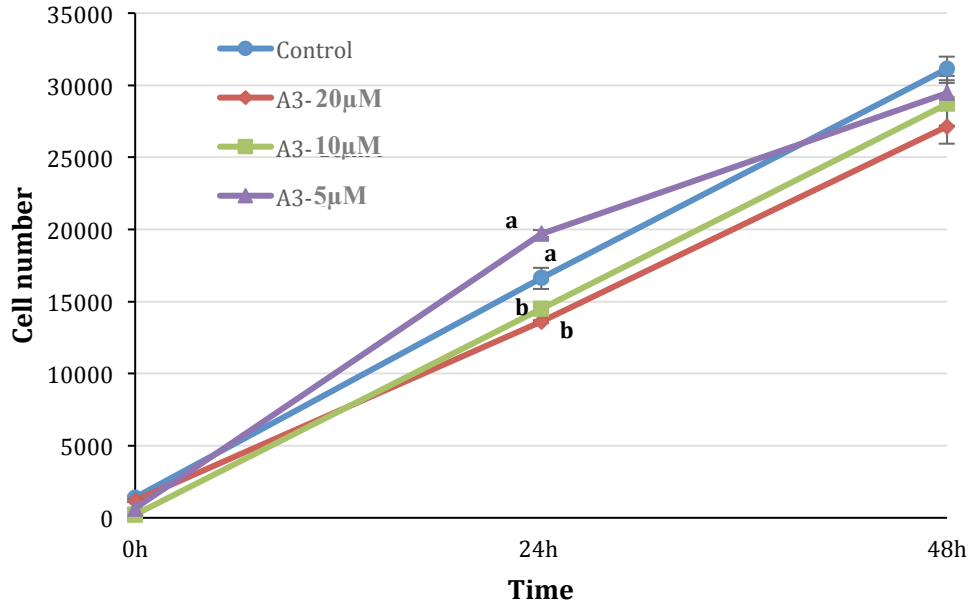

Figure 6. Effect of arachidin-3 on the survival of Caco-2 cells. Values are mean ± standard error of the mean (SEM). Values with different letters at the same incubation time are significantly different (P<0.05).

Chapter V: Discussions

Peanuts (*Arachis hypogaea* L.) contain many nutrients, antioxidants, vitamins, and minerals essential to optimal health (Settaluri et al., 2012). Peanuts have been linked to reduced weight gain to reduced risk of heart disease (Bes-Rastrollo et al., 2007; Settaluri et al., 2012).

The present study investigated the effects of stilbenoids (arachidin-1 and arachidin-3) found in peanuts root on colon cancer cells (Caco-2 cells) proliferation. No significant reduction of cell growth with arachidin-1. There was a significant increase of proliferation at time point 24 and 48 hours for 10μM treatment of arachidin-1. However, there was a significant difference in inhibition of cell growth for treatments 10μM and 20μM of arachidin-3, but none of the treatments showed a significant difference at time point 48 hours. Further research should include higher concentrations of arachidin-1 and arachidin-3 on Caco-2 cell growth.

There have been a few *in-vitro* studies regarding the anti-proliferative behavior of arachidin-1 and arachidin-3, but there is a variation in results and concentrations of these compounds between studies. These studies have reviewed different cells lines and combined alternative drugs or naturally occurring compounds combined with arachidin-1 and arachidin-3 (De Maria et al., 2013, Cheng-Po et al., 2010, Ko et al., 2013, Ball et al., 2015). There was only one study found to look at Caco-2 cells combining antioxidant agents, resveratrol and Polydatin (De Maria et al., 2013). Due to the limited research of compounds arachidin-1 and arachidin-3 effects on Caco-2 cells, there could be a different concentration needed to inhibit proliferation. A study on human leukemia cell line

suggested that arachidin-1 should be more potent than arachidin-3, but this study was not able to concur with these results (Cheng-Po et al., 2010). Based on previous studies concentrations of treatments varies depending on cell line experimented (De Maria et al., 2013, Cheng-Po et al., 2010). Due to the limited research with Caco-2 cell line with peanuts stilbenoids more research need to be conducted to fully understand the effects of these compounds.

Chapter IV: Conclusions

The results of the present study suggest that arachidin-1 and arachidin-3 did not inhibit the growth of human colon cancer cells. In order to understand the biological activities of these compounds more studies need to be conducted.

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