



THE UNTAPPED POTENTIAL OF CABBAGE EXTRACT AS ANTIOXIDANT, ANTICANCER AND PREVENTATIVE AGENT

Huda Ali Salman Almosawey¹, Khitam Khales Al-Masoudi²

huda.ali@uokerbala.edu.iq¹, khitam.k@uokerbala.edu.iq²

^{1,2} Kerbala University, Faculty of Medicine, Department of Microbiology- Iraq

ABSTRACT

The possible anticancer effects of cabbage, a member of the Brassica family, have been investigated. Numerous investigations into its impact on various cancer types have shown encouraging findings, indicating that cabbage extracts may prove to be a useful tool in the prevention and treatment of cancer. Despite extensive research demonstrating the effectiveness of cabbage extract in treating various forms of cancer, this promising therapy was not exploited to gain widespread adoption in the medical community. This oversight has several causes, including commercial interests, regulatory hurdles, and general inclination for traditional cancer treatments. This review will go over the significance of cabbage extract, the concentrations that have been used in earlier studies to combat different types of cancer, and the main arguments against its use as an antioxidant, anti-cancer, or cancer prevention agent, despite the fact that, it is a natural extract and that many studies have demonstrated its efficacy in all of the aforementioned fields.

Keywords: cabbage, anticancer, antioxidant, cabbage extract, preventative agent.

INTRODUCTION

The anticancer effects of cabbage are primarily attributed to its high content of glucosinolates and their degradation products. Cabbage extracts estrogenic and antiestrogenic properties were examined (Ju et al.2000). Based on the results of another study, red cabbage induced apoptosis in breast cancer cells (MCF-7) in vitro, which hastened cell death. Red cabbage may therefore be regarded as a successful breast cancer treatment (Mahdian et al.2015). and as a green fluorescent, non-toxic label for HER2-positive breast cancer cell bioimaging (Rostami et al.2023). Another study tested the antioxidant properties of cabbage extract on human cervical and hepatocarcinoma cancer cells. The results showed that the extract might be a potential anticancer agent, opening new possibilities for natural anticancer therapy (Hafidh et al.2013). even as a diet, it is useful for preventing liver cancer in humans (Wang et al.2015). For the prevention and

treatment of prostate and colorectal cancers, polyphenols (found in cabbage extract) can be an important supplemental therapy (Ahmad et al.2022). Their important bioactive metabolites in the prevention and treatment of colorectal cancer (Ağagündüz et al. 2022). Apoptosis via the mitochondrial, caspase, and calpain pathways was the primary mode of activity (Pena et al.2022). Compared to the juice of the mature vegetable, the juice of young shoots has demonstrated a better anti-proliferation activity against prostate cancer cells in vitro (Drozdowska et al.2020). The same researcher, in another investigation, observed the effect of young shoots and mature red cabbage on prostate cancer cell lines (DU145 and LNCaP) (Drozdowska et al.2021). (song et al. 2018) demonstrated that the superior anticancer potential of kimchi prepared with Amtak Baechu cabbage and treated with brine solution (AK-B) against both cancer cell types, with the effects being stronger on pancreatic cancer cells than liver cancer cells. This was confirmed by a Korean study on the use of the standard Baechu cabbage. This extract may be a source for natural supplements and functional foods to fight pancreatic cancer by examining the anti-pancreatic-cancer impact of a recently produced cabbage line both in vitro and in vivo (kim et al.2019). Higher volumes of the cabbage extract slightly increased the proliferation of the MRC-5 cells, not significantly affecting the proliferation of the ovary cancer cell lines (Furdak et al.2022). And have the potential inhibitory activity against the development of gastric cancer (Ngo et al.2022), and bladder cancer prevention (Abbaoui et al.2018). There are other studies that tested the effect of the extract as an anti-cancer cell and anti-tumor agent without specifying the type of cancer (Fujioka et al.2016); (Przystupski et al.2019); (Mandrich et al.2020); (Mavlonovich et al.2022).

Mechanism of Action

Antioxidant Properties: Extracts from cabbage, especially red cabbage, have potent antioxidant properties that are essential for preventing oxidative stress, which is known to contribute to the development of cancer. At lower doses, these extracts have been demonstrated to remain safe while increasing the mortality rate of cancer cells in a dose-dependent way (Tajalli et al.2020); (El-Said et al.2019).

Induction of Apoptosis: Extracts from cabbage can cause cancer cells to undergo apoptosis or programmed cell death. This is accomplished by downregulating anti-apoptotic genes like Bcl2 and upregulating pro-apoptotic genes like Bax and caspase 3, which prevents cancer cells from proliferating (El-Said et al.2019).

Inhibition of Carcinogen Activation: In animal studies, Chinese cabbage powder has been shown to dramatically lower the incidence of liver cancers by preventing the development of aflatoxin B1-DNA adducts in liver cells. This implies that cabbage can lower the risk of cancer by preventing carcinogens from activating (Hwang et al.2005); (Wang et al.2015).

Types of Cancer Studied

Liver Cancer: Research has indicated that Chinese cabbage powder may be useful in preventing liver cancer by successfully lowering the incidence of aflatoxin B1-induced liver tumors in animal models (Wang et al.2015).

Pancreatic Cancer: By decreasing tumor size and preventing Regulatory-T-cell recruitment, which is essential for the immune system's capacity to fight cancer, a recently developed cabbage line called Amtak-ssamchae has shown notable anticancer effects in pancreatic cancer models (Kim et al.2019).

breast Cancer: It has been demonstrated that dietary cabbage reduces the incidence of mammary tumors in rats, especially when the diet is low in fat. Certain chemicals in cabbage are thought to have this effect because they decrease cancer (Mahdian et al.2015).

Colorectal cancer: The potential of red cabbage and broccoli extracts as chemopreventive medicines for colon cancer has been suggested by their ability to suppress cell growth and trigger apoptosis in colorectal cancer cell lines (El-Said et al.2019).

Method

Up until August 25, 2024, the databases of PubMed and Google Scholar were searched for relevant studies. The focus was on articles published between 2000 and 2024 .Only publications about cabbage extract published in any language were included in the search, along with other limitations.

Selection of studies and inclusion/exclusion criteria

Studies that tested the effect of cabbage extract and the active ingredients (anthocyanin extract and phenolic compound from red cabbage) on unspecified types of cancer were included. Studies that tested its antimicrobial and anti-inflammatory effect and its role in some chronic diseases were excluded. Articles that tested plant extracts in general or other genus of Cruciferous family were excluded. The specific search terms used were "cabbage extract as an antioxidant," "anticancer," and "protective agent." Boolean operators (AND, OR) were used, and the search was restricted to specific domains. Published reviews were excluded, focusing on original research conducted in vitro or in vivo. Research that used cabbage extract in combination with another compound was also excluded. Its use as an anti-inflammatory was excluded from this study.

Data extraction

Following the initial screening, the whole texts of the included articles were posted to a shared Google Drive file. to extract the following data, a standardized Google Drive spreadsheet was made: initial author, year, cancer kind, research design, in vitro or in vivo, and extract concentration.

Synthesis of data and Statistical analyses

Based on information such as the test type (in vitro and/or in vivo) and the impact of cabbage as an antioxidant, anticancer, preventative, or therapeutic agent, a descriptive analysis was conducted. Any kind of cancer was subjected to descriptive analyses, which were followed by extract concentration.

Result

Table.1. Number of involved study

	In vitro	In vivo	both
Number of articles	20(80%)	1(4%)	4(16%)
total	25		

Study through databases and records.

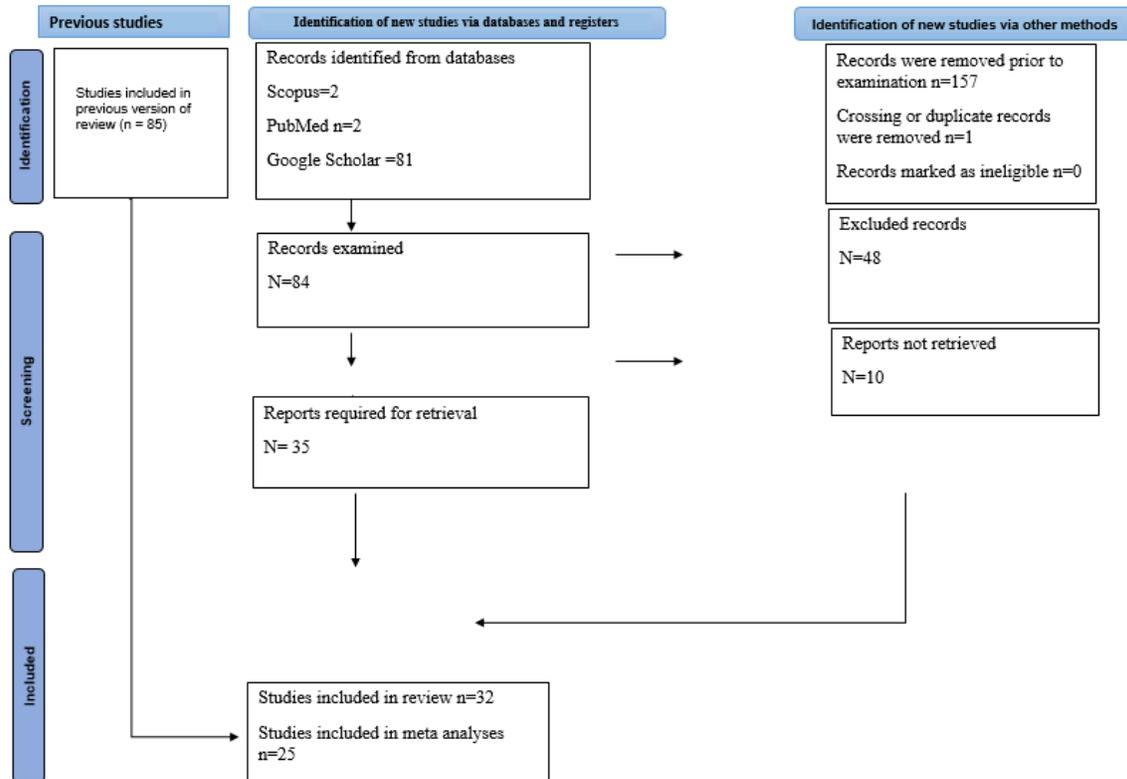


Table 2. Target cells of cancer and concentrations of extract

Type of cancer	cell line	concentration	
		In vitro	In vivo
hepatoma	AH109A	various concentrations	various concentrations
Breast cancer	MCF-7	25-50 µg/mL	
hepatocarcinoma	HepG2 cells	50 µg/mL	
Cervical ca.	HeLa	50 µg/mL	
Human colon Adenocarcinoma	HT-29	11.3 mg/ml**	
Colorectal	Caco-2	6.75 mg/ml	
Breast Adenocarcinoma	MCF-7	5.8 mg/ml	
Human Foreskin Fibroblast	HFF3	6.4 mg/ml	
Breast cancer	MCF-7	2000 g/ml	
liver tumor			various concentrations
Prostate cancer	DU145 and LNCaP	4.0 mg /mL	

prostate cancer	DU145 and LNCaP	various concentrations	
pancreas	Panc02	1.7 mg	
pancreas	Panc02		80 mg/mL
pancreas cancer	Capan-2	2.0 mg/mL	
human liver cancer	HepG2	2.0 mg/mL	
Colorectal cancer	Caco-2	6.4 mg/ml	
Breast cancer	MCF-7		
Cancer cells	HeLa	50 g /mL	
Gastric ca	BGC-823	100 µg/ml	
lung metastasis	B16BL6		1000 µg/ml
hepatocellular carcinoma	AH109A		100 mg/kg*
Colorectal ca	Caco-2	6.75 mg/ml	
Prostate Cancers	DU145 and LNCaP	4.0 mg /mL	
Breast cancer	MCF-7	10 µg/mL	

*Higher concentration in vivo

** higher concentration in vitro

Empty cells in the table mean that the study was tested either in vitro or in vivo.

Table 3. Summary of studies involved in the study.

Cancer Cells	Extraction	Results	Authors
B16BL6 melanoma cells	alcohol in-soluble residue hot water extract	inhibited 47.3% lung metastasis	Lee et al.2019
1. Cervical Cancer Cell Line; HeLa 2. breast cancer cell line; MCF-7. 3. liver cancer cell line; HepG-2.	Extracted by alcohol	considerable anticancer action, particularly against the HeLa cell line, which is found in the human cervical.	Mansour et al. 2021
1. liver cancer 2. kidney	The leaves were washed and dried at room temperature to obtain fine powder. Then, soak in 900 ml of 90% ethyl alcohol for 72 hr.	red cabbage was More effective as compared with white cabbage, to reduce the incidence of liver cancer in liver rats and improve liver and kidney function and antioxidant defense more effectively.	Rezq, et al.2017
breast cancer cell bioimaging	a liquid-solid (Solvent) heat assisted extraction method	as a green fluorescent, non-toxic label for HER2-positive breast cancer cell bioimaging	Rostami et al.2023
gastric cancer cells (100 µg/ml)	ethanol extract	inhibitory action against BGC-823 cell growth	Ngo et al.2022

ovary cancer cell lines (SKOV-3 and PEO1)	Whole white cabbage (<i>Brassica oleracea</i> L. var. capitata) was homogenized in phosphate-buffered saline (1:9, w/v), extracted with shaking for 30 min and centrifuged.	While the proliferation of the ovary cancer cell lines was not impacted, higher quantities of the cabbage extract marginally improved the proliferation of the MRC-5 cells.	Furdak et al. 2022
HeLa cells	Wild cabbage extract	at a concentration of 10 and 50 $\mu\text{g mL}^{-1}$ showed an antiproliferative effect on HeLa cells, while they did not affect the proliferation of normal human skin fibroblasts.	Lučić et al.2023
prostate cancer cell lines DU145 and LNCaP	Heads of many sizes were cut off. Then squeeze in the juice). After freezing, the samples were sealed in a plastic bag and stored in a refrigerator ($-20\text{ }^{\circ}\text{C}$) for further analysis. In addition, fresh plants were used to prepare methanolic extracts and determine vitamin C levels.	Compared to the juice of the mature vegetable, the juice of young shoots has demonstrated a better anti-proliferation activity against prostate cancer cells in vitro.	Drozdowska et al.2020
ascites hepatoma cell line (AH109A) in rat	administered orally to AH109A-bearing rats) It has been squeezed and filtered) in combination with lipopolysaccharide injection	By promoting the cytotoxicity of tumor-infiltrating macrophages, the anticancer effect of cabbage extract, which contains macrophage-stimulating component or components, can be achieved.	Komatsu et al.2002
estrogenic and antiestrogenic activities in estrogen-dependent human breast cancer (MCF-7) cells	freeze-dried fermented cabbage (FDS), freeze-dried cabbage (FDC), and acidified Brussels sprouts (ABS)	0.25-25 nanogram induced MCF-7 cell proliferation. 25-50 $\mu\text{g/mL}$ increased proliferation in MCF-7 cells was observed	Ju et al. 2000
hepatoma cell line (AH109A)	administered orally to AH109A-bearing rats in combination with lipopolysaccharide injection. leaves were ground to powder, extracted 1:10 wt/v with 2.4 mol/L HCl acidified methanol	antioxidant properties of cabbage extract on hepatocarcinoma and human cervical cancer cells	Hafidh et al.2013
anticancer activity on the growth and viability of the desired human cancer cells	powder was extracted 24 hours using methanol in a Soxhlet device with a 1:10 powder to solvent ratio.	Phenolic compounds have strong antioxidants and anti-cancer activity when used in moderation. To avoid typical human cell damage, red cabbage extract should be utilized at concentrations below 6.4 mg/ml.	Tajalli et al.2020
breast cancer cells (MCF-7)	hydro-alcoholic extract	The extract induced apoptosis in cancer cells and had no	Mahdian et al.2015

		cytotoxic effect on healthy cells.	
liver tumor	complex water-soluble extract by spray-drying at an outlet temperature of 130 °C	There were at least 11 potential anticancer substances in Chinese cabbage powder	Wang et al.2015
prostate cancer cell lines DU145 and LNCaP	prepare juices by squeezing in a juicer	The juice included a variety of substances with pleiotropic anticarcinogenic properties that may cause distinct apoptotic pathways.	Drozdowska et al.2021
pancreatic cancer	After freeze-drying, 80% ethanol extraction, and solvent removal in a vacuum evaporator, the mixture was crushed into a fine powder.	indicated that Amtak-ssamchae extract might be used to make functional foods and natural supplements to fight pancreatic cancer.	Kim et al.2029
pancreas cancer cells (Capan-2) and human liver cancer cells (HepG2).	Kimchi was made from Amtak and regular Baechu cabbages, and it was salted using a brine solution or a dry salt treatment.	The findings showed that Amtak Baechu cabbage-based kimchi treated with brine solution (AK-B) exhibited improved anticancer potential against both cancer cell types.	Song et al.2018
MCF-7 breast cancer cell line	environmentally friendly production of magnetic iron oxide nanoparticles (IONPs) from iron (III) chloride using an aqueous peel extract from Brassica	The effective manufacturing of nanoparticles is supported by characterization results, and the dose-dependent lethal effects of nanoparticles on MCF-7 cells further establish their potential	Erdoğan et al.2021
breast cancer	ethanolic extracts	RCE demonstrated selectivity for reducing cancer cell proliferation breast cancer cells, however the individual metabolites or combination with broccoli did not inhibit proliferation to the same level.	Sanchez-Guzman et al.2024

Discussion

Cabbage is a widely cultivated vegetable with a long history of use in traditional medicine. Recent scientific research has uncovered the potential of cabbage extracts to possess anticancer properties, making it a promising candidate for cancer treatment. [(Drozdowska et al.2020); (Wang et al.2015)]. This systematic review aims to synthesize the current evidence on the potential of cabbage extract as a cancer treatment, with a focus on its mechanisms of action and efficacy. Przystupski et al., indicated that further research and development of novel drugs and natural substances is still needed to improve the treatment of cancer in humans because of nature-derived substances' non-selective activity and severe side effects [Przystupski et al.2019]. Fang et al. suggested that, all cruciferous vegetable consumption was not substantially linked to the incidence of colorectal cancer, according to a hospital-based matched case-control research, but according to the gender-specific stratification study, women who consume more cruciferous vegetables overall had a lower risk of colorectal cancer [Fang et al.2019].

For in vitro studies, various concentrations were used to test the effectiveness of cabbage extract. The highest concentration used in the laboratory was 11.3 mg/ml. whereas, lowest concentration was 10 µg/ml. On the other hand, these studies used cancer cells from mice and rats, and in a study, they were isolated from humans.

A study used cabbage extract alone and in synergy with broccoli extract [Sanchez-Guzman et al.2024].

In all the studies reviewed in this article, cabbage extract has proven its effectiveness as an antioxidant, anti-cancer, and protective agent. The question posed in this article can be answered by studies conducted in vivo. As for the studies conducted in vivo, the highest concentration used was 100 mg/kg. and the lowest concentration was 1000 mg/ml, and a study recommended that the dose not exceed more than 6.4 mg/ml [Tajalli et al.2020].

Lučić, found that, at a concentration of 10 and 50 µg mL⁻¹ showed an antiproliferative effect on HeLa cells, while they did not affect the proliferation of normal human skin fibroblasts [Lučić et al.2023].

From all previous studies we concluded that: red, white and wild cabbage extract (mature vegetable or the juice of young shoots) demonstrated a better anti-proliferation activity against several cancer cells and have an antioxidant property, potential anticancer effects by promoting the cytotoxicity of tumor-infiltrating macrophages and induced apoptosis in cancer cells and had no cytotoxic effect on healthy cells .this opens the way for it to be clinically tested on patients, starting with low concentrations as part of healthy nutrition, to achieve the best results from exploiting this plant that is available and less expensive and has fewer side effects compared to anti-cancer treatments that have side effects and are expensive and often weaken immunity.

Challenges and Future Directions of Research

Dose Optimization: It is critical to ascertain the ideal dosage of cabbage extracts for both cancer prevention and treatment. Different effective doses have been found in studies, and more investigation is required to create uniform dosing recommendations [(Wang et al.2015); (Tajalli et al.2020)]

Mechanistic Studies: Although cabbage has clear anticancer effects, further investigation is required to completely comprehend the underlying mechanisms. Investigating the precise substances causing these effects and how they interact with biological pathways is part of this [(Hwang et al.2005); (Komatsu et al.2002)]

Clinical Trials: In vitro and animal research provide most of the available data. To verify the effectiveness and safety of cabbage extracts in human populations, clinical trials are required [Jung Park et al.2002].

Conclusion

Because of its antioxidant qualities, capacity to trigger apoptosis, and suppression of carcinogen activation, cabbage extracts exhibit great promise as a natural cancer treatment. Although encouraging outcomes have been noted in several cancer types, more investigation, including clinical trials, is necessary to fully realize cabbage's anticancer potential.

most of the studies reviewed in this current study indicate that cabbage extract has no potential harm to normal cells of the body of a living organism, and a study assumes that it should be utilized at lower doses than 6.4 mg/ml. Because of its many phenolic components and potent antioxidants and anticancer properties when used in moderation, it can be regarded as a healthy food.

References

1. Abbaoui, B., Lucas, C. R., Riedl, K. M., Clinton, S. K., & Mortazavi, A. (2018). Cruciferous vegetables, isothiocyanates, and bladder cancer prevention. *Molecular nutrition & food research*, 62(18), 1800079.
2. Ağagündüz, D., Şahin, T. Ö., Yılmaz, B., Ekenci, K. D., Duyar Özer, Ş., & Capasso, R. (2022). Cruciferous vegetables and their bioactive metabolites: from prevention to novel therapies of colorectal cancer. *Evidence-Based Complementary and Alternative Medicine*, 2022(1), 1534083.
3. Ahmad, N., Qamar, M., Yuan, Y., Nazir, Y., Wilairatana, P., & Mubarak, M. S. (2022). Dietary polyphenols: Extraction, identification, bioavailability, and role for prevention and treatment of colorectal and prostate cancers. *Molecules*, 27(9), 2831
4. Drozdowska, M., Leszczyńska, T., Koronowicz, A., Piasna-Słupecka, E., & Dziadek, K. (2020). Comparative study of young shoots and mature red headed cabbage as antioxidant food resources with antiproliferative effect on prostate cancer cells. *RSC advances*, 10(70), 43021-43034.
5. Drozdowska, M., Leszczyńska, T., Piasna-Słupecka, E., Domagała, D., & Koronowicz, A. (2021). Young shoots and mature red cabbage inhibit proliferation and induce apoptosis of prostate cancer cell lines. *Applied Sciences*, 11(23), 11507.
6. El-Said, K. S., Abd Elhamid, M. M., & Kenawy, E. R. (2019). Red cabbage and broccoli (*Brassica oleracea*) extracts inhibit cell proliferation by inducing apoptosis in colorectal cell lines.
7. Erdoğan, Ö., Paşa, S., Demirbolat, G. M., & Çevik, Ö. (2021). Green biosynthesis, characterization, and cytotoxic effect of magnetic iron nanoparticles using *Brassica Oleracea* var *capitata* sub var *rubra* (red cabbage) aqueous peel extract. *Turkish Journal of Chemistry*, 45(4), 1086-1096.
8. Fang W., Qu X., Shi J., Li H., Guo X., Wu X., Liu Y., and Li Z., Cruciferous vegetables, and colorectal cancer risk: a hospital-based matched case-control study in Northeast China, *European Journal of Clinical Nutrition*. (2019) 73, no. 3, 450–457
9. Fujioka, N., Fritz, V., Upadhyaya, P., Kassie, F., & Hecht, S. S. (2016). Research on cruciferous vegetables, indole-3-carbinol, and cancer prevention: A tribute to Lee W. Wattenberg. *Molecular nutrition & food research*, 60(6), 1228-1238.
10. Furdak, P., Pieńkowska, N., Bartosz, G., & Sadowska-Bartos, I. (2022). Extracts of common vegetables inhibit the growth of ovary cancer cells. *Foods*, 11(16), 2518.

11. Hafidh, R. R., Abdulmir, A. S., Bakar, F. A., Jalilian, F. A., Jahanshiri, F., Abas, F., & Sekawi, Z. (2013). Novel anticancer activity and anticancer mechanisms of *Brassica oleracea* L. Var. *Capitata* f. *Rubra*. *European Journal of Integrative Medicine*, 5(5), 450-464.
12. Hwang, J. W., Park, J. S., Jo, E. H., Kim, S. J., Yoon, B. S., Kim, S. H., ... & Kang, K. S. (2005). Chinese cabbage extracts and sulforaphane can protect H₂O₂-induced inhibition of gap junctional intercellular communication through the inactivation of ERK1/2 and p38 MAP kinases. *Journal of agricultural and food chemistry*, 53(21), 8205-8210.
13. Ju, Y. H., Carlson, K. E., Sun, J., Pathak, D., Katzenellenbogen, B. S., Katzenellenbogen, J. A., & Helferich, W. G. (2000). Estrogenic effects of extracts from cabbage, fermented cabbage, and acidified brussels sprouts on growth and gene expression of estrogen-dependent human breast cancer (MCF-7) cells. *Journal of agricultural and food chemistry*, 48(10), 4628-4634.
14. Jung Park, E., & Pezzuto, J. M. (2002). Botanicals in cancer chemoprevention. *Cancer and Metastasis Reviews*, 21, 231-255.
15. Kapusta-Duch, J., Kopec, A., Piatkowska, E., Borczak, B., & Leszczynska, T. (2012). The beneficial effects of Brassica vegetables on human health. *Roczniki Państwowego Zakładu Higieny*, 63(4).
16. Kim, S., Kim, S. J., Jo, E. S., Gil, K., Kim, N. Y., Park, J. S., ... & Hwang, K. W. (2019). Anti-pancreatic-cancer effect of a newly bred cabbage line, Amtakssamchae, is mediated by a reduction in Regulatory-T-cell recruitment. *Journal of Functional Foods*, 58, 301-310.
17. Komatsu, W., Miura, Y., & Yagasaki, K. (2002). Induction of tumor necrosis factor production and antitumor effect by cabbage extract. *Nutrition and cancer*, 43(1), 82-89.
18. Lee, S. J., & Shin, K. S. (2019). Immunomodulatory and anti-metastatic activities of polysaccharide isolated from red cabbage. *Korean Journal of Food Science and Technology*, 51(3), 263-271.
19. Lučić, D., Pavlović, I., Brkljačić, L., Bogdanović, S., Farkaš, V., Cedilak, A., ... & Salopek-Sondi, B. (2023). Antioxidant and Antiproliferative Activities of Kale (*Brassica oleracea* L. Var. *acephala* DC.) and Wild Cabbage (*Brassica incana* Ten.) Polyphenolic Extracts. *Molecules*, 28(4), 1840.
20. Mahdian, D., Hosseini, A., Mousavi, S. H., Bihamta, M., & Vahedi, M. M. (2015). The Evaluation of the Effects of hydro-alcoholic extract of *brassica oleracea* (red cabbage) on growth inhibition and apoptosis induction in breast cancer cell line MCF-7. *The Iranian Journal of Obstetrics, Gynecology, and Infertility*, 18(151), 1-11.
21. Mandrich, L., & Caputo, E. (2020). Brassicaceae-derived anticancer agents: Towards a green approach to beat cancer. *Nutrients*, 12(3), 868.

22. Mansour, K. A., Moustafa, S. F., & Abdelkhalik, S. M. (2021). High-Resolution UPLC-MS profiling of anthocyanins and flavonols of red cabbage (*Brassica oleracea* L. var. capitata f. rubra DC.) cultivated in Egypt and evaluation of their biological activity. *Molecules*, *26*(24), 7567.
23. Mavlonovich, B. M. (2022). ANTI-CANCER PROPERTIES OF CRUCIFEROUS VEGETABLES. *Asian journal of pharmaceutical and biological research*, *11*(2).
24. Ngo, D. H., Nguyen, H. N. M., Nguyen, T. N. H., Nguyen, T. L. T., Ngo, D. N., & Vo, T. S. (2022). Growth inhibitory activity of *Brassica oleracea* var. alboglabra on human gastric cancer cells. *Journal of Reports in Pharmaceutical Sciences*, *11*(2), 199-203.
25. Pena, M., Guzman, A., Martinez, R., Mesas, C., Prados, J., Porres, J. M., & Melguizo, C. (2022). Preventive effects of Brassicaceae family for colon cancer prevention: A focus on in vitro studies. *Biomedicine & Pharmacotherapy*, *151*, 113145.
26. Przystupski, D., Niemczura, M. J., Górska, A., Supplitt, S., Kotowski, K., Wawryka, P., ... & Kulbacka, J. (2019). In search of Panacea—review of recent studies concerning nature-derived anticancer agents. *Nutrients*, *11*(6), 1426.
27. Rezaq, A. A. (2017). Antioxidant Role of cabbage (*Brassica oleracea*) ethanolic extract in hepatoprotective of N-nitrosodiethylamine induced initiation of hepatocellular carcinoma in rat liver. *Egypt J Nutr*, *32*(2), 1-53.
28. Rostami, A., & Rabiee, M. (2023). Anthocyanins are extracted as a non-toxic and green, fluorescent label for bioimaging of HER2-positive breast cancer cells. *Environmental Research*, *237*, 116878.
29. Sanchez-Guzman, X., Alvarez-Domínguez, L., Ramírez-Torres, M. F., Montes-Alvarado, J. B., Garcia-Ibañez, P., Moreno, D. A., ... & Maycotte, P. (2024). Cruciferous Plant Extracts, Their Isothiocyanate or Indol Derivatives, and Their Effect on Cellular Viability of Breast Cancer Cell Lines. *Journal of Medicinal Food*.
30. Song, G. H., Park, E. S., Lee, S. M., Park, D. B., & Park, K. Y. (2018). Beneficial outcomes of kimchi prepared with Amtak Baechu cabbage and salting in brine solution: Anticancer effects in pancreatic and hepatic cancer cells. *Journal of Environmental Pathology, Toxicology and Oncology*, *37*(2).
31. Tajalli, F., Saeedi, M., & Malekabadi, A. V. (2020). Anticancer and antioxidant effects of red cabbage on three cancerous cell lines and comparison with a normal cell line (HFF-3). *Journal of Genes and Cells*, *6*(1), 12-20.
32. Wang, T., Li, C., Liu, Y., Li, T., Zhang, J., & Sun, Y. (2015). Inhibition effects of Chinese cabbage powder on aflatoxin B1-induced liver cancer. *Food chemistry*, *186*, 13-19.