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THE ROLE OF PHYTOESTROGENS IN BREAST CANCER PREVENTION -CURRENT STATE OF KNOWLEDGE

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ABSTRACT

Introduction and aim. Phytoestrogens -mainly isoflavones (soy) and lignans (flaxseed, whole grains) are the subject of intensive research in the context of breast cancer prevention and prognosis. This review evaluates epidemiological, experimental, and clinical evidence regarding the impact of phytoestrogens on disease risk and progression.
Material and methods. There were searched PubMed databases and Google Scholar.
Results. In meta-analyses and large observational cohorts, soy consumption is associated with a moderate reduction in the risk of breast cancer. After a diagnosis of breast cancer, soy consumption does not increase the risk of recurrence and may be associated with a reduction in overall mortality. Lignans (enterolactone) show beneficial correlations with prognostic endpoints, especially in postmenopausal women. However, data from randomized intervention studies and the effect of isoflavone supplements remain limited.
Conclusion. Consuming foods rich in phytoestrogens may be part of a strategy to reduce breast cancer risk and is generally safe for women diagnosed with breast cancer, but there is insufficient evidence to support routine supplementation with isoflavones. RCTs in Western populations, studies on dosage, exposure time, and the role of gut microbiota are needed.

KEYWORDS

Policy development, School Management, Indiscipline, Leadership, Challenges and Strategies

CITATION

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Introduction and aim

Breast cancer remains the most common malignant tumor in women worldwide and the leading cause of cancer deaths in this population. In 2022, approximately 2.3 million new cases of breast cancer were reported in women worldwide, with an estimated 670,000 deaths[1]. Genetic factors (including BRCA1/2 mutations), hormonal factors (exposure to estrogens), and environmental factors, including lifestyle and diet, all play a role in its etiology[2]. Increasing attention is being paid to the potential chemopreventive properties of food components, particularly phytoestrogens. These are natural plant compounds with a structure and action similar to endogenous estrogens. Their possible impact on the risk of breast cancer is the subject of intensive epidemiological and experimental research[3,4]. In Asian populations, where soy consumption is significantly higher than in Western countries, the incidence of breast cancer is lower[5]. This raises the question of the role of phytoestrogens in breast cancer prevention. The aim of this review is to critically evaluate the evidence regarding the impact of phytoestrogens (isoflavones and lignans) on breast cancer risk and survival, their mechanisms of action, and clinical safety—especially in patients with hormone-dependent breast cancer.

Material and methods

This review is based on a narrative analysis of scientific publications concerning.

The literature search was conducted using databases such as PubMed, Scopus, and Web of Science, covering the period from 2000 to 2025. Keywords included “breast cancer”, “phytoestrogens“,”prevention“, ”diet,” “nutrition,”, “isoflavones”, “lignans”. Both randomized controlled trials and observational studies, as well as systematic reviews and meta-analyses, were included. Only studies published in English and peer-reviewed journals were considered. Articles were evaluated for methodological quality, clinical relevance, and potential contribution to the understanding of supportive interventions breast cancer prevention and treatment.

Analysis of the literature

Characteristics of phytoestrogens

Phytoestrogens are a group of polyphenolic compounds found in many plant-based products[6]. Phytoestrogens include several classes of compounds: Isoflavones – mainly genistein and daidzein; found in soybeans, chickpeas, and beans. Lignans - present in flaxseed, sesame seeds, and whole grains; metabolized in the intestine to enterolactone and enterodiol. Coumestans - present in alfalfa sprouts. Stilbenes, e.g., resveratrol (grapes, red wine)[7,8]. The mechanisms of action of phytoestrogens include binding to estrogen receptors (higher affinity for ERβ than Erα), acting as selective estrogen receptor modulators (SERM-like), inhibition of proliferation and induction of apoptosis of cancer cells, antioxidant, anti-inflammatory, antiangiogenic effects, modulation of gut microbiota and endogenous estrogen metabolism. We can also describe biological mechanisms such as: competitive binding to ER, antagonistic action against endogenous estrogens, aromatase inhibition and reduction of estrogen synthesis, and changes in the expression of genes related to proliferation (e.g., cyclin D1 inhibition)[9,10].

Soy isoflavones and breast cancer

Most data concerns isoflavones contained in soybeans. Cohort studies in Japan and China have shown that high soy consumption is associated with a reduction in breast cancer risk of up to 25–30% compared to women with low consumption (<10 mg/day)[11]. The strongest effect is observed in postmenopausal women[12].

Meta-analysis of 8 cohort studies, 26% reduction in breast cancer risk in women with the highest soy intake. Higher soy intake is also associated with improved survival in women diagnosed with breast cancer. In Asian populations, where soy intake is high, lower breast cancer incidence is observed. Cohort studies have shown that a diet rich in isoflavones is associated with a lower risk of breast cancer, especially in premenopausal women[13].

Other meta-analyses suggest that regular consumption of soy may reduce the risk of breast cancer by 20–30%. Among patients after diagnosis, consumption of soy products is associated with improved survival and a reduced risk of recurrence. Isoflavones can compete with estrogens for binding sites, acting as weak receptor modulators, and can reduce aromatase activity and estrogen levels in tissues[14].

Lignans and other phytoestrogens

Flaxseed is the main and richest source of lignans, which are metabolized in the intestines to enterolactone (which has antiestrogenic and antiproliferative properties) and enterodiol. Epidemiological studies indicate a link between high lignan intake and a lower risk of breast cancer in postmenopausal women[15]. Other phytoestrogens, such as coumestans, have been less studied but exhibit similar biological properties. Studies have shown that higher plasma concentrations of enterolactone are associated with a lower risk of breast cancer in postmenopausal women[16]. Lignans may also support hormone therapy (tamoxifen) through synergistic antiestrogenic effects[17].

Controversies and limitations

The results of the studies are partly contradictory, and the effect depends on: age and menopausal status, dose and source of phytoestrogens, differences in metabolism (role of gut microbiota), population (Asia vs. Europe/USA). The results of studies in Western populations are less clear (lower soy consumption, differences in metabolism). Menopausal status affects the effect; in premenopausal women, this protective effect is stronger. Safety concerns in patients with ER+ breast cancer; current data indicate that moderate soy consumption is safe and may improve prognosis, but isoflavone supplementation in tablets is controversial. Individual differences – approx. 30% of people are so-called "equol producers" (microbiota converts daidzein into equol, a compound with stronger estrogenic activity)[18].

Clinical aspects include:

-**American Cancer Society (2020)**: soy and soy products are safe for women with breast cancer; there is no evidence of harm[19].

-**World Cancer Research Fund (2018)**: recommends a diet rich in plants, including sources of phytoestrogens, as part of cancer prevention[20].

Further RCT studies in Western populations are needed. More attention should be paid to the role of gut microbiota (equol producers vs. non-producers). The use of biomarkers (plasma/urine phytoestrogen concentrations) in prospective studies may be useful[21]. Potential integration of phytoestrogens into personalized nutritional strategies for women at high risk of breast cancer (e.g., BRCA1/2 mutations)[22,23,24]. Some cohort studies suggest that early-life exposure to soy (during childhood or adolescence) may confer stronger long-term protection against breast cancer compared to initiation in adulthood. This supports the concept of a critical window of hormonal imprinting during breast development[25].

Conclusions

Available epidemiological and clinical data indicate that phytoestrogens, particularly soy isoflavones, may play a protective role in breast cancer prevention and do not worsen the prognosis in women diagnosed with the disease. This effect is most evident in populations with high and long-term consumption of soy products, especially in Asian countries. Biological mechanisms include modulation of estrogen receptors, antioxidant activity, aromatase inhibition, and effects on the cell cycle. Understanding the molecular pathways through which phytoestrogens exert their effects may facilitate the development of personalized nutritional strategies and targeted preventive interventions for hormone-dependent cancers. Moderate consumption of soy products can be considered safe and potentially beneficial components of an anti-cancer diet, while the use of isoflavone supplements requires further research and clinical caution. Further randomized controlled trials are needed to clarify dose–response relationships, the influence of timing and duration of exposure, and the interaction between phytoestrogen metabolism and gut microbiota in modulating breast cancer risk.

Disclosure:

Authors contribution:

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