## Abstract

**Introduction:** Breast cancer is one of the most important causes of cancer deaths among women worldwide. Therefore, finding an effective treatment for this cancer is an urgent need. Cancer immunotherapy, as a new field, plays a significant role in breast cancer treatment. Among different strategies in cancer immunotherapy, peptide vaccines play a prominent role. In the present study, different strategies were implemented to design an efficient multi-epitope vaccine. The use of epitopes of cytotoxic T lymphocytes, helper T lymphocytes, and adjuvant were three critical components in the design of this peptide vaccine.

**Materials and methods:** In the present study, the sequences of four HER2, MUC1, Alpha lactalbumin and Mammaglobin-A antigens and MS2 as an adjuvant were retrieved. HTL and CTL inducing epitopes were identified by different servers and their antigenicity and allergenicity were analyzed. Docking was performed between the selected epitopes with the corresponding MHC. Then the best selected epitopes and adjuvant were connected together by GPGPG linker. In the next step, the allergenicity, antigenicity, solubility and physicochemical properties of the designed vaccine were analyzed. B lymphocytes and IFN-γ inducing epitopes identified. Finally, Homology modeling, refinement and final validations were performed.

**Results:** By selecting appropriate epitopes that are antigenic and non-allergenic and have a good docking rating, a vaccine with a length of 556 amino acids was designed. Allergenicity, antigenicity, solubility and physicochemical parameters studies have shown that the protein is antigenic, non-allergen, soluble and stable. Moreover, when the refined 3D structure was compared to the original model, it was indicated that the 3D structure had improved and the potential mistakes were minimized.

**Discussion and conclusion:** In this research, a subunit vaccine consisting of 18 epitopes from four antigens (which are expressed in different stages of breast cancer), and MS2 adjuvant was designed. Using VLP adjuvant in this study, helps to make the vaccine more effective by better antigens presentation and inducing a strong response of B and T lymphocytes. Analyzing the physicochemical properties of the vaccine showed that the designed vaccine can potentially be used for preventive or therapeutic purposes. However, *in vivo* studies are necessary to determine the true efficacy of the vaccine.

**Keywords:** Bioinformatic, Breast cancer, Epitope, Vaccine, Virus-like particles (VLP)