ABSTRACT

Early and accurate diagnosis of cancer is important for proper management and treatment of the disease. The conventional techniques used for cancer diagnosis are expensive, require specialized training and do not carry out prognosis effectively. This necessitates developing techniques that are rapid, direct, affordable and accurate for cancer detection especially in the early stages.

Biometal analysis in tissue for the purpose of cancer prognosis and diagnosis is important since the trace metals can be utilized as disease biomarkers. LIBS analysis uses pulsed laser for ablation (simultaneous atomization and excitation). Laser Induced Breakdown Spectroscopy (LIBS) has been used to obtain spectral data from the samples under study (simulate, breast, liver, abdominal tissues and cultured cell lines) and multivariate chemometric tools applied for data preprocessing towards quantification of trace elements in human tissues and cancer cell lines. The samples were obtained from Kenyatta National Hospital (KNH) then processed and fixed in paraffin wax to make 2 cm thick blocks. These blocks were sliced to 2 cm thickness, weight of 2 g ready for study.

Simulate tissue samples prepared by embedding known concentrations of Fe, Cu, Zn, Mn and Mg on molten paraffin wax, were used to create a multivariate calibration model by exploiting Artificial Neural Network (ANN) for predicting concentrations of the above named trace elements in body tissues (value > 0.95). Multivariate chemometric techniques (PCA, ANN and SVM) were used to achieve prognosis and diagnosis of cancer using modeled LIBS spectral data, trace biometal concentrations and multivariate alteration of the biometals (Cu, Mg, Mn, Fe and Zn). These metals were chosen based on the frequent occurrences of these elements in the tissues. The method was used to identify the trace biomarkers in the tissues. The concentration ranges for the tissues obtained are Fe (51.2 - 137.2 µg/g), Cu (5 - 18.7 µg/g), Zn (36 - 56.8 µg/g), Mg (78.2 - 507.4 µg/g) and Mn (8.8 - 19.5 µg/g) for liver tissue. Breast tissue had Fe (87.7 - 113.9 µg/g), Cu (10.9 - 12.3 µg/g), Zn (49.3 µg/g to 55.7 µg/g), Mg (194.3 - 242.3 µg/g) and Mn (14.5 µg/g - 16.1 µg/g). Abdominal tissue had Fe (96.7 - 125.7 µg/g) Cu (6.7 - 7.5 µg/g) Zn (88.3 - 93.9 µg/g) Mg (467.5 - 583.1 µg/g) Mn (9.5 -10.5 µg/g).

PCA was employed for pattern recognition as it grouped the human tissue samples with respect to the part of the body from which it was obtained based on trace biometal signatures. Besides, it also characterized them in terms of malignant and benign cancer staging. Support Vector Machine (SVM) was used to develop a classification model using simulate samples.

The developed method is rapid and suitable for early diagnosis of cancer and thus can be applied for proper cancer management. The whole process of acquiring data and analyzing to give results takes about 15 min as compared to the other methods, which take approximately 1 hour. This makes the methodology viable for spectral diagnostics of cancer in human tissue including at its early stages.