Chapter 6

Conclusion

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This research project was undertaken to standardize the quality parameters of Indian wine and harmonize the same with international quality standards. In India, the wine industry has grown significantly in recent years. The wineries in peninsular India are producing a variety of red and white wines not only for domestic consumption, but also to export to other Asian countries, European Union, USA, Australia, etc. But till date, we do not have a comprehensive quality standard for wines produced in India, which is essential to regulate import, export as well as domestic sales of wines. Evaluation of wine quality includes monitoring of physico-chemical parameters, nutraceutical properties, screening of compounds characteristic to specific grape varieties, and food safety assessment through monitoring of the residues of contaminant chemicals as well as spoilage compounds.

To achieve the above objectives, a large number of wine samples drawn from different wineries from different regions of India were evaluated with reference to various international standards. The limitation of the BIS standard has been identified and several new parameters proposed for a holistic quality and food safety assessment. Indian wines were found to comply with the parameter limits specified in the standards.

Analysis of physico-chemical parameters is of utmost importance for evaluation of the quality parameters of red, rose and white wines, since they contribute to wine organoleptic characteristics such as colour, astringency, aroma and bitterness. In all wines Ethanol, pH, total acidity, Total and free SO_2, Reducing Sugar, Colour intensity, Dry Extract, Higher alcohol as Isoamyl alcohol comply specified limits of all standards.

The pH value, total acidity and organic acids provide important information about acidic and sensorial characteristics of wine. The quantitative analysis of organic acids is important for quality control of wine, because classes and content of organic acids give a characteristic taste to wine. In particular, intensity and duration of acidic sensation play an important role as quality parameters of white wines, as well as in astringency perception of red wines. Tartaric acid, lactic acid, malic acid and citric acid are the main organic acids found in wine. These acids directly and

indirectly affect the quality of wine, because they influence the flavour and stability of wine. All wines were within the range of good quality wine which posse good quality for flavour and colour to wine.

Phenolic compounds play an important role in producing antioxidant activity and regulate organoleptic characteristics. The phenolic antioxidants in red wines are well-known for their effect in lowering death rate from coronary heart disease. These phenolic compounds have an ability to prevent human diseaseses. From the results ,it is verified that the red wines have higher phenolic levels than white and rose wines and the same result is obtained for antiradical activity as well as ferric reducing antioxidant capacity. The amounts of phenolic content and antioxidant activity vary considerably in different types of wines, depending on the grape variety, vintage year, and geographic region. Total phenolics and antioxidant activity were highly correlated. There was a significant difference in total phenolic content and antioxidant capacity between red, rose and white wine samples used in the studies. Direct injection with LC- MS/MS has been used successfully to achive good sensitivity and specificity without any sample preparation technique loss as well as false identification. Individual phenolic composition of wine was getting within short run time as previously reported GC and HPLC methods. It was observed that there was high correlation between the content of total phenolics as well as individual phenolic compounds, which further correlated with their reducing power and antiradical activity confirming that the individual phenolic compounds are likely to contribute to the antioxidant activity of these wines.

In sensory studies based on consumer preference, flavour of wine was found to be one of the most important attributes considered when buying wines. Volatile compounds play an important role in the organoleptic properties of the wine, which is contributed by hundreds of the compounds of different classes such as, alcohols, esters, aldehydes, ketones, volatile acids, terpenes, contaminants like 4 ethyl phenol. A fast, sensitive, cost-effective and accurate method is presented for the determination of 23 target and 22 non-target volatiles in wine by GC-TOFMS. MTBE was found as a promising solvent for the extraction of volatile compounds in wine as well as for injection into the GC-MS system as far as analysis of volatile compounds is concerned. Several factors including solvent selection for extraction, sample to solvent ratio, cleanup and GC-TOFMS parameters were optimized.

Method was further applied to wine sample to evaluate aroma of wine. Aromatic compounds concentrations were found within the threshold of good wine aroma.

For evaluation of spoilage of wine volatile acidity, methanol, acetaldehyde, ethyl acetate, heavy metals were quantified by already standardized method. In all analysed wines these compounds were found within the range specified by BIS, other country standards as well as International OIV standard.

Screening pesticide residues for safety assessment was done by developed multiresidue method is described for simultaneous estimation of 83 pesticides and 12 dioxin-like polychlorinated biphenyls (PCB) in wines. Distinct advantages were noted compared to the conventional solid-phase extraction techniques. In comparison to the time-consuming and cumbersome SPE/tandem SPE techniques, this method had definite advantages in terms of the input cost and time of analysis. In addition, cleaner samples could be obtained that increased the GC column life. Method detection limits were significantly lower than the stringent international regulatory standards. A total of 95 analytes could be quantified in a single chromatographic run time of 31 min with considerable accuracy and low measurement uncertainties. Out of the 50 commercial wine samples, pesticides could be detected in only four samples at less than 10 ng mL^{-1} (precisely 2-6 ng mL^{-1}), which is less than the specified maximum residue limits of the European Union . The compounds detected included lambda-cyhalothrin in Cabernet Sauvignon, triadimefon in Ugni Blanc and chlorpyriphos and myclobutanil separately in two different samples of Chenin Blanc. PCB was not detected in any of the samples. From the results, Indian wines are free from the pesticide residues.

A fast, sensitive, cost-effective and precise GC-MS based method is presented for the determination of 2,4,6-trichloroanisole (2,4,6-TCA) residues in wine. 2,4,6-TCA is considered as a spoilage compound, which adds mouldy-musty aroma to wine. Several factors including selection of solvent, sample to solvent ratio for extraction, cleanup and GC-MS parameters were optimized for red and white wine samples. The method has potential in routine analysis to determine trace levels of 2,4,6-TCA in red and white wine samples due to its sensitiveness, precision, simplicity and ruggedness. Distinct advantages were noted compared to the conventional extraction techniques. In comparison to the time-consuming and

cumbersome SPE/tandem SPE, HS-SPME, SBSE techniques, the proposed method had definite advantages in terms of lower input cost and time of analysis. In addition, cleaner samples could be obtained that increased the life of GC liner and column, and reproducible results could be achieved even after analyzing hundreds of samples. MDL were significantly low with acceptable precision. 2,4,6-TCA could be quantified in MS/MS as well as in full scan mode within the run time of 21.67 min with low measurement uncertainties. 2,4,6-TCA was found in all the 5 tested incurred samples from India within the range of 5-20 ng L^{-1} while the 2,4,6-TCA concentration in 4 Argentinean wines ranged within 180-280 ng L^{-1}. 2,4,6-TCA was detected only in four samples (3 red and 1 white) of the 50 commercial samples. The 2,4,6-TCA concentrations were <10 ng L^{-1}, which is less than the specified odour threshold.

Biogenic amine and free amino acid content of the Indian wine was studied. Simultaneous determination of 15 underivatized amino acids and biogenic amines were carried out by ESI-MS/MS with PDFOA ion pairing reagent and acidified mobile phase. The total amount of free amino acids and biogenic amines was higher in red wines than in white and rose wines. The main amino acids were proline and arginine, while major biogenic amines were tyramine, histamine and spermidine. In this study, we quantified 15 amino acid and 4 biogenic amine without any derivatization by LC-MS/MS direct injection within 20 minutes run time. Biogenic amines content in Indian wines did not represent any possible toxicological problem for human health.

Finally, this endeavor proposes a comprehensive quality standard for Indian wine in harmony with different international standards. Along with the routine parameters it also recommends monitoring of the compounds characteristic to specific grape varieties; safety assessment by screening for the residues of spoilage compounds and variety of contaminants that might find their place in wine from direct and indirect sources. Thus a holistic quality assessment will be possible, which will improve the image of Indian wine in the international arena and establish its own footprint in quality.