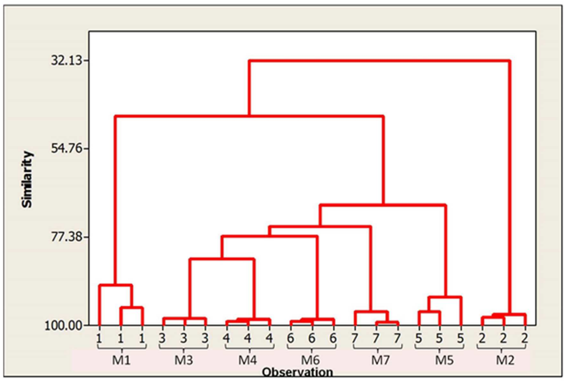

Fig. 1 Dendrogram showing clustering of Muruku for the different brands; the same numbers showed triplicate of each sample

Discriminant analysis (DA) was also carried out on the twelve parameters. Six discriminant functions (DF) were found to discriminate the seven samples as shown below, Eq. 4 to Eq.7.

$$DF1 = -0.05\,MC + 2.64\,L* + 1.66\,a* - 0.56\,b* + 0.53\,PAV + 0.62\,TBA - 0.70\,SFA \quad (4)$$

$$DF2 = -0.34\,MC - 0.29\,L* + 0.35\,a* + 1.53\,b* - 0.86\,PAV - 0.10\,TBA - 0.11\,SFA \quad (5)$$

$$DF3 = -0.30\,MC - 0.04\,L* - 0.22\,a* + 0.50\,b* + 0.98\,PAV - 0.01\,TBA - 0.09\,SFA \quad (6)$$

$$DF4 = +0.76\,MC + 0.02\,L^* + 0.85\,a^* - 0.34\,b^* + 0.14\,PAV + 0.63\,TBA + 0.41\,SFA \quad (7)$$

$$DF5 = +0.45\,MC + 0.01\,L* + 0.21\,a* - 0.02\,b* - 0.01\,PAV - 0.35\,TBA + 0.92\,SFA \quad (8)$$

$$DF6 = +0.49\,MC - 0.06\,L* - 0.62\,a* - 0.02\,b* - 0.06\,PAV + 0.67\,TBA + 0.24\,SFA \quad (9)$$

Out of the twelve parameters, only seven parameters contribute significantly in explaining the differences between samples of different types. Wilk's Lambda test showed that DFs are statistically significant at $p < 0.0001$. The relative contribution of each parameter is represented by the coefficient associated with each parameter (DF1-DF6). It can be seen that the differences between different samples were explained by six DFs. The explanation of each DF depends on the magnitude of each coefficient in the DF as follows: the parameters L*, a*, b*, PAV, TBA, and SFA contribute greatly to the first function which explains the highest amount of variance between different samples. The relative contribution for different parameters can be arranged in the order L* > a* > SFA > TBA > b* > PAV (DF1 – DF6). Furthermore, the DF2 contributes less in explaining the differences by the parameters b* and PV (b* > PAV) whilst other parameters contribute less. Other DFs can be interpreted in a similar way.

An attempt was also made to study the relationship between the scores (the value of DF for each sample) of DFs (y-axis) and the samples (x-axis) that correspond to the scores of discriminant function for various samples, as shown in Fig. 2. It can be seen clearly in Fig. 2 that the samples were different based on the DA scores. Some samples showed positive contributions that was due to high values of L*, a*, PAV, and TBA, whilst negative contribution was attributed to high values of SFA and b* values. Moisture content did not contribute highly to DF1. The result of the first DF is similar to the cluster analysis grouping. The classification matrix (though not presented here) showed that 100% of the cases were correctly classified to their respective sources or markets/stores/vendors. The result of classification showed that significant differences exhibited between different markets, which are expressed in terms of DFs.

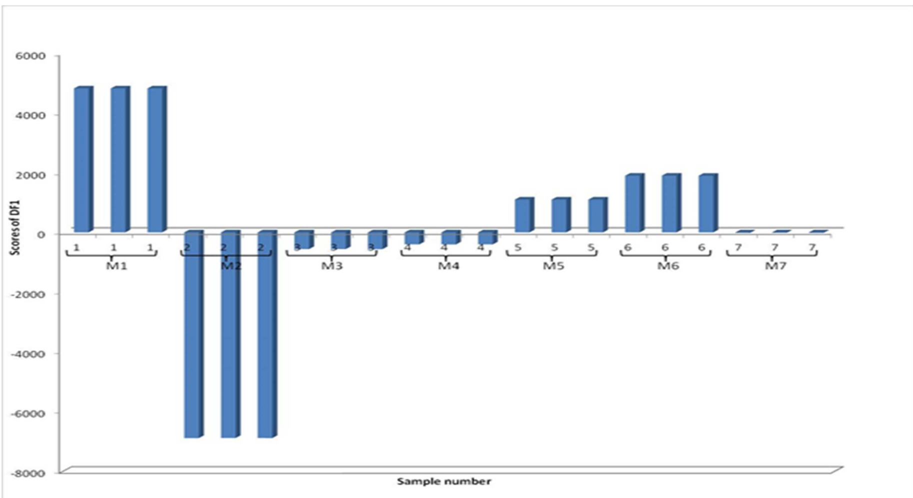

Fig. 2 Scores for the first discriminant function (DF1)

Other than causing deterioration in nutritional quality, oxidative rancidity may give rise to unsafe food for consumption because highly oxidised oils or fats in food product might pose toxicity risk. The present investigation on seven different types of Muruku samples showed different chemical and physical parameters indicating differences in quality of fried snacks as a result of processing and storage. Raw materials and ingredients used in those samples were different as some might have antioxidative effects such as spices like cumin and caraway, which can also influence the shade or color of the Muruku. The antioxidant can delay the development of rancidity in food systems, so it will lower down the oxidative rancidity in food product [21].

PV of frying oil is considered rancid when the peroxide value is above 10 meq O_2/kg, PAV value more than 6.0 and AV is higher than 4.98 [22]. The present study indicated that PV of M1 was higher than the recommended value. As for PAV, only M2, M5, and M6 were within the recommended range. M3, M4, M5, and M6 were lower than the maximum limit for AV but for TBA value, only sample M4 and M6 fell within the recommended value. Hence, M6 had the highest quality characteristics compared with the other sources as M6 possibly strategised well in terms of quality of oil used and choice of packaging technologies (opaque bag with a window).

IV. Conclusions

Based on the chemical and statistical analyses conducted of food quality parameters, it can be said that the quality of the Muruku snacks was different between types or brands as shown by Cluster Analysis. Discriminant Analysis showed that the quality characteristics studied i.e., lightness values, saturated fatty acid contents, thiobarbituric acid, p-anisidine value and moisture content are the main contributors to discriminating the samples, indicating that most of the Muruku were subjected secondary oxidation either due to long storage or exposure to light and heat, which may increase the risk of rancidity. This can be avoided by using opaque packaging. The oil oxidation process was likely accelerated since the common food processing practices were to reuse the cooking oil. Types of frying oil used, processing practices, packaging technology, and storage conditions played some roles in controlling the final quality of the Muruku snacks. However, packaging technology might be the most important factor in producing a Muruku product with desirable food quality characteristics.

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