Abstract

Spices are essential to our daily lives, and a vast variety of spices are used extensively in our nation. The main subject of this study is turmeric (Curcuma longa), a perennial herb that is widely used in South and Southeast Asia, especially India, as a main spice. Three to five curcuminoids, the main bioactive substances in turmeric known for their medicinal qualities, are present. India is the world's biggest producer and exporter of turmeric, with a 1700 crore-a-year revenue. But because of its great commercial demand, dishonest traders can adulterate it. Turmeric is adulterated primarily for two reasons: to make it seem better and to make it have more volume. Illegal colors like Sudan dye and metanil yellow are applied to enhance luster. In cases where there is not enough turmeric, additional ingredients such as corn starch are added to increase volume. As a result, the turmeric business has to give quality control top priority. Therefore, to maintain the high standards of quality for this spice, methods for identifying these adulterants must be developed. The present methods available in the market are conventional. They require more time for sample preparation and as well as measurement procedure is time consuming. The common example of these technique are gas chromatography, HPLC, NIR, Spectroscopy, etc. These methods are in vasive in nature .So rapid and non-invasive detection of adulterant mixed with turmeric is necessary .Machine vision is a new technique in this field to detect the presence of adulterants turmeric powder. In this work with the help of machine vision system coupled with deep neural network and convolution neural network three adulterants were detected as mentioned below.

In the first study of the thesis work metanil yellow adulteration was detected using machine vision. Here five varieties of turmeric powder were examined in this study; one was made in-house, and the other four were packaged organic turmeric powders from four well-known companies that claim to be 100% pure. MET of the Sigma Aldrich brand was procured from research lab suppliers. One part was labelled "pure" since it had not been subjected to mixing

of MET. The remaining three portions were marked as "adulterated" after being adulterated with three different percentages of MET. The weight-on-weight (w/w) percentages of MET were 5%, 10%, and 15%. The successful completion of classification and prediction tasks from the sub-images derived from the acquired photos was made possible by the deployment of Random Forest (RF) and Deep Neural Network (DNN) models. The findings show that the suggested methodology predicts the degree of MET adulteration with an accuracy surpassing 94% and achieves classification accuracy over 98% for differentiating between pure and adulterated turmeric powder.

In the next study Sudan Dye-I was detected using machine vision. Five different pure turmeric powder varieties were selected for testing. Of the five varieties, four were advertised as 100% pure organic turmeric powders and were purchased from the neighbourhood grocery store, while one pure variation was home made.The Sudan dye of Sigma Aldrich brand was procured from a lab chemical supplier. Each of the 5 variants of *pure* turmeric was divided into 4 equal portions that resulted total of 20 portions. Among the 20 portions, 1 portion of each variant was kept unadulterated while the rest 3 portions were adulterated with 3 different percentages of concentration (w/w) that are 5%, 10%, and 15%. Such mixing resulted in 5 *pure* and 15 *adulterated* samples comprising of 5 adulterated samples for each concentration level.

Finally corn starch was detected using machine vision.5 variants of *pure* turmeric powders were taken for experimentation. Among those 5 variants, 4 were branded organic turmeric powders that claim 100% purity and were procured from the local supermarket and 1 pure variant was prepared in-house.The starch was added with the turmeric powder in four different percentages by volume, i.e. 10%, 20%, 30%, and 40%.Here convolution neural network (CNN) is used for both the detection as well as prediction of degree of adulteration starch in turmeric powder. Here accuracy achieved in tune of 98%.This method has shown remarkable improvement of CNN model to address the limitations of conventional methods.