A Novel Approach to Food Safety Hyperspectral Imaging for Automated Adulteration Detection

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Abstract

Objective of this study was to design and develop new methods for detection of adulteration using Hyperspectral Data. To overcome the gaps between production, consumption, and inability of governing authorities to check adulteration are a big temptation for fraudsters to make easy money through food adulteration, at the cost of nutrition and health of consumers. In present scenario, food adulteration analysis is performed based on chemical extraction; to fill the gap our proposed system makes automatic food type and quality adulteration based on hyperspectral data in the visible and NIR spectral band. The system is cost-effective, time consuming and user friendly for the end users. The final accuracy was analysed using Support Vector Machine (SVM), K-Nearest Neighbour (KNN) techniques.

Keywords*:* Hyperspectral Dataset, Adulteration, SVM, PCA, KNN.

1. Introduction

It is one of the main problems in current worldwide food manufacturing is ensuring the safety and quality of expendable foods. As the world's population remains to grow quickly, the demand used for nourishing, superior food is also growing. Many people are choosing for packed food, expecting it to be a harmless and appropriate option. But a main concern is that several processed food products contain extracts that enhance taste but can harmfully influence healthiness. Junk food, which is popular among both children and adults due to its taste, often contains harmful substances that may lead to serious health problems over time. In India, food adulteration is a common problem, affecting a wide range of edible products. Even packaged milk, which is widely regarded as a healthy option, can sometimes contain contaminants that pose potential health hazards. There have been several cases of adulteration in our country [1]. In some states, the consumption of chemically processed milk and artificially ripened fruits and vegetables has led to severe health issues, even resulting in fatalities. Shocking revelations have exposed the use of caustic soda in milk production, which is then transported to major urban centers like Delhi and Mumbai. This alarming issue is not confined to small towns and rural areas adulteration has infiltrated every level of the food supply chain, affecting millions, often without their knowledge. Despite being direct consumers, many remain unaware of the hidden dangers lurking in everyday food items, making it an urgent crisis that demands immediate attention. Injections are used to ripe fruits and vegetables [2]. People engage in this unethical practice solely for financial gain, showing no regard for the lives they endanger. Driven by greed, they prioritize profit over public health, knowingly putting countless individuals at risk. Their actions reflect a complete disregard for human well-being, as they continue to compromise food safety for their own selfish benefits. In the ‘modern’ scientific era, the first to address this issue was the German analytical chemist Frederick Accom who completed a treatise on adulteration of food and culinary poisons published in 1820 [3]. This was first significant effort to reveal widespread prevalence then serious health risks associated with food adulteration. It shed light on the hidden dangers within the food industry, raising awareness about the harmful substances being unknowingly consumed. This initiative played a crucial role in emphasizing the need for stricter regulations and improved food safety measures to protect public health. Table.1 show Food Item, Adulteration Content and harmful effect of human bodies.

2. Study Area

Healthy, infected and dry leaves and stem samples were collected at healthy and infected plots. Hyperspectral datasets were generated using Resonon Pika-L with wavelength range 400-1000 nm with imaging view of crops. Spectral responses of leaves exterior were captured. Data were collected at the Chhatrapati Sambhjinagar (MS) region from July 2020 to February 2020. The imaging Pika-L system consists of hyperspectral line scanner, including FOV at 13.80 placed on a stand, a configured laptop with Spectron on Pro software for operating the sensor and 70-watt illuminator lamp to provide stable illumination over 400 -1000 nm range with 2.1 nm spectral resolution.

3. Database

The reflectance spectra of the foods four samples were recorded uses a modular silicon array detector and was calibrated using a Spectral on white panel, a polytetrafluoroethylene polymer resin compressed into a hard porous white material, providing high diffuse reflectance over the UV-VIS-NIR region [4],[5],[6]. The data analysis was conducted using the wavelength range of 400–800 nm, which falls within the visible spectrum. The spectral response curves of similar cosmetics were again recorded using Pika-L imaging sensing device providing the range of 350-1000 nm [7],[8]. All measurements were occupied using a high-intensity contact review accessory from four different viewpoints. The study was executed within the wavelength range of 400–800 nm, cover the visible spectrum.

4. Methodology

In the previous studies A single illumination source was employed for database collection. Specifically, certain studies were conducted under halogen illumination, while others relied solely on UV illumination. In this research, both excitation sources were utilized to evaluate their impact on classify act. Figures 1 & 2 present a overall outline of the hyperspectral imaging system and the planned system architecture, respectively.

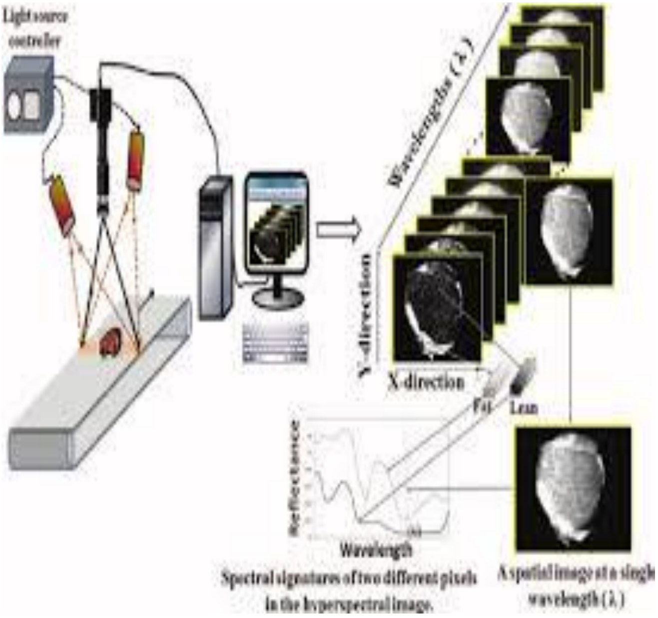

Figure.1 Complete Overall the Hyperspectral Imaging System

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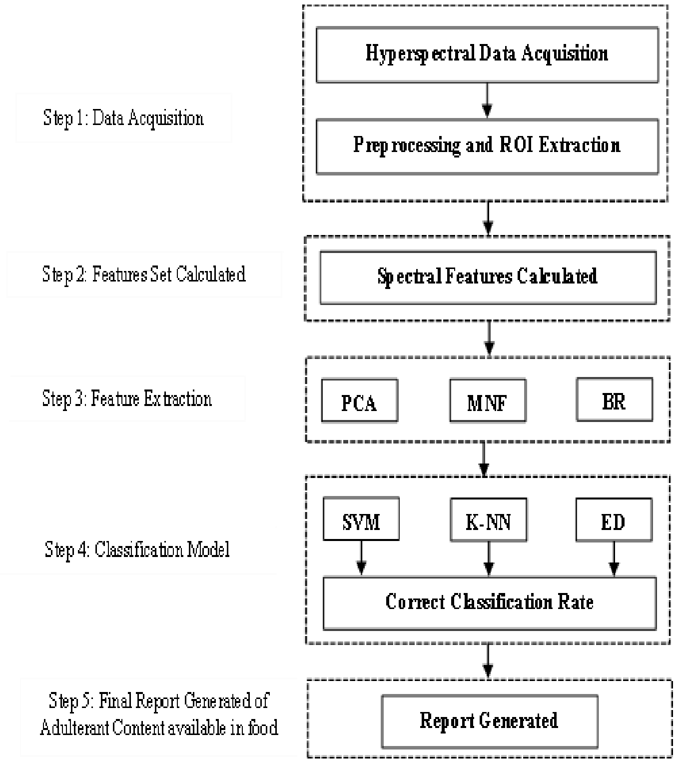


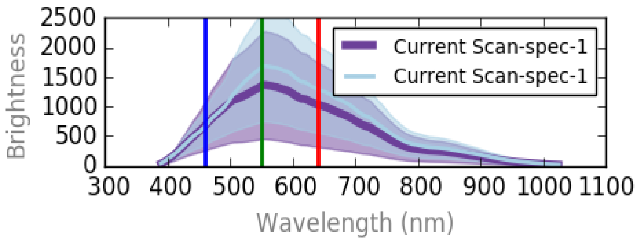
Figure.2 Proposed Architecture of the System

Figure.3 Food Sample Collection Using the Hyperspectral Imaging Pika-L Classification

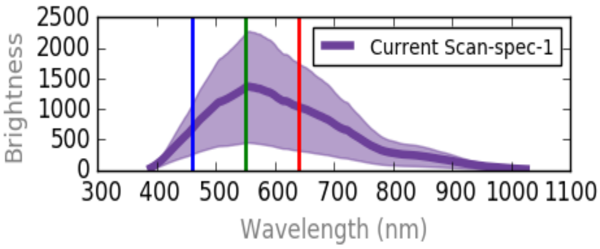
The significant surveys these stages guide. The figures are divided into two portions calibration and prediction set, keeping 4:1 proportion. The 1st step includes establishing the information accordingly, confirming that four parts are used for calibration training and one part is used for making calculations. We acquire the hyperspectral images of the three food differences within the wavelength region of 350–1000 nm for using Pika- L Imaging Sensor. The reflectance data is extracted from region of interest of the hyperspectral images of each illustration then used as feature paths. In the 2nd step we calculate the spectral features in separate wavelength spectrum. In the 3rd step, significant features are recognised using principal component analysis. To certify a full comparison, various optional algorithms, such as list exact algorithms are considered minimum noise fraction, Band Ratio are also used to recognize most significant features or wavelengths. In subsequent stage, a classification model is established using a support vector machine to accurately classify desired features, k- Nearest Neighbors. The greatest identification model is selected by evaluating its presentation based on the accurate classification amount. Finally, the model determines whether the food models meet the required quality standards.

5. Result & Discussion

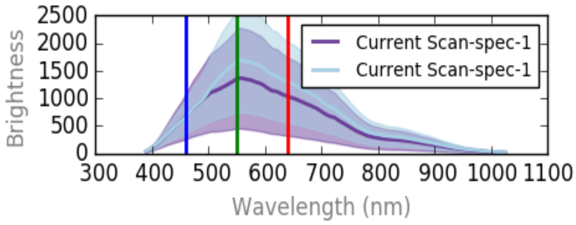
The Table.2 describes about the contents present in various foods as mentioned. The available contents of foods were identified based on chemical analysis along with optimal band automatic identification method. The optimal bands were detected for protein, nitrogen cellulose accordingly. The Fig.4 represents the spectral measurements with wavelength versus reflectance. The (a) section plots about gram flour with the healthy contents like protein at wavelength 910, 1020 Cellulose with wavelength band 548, 940 and nitrogen at 850. All other three also represents the same contents with varying range as per the availability in (b), (c), (d), (e) and (f) using Pika-L sensing device. Only one sample was targeted for chemical extraction, as per the results other threes were detected through optimal bands.



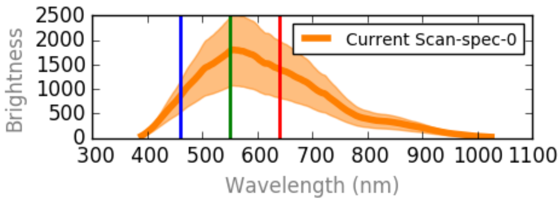
a) Gram Flour (Besanpeeth)



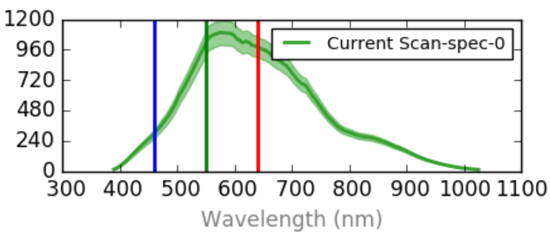
b) Jawar



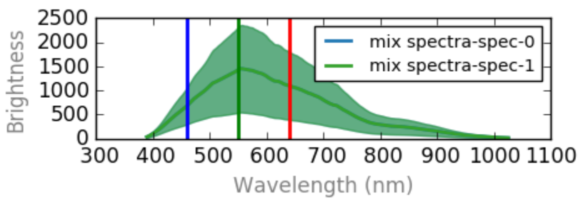
c) Maida



d) Wheat



e) Pedha



f) Mix (Jawar, Maida, Wheat)

Figure 4: Spectral measurements of foods through hyperspectral imaging Dataset

6. Conclusion and Future Scope

The developed system recognises several food flour adulterations using hyperspectral data. Presently no any application is made available for the detection and automatic identification of foods with their contents and quality without using any chemical reaction. As per the health issue raises food adulteration plays vital role in human life, for avoiding the food adulteration issue general awareness needs to be important within peoples, stakeholders. The chemical analysis is very costly for the daily routine adulteration analysis The SVM with kernel function gives better accuracy as compare to KNN. In this research work the hyperspectral database is collected in our departmental research laboratory. The system is applied using software for native languages.

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References

[1] Lamis Hamrouni, Ramla Bensaci, Mohammed Lamine Kherfi, Belal Khaldi, and Oussama Aiadi, (2018). Automatic Recognition of Plant Leaves Using Parallel Combination of Classifiers. Springer International Publishing AG, doi.org/10.1007/978-3-319-89743-1-51.

[2] Anami, B.S., Suvarna, S.N., Govaradhan, A.A., (2010). A combined color, texture and edge features based approach for identification and identification and classification of Indian medicinal. In. J. Comput. Appl. 6(12), 45-51.

[3] Varpe A.B., Surase R. R., Vibhute A. D., Gaikwad S.V., Rajendra Y.D., Kale K.V., Mehrotra S.C., (2017). Synygium Cumini Plant Photosynthesis Pigment Detection from Hyperspectral Datasets Using Spectral Indices. 2nd International Conference on Man and Machine Interfacing (MAMI).

[4] Siravenha, A.C., Carvalho, S.R., (2016). Plant Classification from Leaf Textures. International Conference on Digital Image Computing Techniques and Applications, Gold Coast, QLD, pp.1-8, doi.10.1109/DICTA.2016.7797073.

[5] Fu, H., and Z. Chi. (2006)., Combined thresholding and neural network approach for vein pattern extraction from leaf images. IEE Proceedings-Vision, Image and Signal Processing 153, no. 6 (2006): 881-892.

[6] Park, JinKyu, EenJun Hwang, and Yun young Nam., (2008). Utilizing venation features for efficient leaf image retrieval." Journal of Systems and Software 81, no.1, 71-82.

[7] Nursuriati Jamil, Nuril Aslina Che Hussin, Sharifalillah Nordin, Khalil Awang., (2016). Automatic Plant Identification is Shape the Key Feature., Procedia Computer Science, Volume 76, 2015, Pages 436-442,

[16] A. C. Siravenha and S. R. Carvalho, "Plant Classification from Leaf Textures," 2016 International Conference on Digital Image Computing: Techniques and Applications (DICTA), Gold Coast, QLD, 2016, pp. 1-8. doi: 10.1109/DICTA.2016.7797073.

[8] Amarsinh B. Varpe, Yogesh D. Rajendra, Amol D. Vibhute, Sandeep V. Gaikwad., (2015). Identification of plant species using non-imaging hyperspectral data, International Conference on Man and Machine Interfacing (MAMI), 1-4.

Table.1 Foods & Adulteration Content

Food Item	Adulterant	Harmful Effects
Milk & Milk Product		
Milk, milk powder	Water, Starch, Urea, Vanaspati, Formalin, Detergent, Synthetic milk	I have mention here few harmful effect on human bodies from Adulteration in foods. For e.g. Food Poisoning ,Heart Problems, Cancer, Vomiting, Nausea, Diarrhoea, Giddiness, Joint Pain, Artificial Color can cause cancer, Carcinogenic,
Ghee, cottage cheese, khoa	Coal Tar Dyes	
Sweet Curd	Vanaspati	
Rabri	Blotting paper	
Khoa and its products	Starch	
Chhana or Paneer	Starch	
Oil and Fats		
Ghee	Vanaspathy or Margarine, Mashed Potatoes, Sweet Potatoes and other starches.	
Butter	Vanaspati or Margarine, Mashed Potatoes and other starches	
Edible oil	Prohibited colour	
Coconut oil	Any other oil	
Sweetening Agents		
Sugar	Chalk powder, Urea, Chalk powder, Yellow colour (Non -permitted)	
Honey	Sugar solution	
Jaggery	Washing soda, Chalk powder, Metanil yellow colour, Sugar Solution,	
Bura sugar	Washing soda	
Sweetmeats, Ice-cream and beverages	Metanil yellow (a non - permitted coal tar colour), Saccharin	
Food grains and their products		
Wheat, Rice, Maize, Jawar, Bajra, Chana, Barley etc.	Dust, pebble, Stone, Straw, weed seeds, damaged grain, weevilled grain, insects, hair and excreta of rodent	

Maida	Resultant atta or cheap flour	Epidemic dropsy, Severe Glaucoma, Carcinogenic, Anaemia, Enlargement of heart, Stomach Disorders, Liver Disorders, etc.
Maida/ Rice	Boric Acid	
Wheat, bajra and other grains	Ergot (a fungus containing poisonous substance), Dhatura, Karnal Bunt	
Sella Rice (Parboiled Rice)	Metanil yellow(a non-permitted coal tar colour), Turmeric (colouring for golden appearance)	
Parched rice	Urea	
Wheat flour	Excess bran, Chalk powder,	
Dal whole and spilt	Khesari Dal, Clay, stone, gravels, webs, insects, rodent hair and excreta, Metanil yellow (a non-permitted coaltar colour)	
Atta, Maida Suji (Rawa)	Sand, soil, insects, webs, lumps. rodent hair and excrete, Iron filings	
Bajra	Ergot infested Bajra.	
Sago	Sand or talcum	
Besan	Metanil Yellow, Khesari Flour	
Pulses	Lead Chromate	
Spices		
Whole spices	Dirt, dust, straw, insect, damaged seeds, other seeds, rodent hair and excrete	
Black pepper	Papaya seeds, Light black pepper, Coated with mineral oil	
Cloves	Volatile oil extracted (exhausted cloves), Coated with mineral oil	
Mustard seed	Argemone seed	
Powdered spices	Added starch, Common Salt,	
Turmeric powder	Coloured saw dust	
Turmeric whole	Lead chromate, Chalk powder or yellow soap stone powder	
Chillies powder	Brick powder, talc powder, Artificial colours, Water soluble coal tar colour	
Asafoetida (Hing)	Soap stone or other earthy material, Starch, Foreign resin	
Spices	Powdered bran and saw dust	
Cinnamon	Cassia bark	
Cumin seeds	Grass seeds coloured with charcoal dust	
Green chilli and green vegetables	Malachite green	
Green peas	Artificially coloured	
Saffron	Dried tendrils of maizecob	
Miscellaneous Products		
Common salt	White powdered	
Iodized salt	Common salt	
Tea leaves	Exhausted tea, Iron fillings, Chicory	
Supari Pan Masala	Colour, Saccharin	
Catachu powder	Chalk	
Lemonade soda	Mineral acid	

Sweet Potato	Rhodamine B colour	
Pulses	Lead Chromate	
Iodized salt	Common salt	
Silver leaves	Aluminium leaves	
Vinegar	Mineral Acid	

Table.2 Nutrient Composition of Various Foods

Food Product	**Available Content**	**Optimal Band Identification**
Gram Flour (Besanpeeth)	Fiber, Iron, Potassium, Manganese, Copper, Zinc, phosphorus, Magnesium, Folate, Vitamin B-6 and Thiamine	Protein: 910, 1020, Cellulose: 548, 940 Nitrogen: 850
Jawar	Protein, Calcium, Iron, Phosphorous, Potassium & Sodium	
Maida	Protin, carbohydrates, fat, crude fibre, minerals	
Wheat	Water, Protein, Protein, Carbs, Sugar, Fat, Saturated, Monounsaturated, Polyunsaturated, Omega-3, Omega-6	
Pedha	Saturated Fat, Polyunsaturated Fat Monounsaturated Fat, Cholesterol Sodium, Potassium, Carbohydrate Sugars, Protein, Vitamin A, B-12, B-6, C, D, E, Calcium, Copper, Folate, Iron Magnesium, Manganese, Niacin, Pantothenic Acid, Phosphorus, Riboflavin, Selenium, Thiamine, Zinc	
Mix (Jawar, Maida, Wheat)	Water, Protein, Carbs, Sugar, Fat, Saturated, Monounsaturated, Polyunsaturated, Omega-3, Omega-6, carbohydrates, crude fibre, minerals, Calcium, Iron, Phosphorous, Sodium Fiber, Potassium, Manganese, Copper, Zinc, Folate, Vitamin B-6 and Thiamine	