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The Outlook of Food Industry: Effectual Traceability Practice in Supply Chain Management using Internet of Things

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***Abstract*—Traceability can be used to improve processes, increase productivity, and ensure the quality and safety of perishable foods. But it's frequently seen as unnecessary red tape and a financial bur-den. Small and medium-sized businesses frequently exhibit this. Since they make up the majority of the food industry, the adoption of traceability systems is relatively sluggish and primarily done to meet legal requirements. In this paper, we propose effective food traceability techniques using the Internet of things and derive a solution for data communication. The improved Naïve Bayes Classifier is developed for food traceability using the enhanced prediction data. The purpose of the food traceability is used to maintain the computerization, reduced cost and reasonable system complexity. The most important parameter for this system is the food transportation from the manufacturer to the consumer. The Internet of Things is developed to connect the manufacturer to the consumer with an efficient transportation system. An economical solution is achieved using the IoT based food traceability. The Naïve Bayes Classifier is simulated and the investigational results proved that the proposed algorithm is more efficient for food traceability techniques compared to the SVM and KNN methods.**

***Index Terms*— Naïve Bayes Classifier, Traceability, supply chain management, KNN, Classification, SVM.**

I. INTRODUCTION

The capacity to follow a product batch and its history through all or a portion of a production chain, from harvest to transport, storage, processing, distribution, and sales, or internally at one of the steps in the chain, is known as food traceability. The issue of traceability is universal and unrelated to the nature of the product, its manufacture, or the control system it supports. A traceability system that tracks information about a product's movements should be developed as a result of systematizing the implementation of traceability as a quality control tool [1].
Customers' trust in the supply chain has suffered greatly in recent decades as the nutritional value of items has deteriorated throughout transportation from manufacturer to customer. As an effect, further rising consumer concerns over the protection and quality of food have tense more and more courtesy from intellectual and

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industrial areas. In reaction to increasing food safety issues, many Internet of Things (IoT) technologies, such as RFID, sensor, barcode and wireless network technology are useful to supply chain traceability and monitoring the system [2,5-8]. In recent years, there has been an increase in interest in the IoT, smart connected things in directive to implement the different perspectives of the supplier, manufacturer, and customers and come up with a standard that not only supports product performance and quality, but also estimates the benefit of smart connected equipment's [3].

At the moment the diverse communication technologies are used to interconnection for the transport of information, more number of issues in the quality precision. IoT discovers its application in the all the fields, since new form of communication between the different systems and devices. In increasing aspect and demands of modern cities, the association of supply chain in food has turn into enormous difficult exceptional for quality of foods using the IoT based food traceability. Supplementary concerns also happen from this dilemma regarding loss of quality accuracy due to time and performance of tracing scheme [4]. Fig.1 illustrates the applications of IoT in the recent years; the IoT has the interconnectivity with all the day to day life.

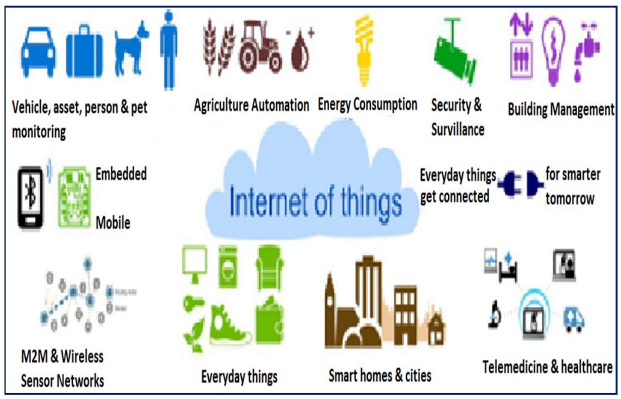

Fig.1. IoT applications

Research in various technologies like RFID system is developed to meet the particular requirements of live fish processing. The RFID tag is on all live fish and is called the mediator that links the live fish, retail and consumer logistics centre. The PLC-controlled sensors are used to collect agricultural data and computerized transport processes. The information on traceability is intended for farmers and consumers to be shared on a web network. RFID and Blockchain technology play an important part in the agro-food supply chain. [9]. Examined the advantages and inconveniences of developing the traceability system for agro-food supply chain using RFID and IoT technologies, and explained the method of implementation of this system. Based on that, it can traceability with reliable evidence across the agrifood supply chain, which effectively safeguards the quality of consumers, through the processing, storage and sharing of correct agrifood data in the production, import, inventory and sale relationships[10].

The traceability takes part in the health of the people and the social development. The main measurement of food related management is to operate the entire supply chain. If any problem occurs in the production of food safety then it can be easily identified with the effective management [11].

II. LITERATURE REVIEW

Several papers were examined using Elsevier's Science Direct, Mendeley, Scopus, and IEEE Xplore. Key terms like "food traceability" were initially utilised as search criteria. As can be seen in Fig. 2, this search yields thousands of results, and the quantity tends to raise over time as the importance of food traceability rises.

Food is the most important provider of economic grows in rural areas. It is crucial for farmers to perform well-organized and technological process to raise productivity diminishes the contamination [12] and nutrient-related problems. The progress in work process and data storage has afforded huge quantity of information. This system designed to measure [13] the IoT techniques and concerns them to Food database to launch significant associations. This learning centres on the Naive Bayes Classifier to categorize the food sensing data. Food accomplishes each and every person around the world.

Traceability systems can significantly improve productivity, logistics, and sustainability, as has been shown in Fig.3. Correctly implementing traceability systems is required to get these benefits. Even while the systems

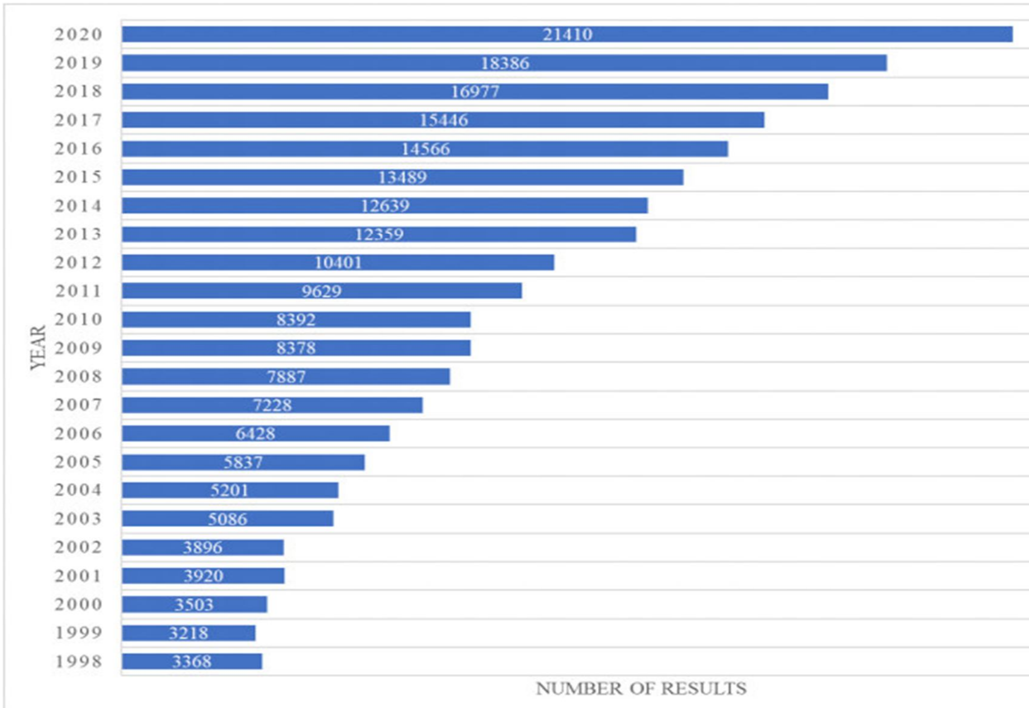

Fig.2. Evolution of the number of results of the search term "food traceability" from 1998 to 2020

being provided accurately serve the purposes for which they were designed, they occasionally lack comprehensiveness, are only useful for a particular organization in its current circumstances, or are too onerous for SME's. As a result, it becomes necessary to create a traceability model that can be used throughout the whole food supply chain, is adaptable enough to allow any company to change the level of detail, requires little up-front cost, and can be improved upon over time.

For last years, consumer faith in the food related production was ultimately scratched due to conserve the nutritional characteristic [14] of goods during the shipping from supplier to consumer. As an effect, further rising consumer concerns over the protection and quality of food have tense more and more courtesy from intellectual and engineering areas. In response to growing food safety trouble, several IoT knowledge's, such as Radio Frequency Identifier, bar-code and WSN technology are useful to supply chain [15] and supervise the system.

In the past years an amplified interest in the IoT, smart linked things in instruction to execute the dissimilar attitude of the provider, maker and consumers and finalize a criterion which ultimately supports accuracy and worth of the product sustain on the approximate the advantage of smart connected things [16].

Sensor and barcode-based Internet of Things (IoT) data is life form useful to food supply chains from their list of basis to their procedures principle in dispensation plants, storage space warehouses, allocation points, and in the retail stores [17]. The laterally monitoring and traceability that barcodes and sensors offer facilitate accumulate chains, food brands, and commodities contribute networks to quickly recognize direct of source and delivery if it's exposed that food is disfigured.

Traceability in food supply chain has been used to deliver the high quality of food globally in complex situations. Blockchain concept has been implemented to provide the traceability in food supply chain with trust. The boundaries are identified to categorize the quality of traceability to effective independent governance [18]. Security in the Eco system has been maintained by utilizing the natural resources and Food supply chain management.

The food supply net-works may cover the food components and to maintain the eco system with safety. The optimized mathematical modelling has been generated to utilize the Internet of Things [19]. The food supply chain with the traceability functionality has been developed to maintain the confidence to the customer. The grey related methodology is utilized to identify the relationship with the customers and supply chain management [20].

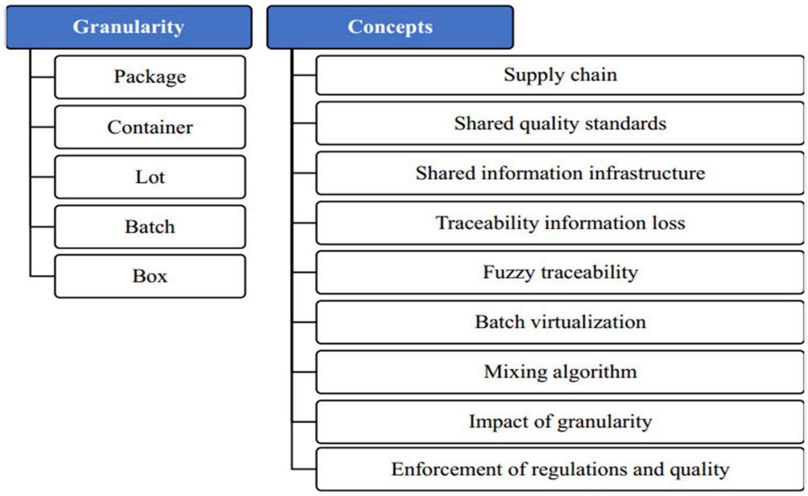

Fig.3. General Structure of concepts of traceability systems

III. Problem Formulation

The Naïve Bayes Classifier is the way which can forecast the upcoming possibilities from the existing data. Clustering and classification are used in the approaches. The method for the food manufacturer is evaluated in the literature review, and the dataset is gathered from various online sources. This forecast analysis of this model is based on the Internet of Things. The clustered data is provided as a contribution to the classification algorithm, which is capable of dividing the dataset into two parts: training data and testing data. The SVM classifier is used to divide the data into a set of categories.

The centered points are considered in the k-mean clustering technique by taking the arithmetic mean of the total dataset, which might lower the accuracy of forecast analysis. It is difficult to establish a link between the dataset's properties when the dataset is diverse. The KNN classifier is useful in this study effort, and it can categorize food production into a set of classifications. The KNN classifier may be used with numerous different classifiers to improve classification accuracy.

In general, for events A1 and B1, where A1 depends on B1, than P (B1) $\neq 0$,

$$P(A1 \mid B1)=(P(A1)P(B1 \mid A1))/(P(B1)) \qquad (1)$$

In several circumstances event B1 is fixed P(B1) = 1 and consider the impact of probability of other possible events A.

Initially, we require keeping the study for traceability of the entire simulation of the supply chain and scheme the entire improvement. At the current, it is a chance to put a suggestion to the standard of the Bayes, which is, among the features, self-rule. So now, we are divide verification into the novel parts. Now if these two X and Y incidents are divide,

$$P(X, Y) = P(X)\,P(Y) \qquad (2)$$

Consequently, we enter the result:

$$P(y|(x1, x2..., xn)) = P(x1|y)\,P(x2|y)\,.....P\,(xn|y)\,P(y)\,/\,P(x1)\,P(x2)....\,P(xn) \qquad (3)$$

this can be translated as

$$P(y|(x1, x2..., xn)) = P(y) \prod_{i=1}^{n} P(xi|y) / P(x1)\,P(x2)....\,P(xn) \qquad (4)$$

Now, the denominator for a effort leaves constant, we can remove that term:

$$\propto$$

$$P(y|(x1, x2..., xn)) \quad P(y) \prod_{i=1}^{n} P(xi|y) \tag{5}$$

Now, for the entire possible standards of the class variable y, we require to construct a food model to learn the possibility of standard position of contributions and wish the yield with the maximum probability. That can be logically expressed as:

$$y = \text{argmaxy}\, P(y) \prod_{i=1}^{n} P(xi|y) \tag{6}$$

Finally, the manipulation of P(y) and P(xi), where P(y) is also known as probability of class and P(xi) is known as probability of condition. The recommendations made by the various Bayesian networks differ significantly when it comes to the P(xi) distribution. It means that if the changeable has a wide circulation, customers are more likely to get it. The food data for the Bayesian network may be forecasted using shared data, which is a dependency function be-tween two random variables. Meaningfulness is linked to a reduction in uncertainty, and vice versa. The data is between 2 variables and is given by:

$$D(A, B) = \sum_{a,b} p(A, B) \log \frac{P(A,B)}{P(A)P(B)} \tag{7}$$

P(A, B) is the combined probability distribution's object, and P(A) and P(B) are the A and B probability distribution functions' bounds, respectively. The stronger the influence of A on B, the more well-constructed the relevance of P (A,B).
The volatile outcome would then be ranked according to the value of P (A, B). And the element that plays the most important function in the production process should be given particular attention and order in real time. Create a food prediction model to determine the probability of the reported input location for all possible class vector y values, and wish the yield with the highest probability. This can be objectively described as:

$$B = \text{argmaxy}\, P(B) \prod_{i=1}^{n} P(Ai|B) \tag{8}$$

To prove that the classification regulation's attribute tuple X corresponds to one of the class mark attributes (R1,R2,... Rn), we must show that A belongs to Rx. It's possible only if, and only if,

$$P(Ra|X) > P(Ri|X) \ 1 \leq i \leq n, i \neq a$$

Evaluating all class mark attributes possibility P(Rk) and probability of P(X|Rk):

$$P(Rk) = |Rk,D| \,/\, |D|, \text{ where } k = 1,2,.....i \tag{9}$$

where s(k = 1,....,n) is the class mark attribute, which has n types of classes that define n types of classes, Rk,D is a set of tuples in training set D that belong to class Rk, where |D| is the number of training set D and |Rk,D| is the number of Rk,D. With the help of data set D, the value of P(X|Ra) may be computed.
Using Bayes theory,

$$P(Ra/X) = P(X/Ra) * P(Rx) \,/\, P(A) \tag{10}$$

Only if the value of P (X|Ra) is maximum may attribute tuple A be categorized into class Sx. This signifies that you shouldn't prune this branch. The branch should be trimmed if this criterion is not met.

IV. Research Methodology

The stages of the research process are as follows:-
1. **Pre-Processing**:- Pre-processing is the initial step in the research process, during which a dataset is imported from the UCI repository. This step cleans the input data, removing any missing values from the dataset.
2. **Feature Extraction**:-The feature extraction approach is used in the second phase to build a link between each property of the data and the target set. It is simple to find essential qualities when the feature extraction approach is used.
3. **Classification**:- The data is then sent to the Nave Bayes classifier in the last phase. The out-put of the forecast is generated by the classification findings. Nave Bayes is a subset of Bayesian decision theory that has recently

gained prominence. Because it takes less storage and has a quick training phase, this method is used in essential applications. The goal of this algorithm is to provide a rule for allocating future items from a set of objects to a class based on the vectors of variables that identify the future objects.

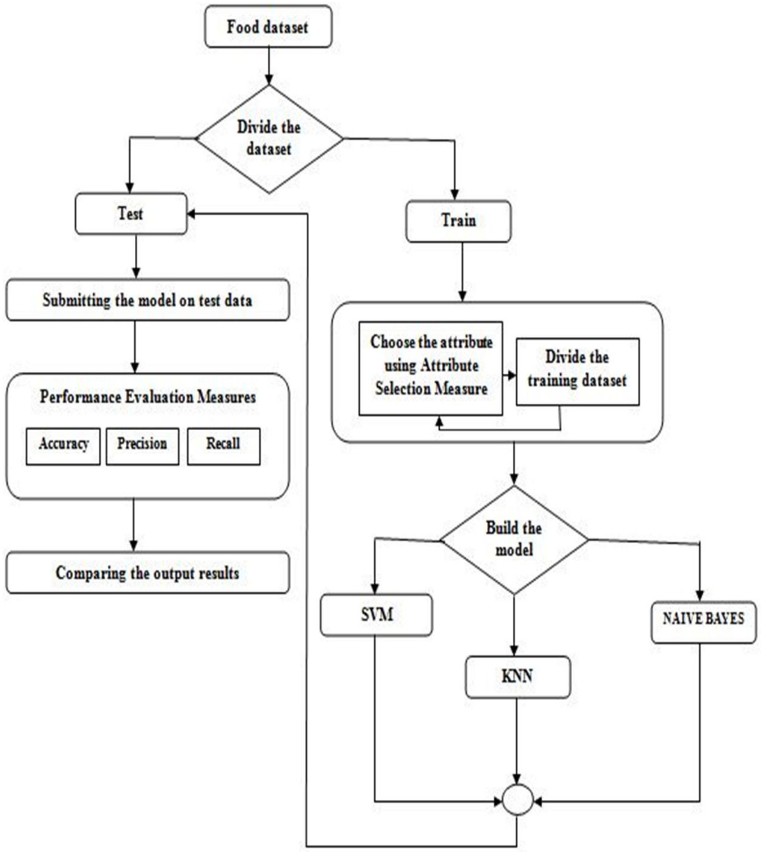

Fig.4. Steps of work

A supervised classification problem is quite frequent, and various approaches for constructing such rules have been developed. This technique does not require any sophisticated repeated parameter estimation mechanisms, allowing it to be used to large data sets. Because the classification process is simple to grasp, even inexperienced users who utilize the classifier approach may understand it. Fig 4 represent the stages of work.

V. FOOD SAFETY MONITORING PROCESS

In spite of creating the optimized solution for the food supply chain management system, the container is connected with CPU and the temperature and the humidity is measured by the sensors. The prime usage of the proposed work is the enhancement of the supplementary sensors with the constraint of the connecting devices is illustrated in Fig. 5.

The entire system is attached to the devices for Bar code reader and RFID is connected to the Bluetooth. The Web service is maintained with the Internet and GSM. The sensor is responsible for identifying the RFID communication range. Whenever the vehicle is in travelling, the sensor will scan the details about the RFID. After the available detail is scanned, the details could be read from the Monitoring system. The customers who are inside the CAR can be easily connected to the supply chain in Internet of Things using the communication media. The GSM is used to connect the customer with the producer or the retailer in the proposed model.

The Processing system finds the database connectivity by identifying the necessary constraints for the measurement of the sensors. The fuzzy-based neural network model is used to monitor the system. The real-time food traceability management modelling is adapted to check the product is damaged or not. The entire system is

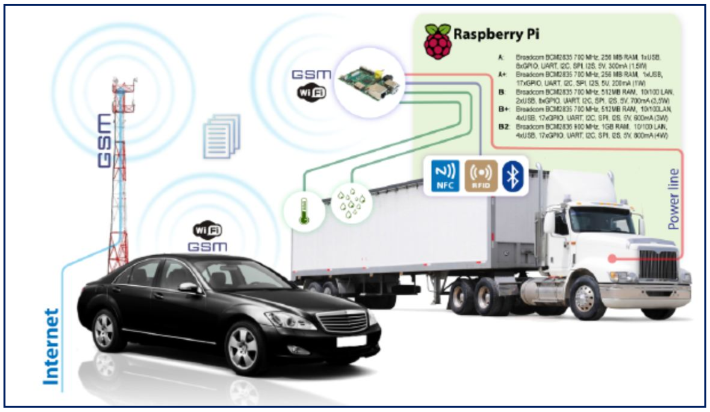

Fig. 5 Food Safety monitoring process

powered using the independent power system. The proposed work is implemented using the sensor networks with the connected vehicular system.

VI. Performance Evaluation

In this section, we argue the statements of the study and the investigational to get the outcome. The objective is to model wine quality based on physicochemical experiments. This can be used for business purpose. Wine Quality Dataset [20] is used for the performance evaluation. The projected model is qualified using the classifier and the training dataset has the limitation of variable selection and validation process. It is used to generate the proficient outcome. It contains 1599 instances which split into two parts train 1071 and test 528 and includes 12 attributes itemized below:

TABLE I: Simulation Parameters

Simulation parameter	Meaning
Software	Google Co laboratory
Output	Naive Bayes Classifier
Libraries	Pandas, Numpy, Matplotlab and Sklearn
Data Set Characteristics:	Multivariate
Attribute Characteristics:	Real
Associated Tasks:	Classification
Number of Instances:	1599
Number of Attributes:	12
Missing Values:	N/A
Area:	Business

Fixed acidity {Real}, volatile acidity {Real}, citric acid {Real}, residual sugar {Real}, chlorides {Real}, free sulfur dioxide{Real}, total sulfur dioxide {Real}, density {Real}, pH {Re-al},sulphates {Real},alcohol {Real},Output variable (based on sensory data) , quality (score between 0 and 10).

The dataset is divided into training and testing sets. The proposed Enhanced Naïve Bayes classifier is used to implement the training of the dataset and produced the output. The simulation parameters are demonstrated in Table1. Experiments have been carried out on food's data using SVM, KNN and Naïve Bayes algorithm. This study is about using wine quality dataset to predict food quality. In this study, the Nave Bayes method is used to forecast food manufacture. The KNN approach is utilized in the present work to analyze food quality.

The food production data was gathered from a variety of online sources. In terms of performance, the SVM, KNN, and Nave Bayes algorithms are compared. As demonstrated in Fig. 6, the accuracy of the three classifiers, SVM, KNN, and Nave Bayes, for predicting food quality is compared. When compared to other classifiers such as SVM and KNN, the Nave Bayes classifier has the highest performance depicted in Table II.

TABLE II: PERFORMANCE EVALUATION

Parameters	Classifiers		
	SVM	KNN	Naïve Bayes
Accuracy	76.58	90.53	94.21
Precision	71.58	89.53	93.34
Recall	79.81	93.93	96.32
F-score	76.81	92.93	94.32

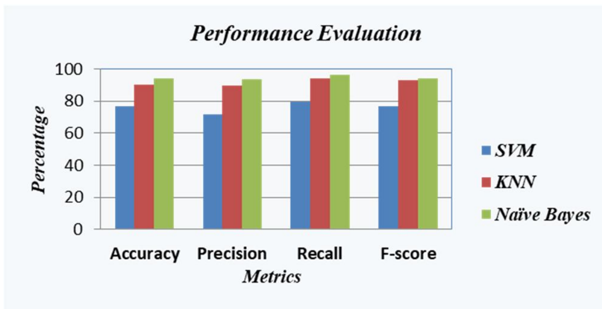

Fig.6. Comparison of efficiency for SVM, KNN and Naïve Bayes classifiers

The performance of the SVM, KNN, and Nave Bayes is statistically compared in the above tables. When compared to other classifiers for forecasting food production, the Nave Bayes provides the highest level of efficiency. The sensitivity of the Food Supply Chain management is experimentally evaluated that the proposed method has improved sensitivity according to the normal value. Fig. 7 illustrates the food supply chain management with sensitivity.

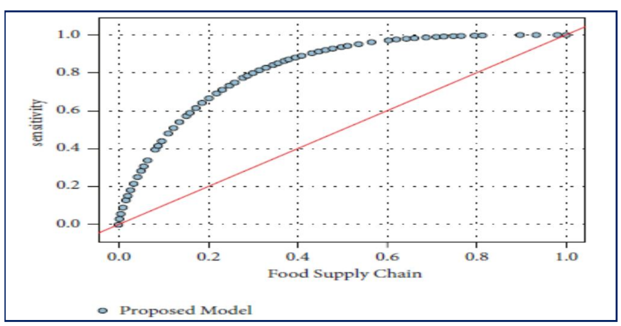

Fig. 7 Sensitivity of the food supply chain management

VII. CONCLUSION

This paper is to investigate the comparative analysis between three classification algorithms using IoT. Improved Naïve Bayes classifier is performed well compared to the KNN algorithm and SVM. The Nave Bayes classifier is used to forecast food quality in this study. The Nave Bayes algorithm predicts food quality with a maximum accuracy of 94.21. The enhanced Nave Bayes are implemented to produce the efficient food traceability management using Internet of Things. The quality is maintained from the producer for the needs of the customer with effective transportation. The proposed methodology has been implemented in an abnormal food condition. The unwanted data has been removed to enhance the health of the customer with economic growth.

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