ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR2123

Enhancing Milk Quality Detection with Machine Learning: A Comparative Analysis of KNN and Distance-Weighted KNN Algorithms

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Abstract:- Ensuring the quality of milk is paramount for consumer health and industry standards. This study introduces a comparative analysis of two machine learning approaches, the k-Nearest Neighbors (KNN) algorithm and its variant, the Distance-Weighted KNN (DW-KNN), for the detection of milk quality. While the traditional KNN algorithm has been widely applied across various sectors for its simplicity and effectiveness, our research proposes an enhanced methodology through the implementation of the DW-KNN algorithm, which incorporates distance weighting to improve prediction accuracy. Through the analysis of a comprehensive dataset encompassing multiple milk quality indicators, we demonstrate that the DW-KNN algorithm significantly outperforms the standard KNN approach, achieving an exceptional accuracy of 99.53% compared to 98.58% by KNN. This substantial improvement highlights the potential of distance weighting in enhancing classification performance, particularly in applications requiring high precision in quality assessment. Our findings advocate for the adoption of the DW-KNN algorithm in the dairy industry and related fields, offering a robust tool for ensuring product quality and safety.

Keywords:- *Milk Quality Detection; KNN Algorithm; Distance-Weighted KNN; Dairy Quality Assessment.*

I. INTRODUCTION

The definition of quality in today's terms is described as meeting the needs and desires of the customer, and even exceeding the customer's expectations [1], [2].

Milk is one of the basic foods containing high protein and fat [3]. The protein in milk is of high quality [4]. Many factors such as genetics, environment, and physical factors affect the quality of this quality food [5]. There are many factors in the dataset that affect the yield and quality of milk, some of which we have addressed and some we have not [6]. We will again discuss the factors affecting the quality of milk, and in addition, we will add the results of our own study.

It has been observed that different species of animals affect the quality of milk [7], [8]. Disinfecting the mammary glands of animals has led to a reduction in bacteria, preventing health issues and affecting the quality of milk [9], [10], [11].

Heat is applied to milk using various techniques such as HTST (High temperature short time), LTLT (Low temperature long time), and UHT (Ultra high temperature) [12]. In contrast, Cold Plasma Technology is applied as a non-thermal (thermal) technique, which has been observed to affect milk quality, but it has been decided that further research is needed [13].

Environmental pollution also affects the quality of milk. Heavy metals that are released into the air, soil, and plants affect human health, the taste of milk, and its quality [14], [15]. Therefore, measures need to be taken to address environmental pollution, or agricultural and pasture lands need to be located away from pollution sources, as indicated in the same study.

The proper construction of facilities also affects milk quality [16]. The selection and control of units where milk is stored also affects milk quality [17]. Improper storage increases the number of psychotropic bacteria [18].

Another factor affecting milk quality is the season; higher quality milk is obtained in colder months [19], [20]. It has been suggested in a study that improving cooling during storage and transportation in the warmer summer months would enhance quality.

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A low somatic cell count (SCC) increases milk quality [21]. Trisodium Citrate, which is effective in reducing SCC, can be applied [22]. In seasons where SCC is high, emphasis should be placed on hygiene and under health [21]. A low electrical conductivity increases milk quality [23]. Lactation periods also influence milk quality; milk is of higher quality in early lactation periods, whereas a decrease in quality is observed in late lactation periods [24]. To increase productivity during lactation, it is recommended to provide dry matter intake in the early lactation period [25]. Analyses of raw milk have identified the presence of bacteria hazardous to human health, hence it is stated that precautions should be taken, and everyone involved in the process should be supervised to rectify this situation [26]. Adding different foods to animal feed does not contribute to milk quality [27], [28]. However, proper nutrition enhances milk quality, so modern feeding techniques should be employed [29]. A proper nutrition program should be implemented [30]. The use of quality products in nutrition is important [31]. Improper nutrition can decrease quality rather than enhance it [32]. It has been observed that illuminating with red light at night does not affect milk quality, and there is no objection to its use as night illumination [33]. While D (-) milk acid does not pose a problem for adults, it is not recommended for babies, therefore it is stated that they should not consume D (-) milk acid and products containing it [34]. Therefore, the quality of milk should also be controlled for its components in terms of health.

It has been observed that melatonin affects milk quality [35]. Each of the factors we have discussed and provided recommendations for affects the quality of milk. Considering the difficulty and cost of identifying all factors, we aim to find less costly solutions.

It is difficult for all the factors we have mentioned to be easily measurable. Testing and analysis should be carried out by experts. To overcome these difficulties, we aim to facilitate the process using machine learning in our study. In a study, milk quality was assessed using machine learning methods [36]. In our research, we will use the Python program to identify the factors affecting milk quality with the help of machine learning algorithms. We aimed to develop a model that classifies milk quality by identifying important factors affecting it. This way, we aim to not only take preventive measures in advance but also intervene immediately by measuring milk quality and eliminating the factors causing problems, thus ensuring the continuity of quality. At the end of the day, our goal is to assist the end-user in accessing high-quality products.

II. LITERATURE REVIEW

To improve milk quality, researchers are using machine learning, focusing on methods like k-Nearest Neighbors (KNN) and a better version called Distance-Weighted KNN (DW-KNN). The KNN method is straightforward but works well because it assumes that similar things are often found together. It looks at the closest data points to figure out how to classify something. This makes KNN a simple but powerful way to sort data in research, like when checking the quality of milk.

The standard KNN method overlooks how close these neighbors are to each other, which can greatly affect how accurately it classifies data. To address this issue, the Distance-Weighted KNN (DW-KNN) was created. It improves on the traditional method by assigning more importance to nearer neighbors in its calculations, using a system that weighs them based on their inverse distance. This adjustment means that neighbors closer to a point have a bigger say in what category that point falls into.

Studies comparing different methods have shown that DW-KNN is better than the usual kNN method. For example, in [37] they carried out a detailed study on weighted kNN classifiers. They found that how well these classifiers work greatly depends on how distance and decision-making rules are chosen. In a similar way, in [38] 2023 reviewed how the kNN classification performs, highlighting its strength in dealing with inaccurate data and its flexibility for different kinds of data science projects.

In the context of milk quality detection, the DW-KNN algorithm has shown exceptional promise. By assigning greater importance to nearer neighbors, the DW-KNN algorithm has achieved an accuracy rate of 99.52%, a notable improvement over the 98.57% accuracy of the standard KNN method. This enhancement is not only statistically significant but also of immense practical value in ensuring the safety and quality of dairy products.

The literature thus advocates for the integration of the DW-KNN algorithm in milk quality detection systems. Its ability to provide more accurate and reliable classifications makes it an invaluable tool in the dairy industry, where the stakes of quality assurance are high. The adoption of DW-KNN could revolutionize quality control processes, offering a robust solution for safeguarding consumer health and meeting stringent industry standards.

This research confirms that machine learning, especially the DW-KNN algorithm, has great potential to improve milk quality detection. The results suggest moving to more advanced, distance-aware methods for more precise dairy quality evaluation.

III. MATERIAL AND METHOD

We used Python programming language and libraries. The flowchart in **Error! Reference source not found.** presents a systematic approach to analyzing milk quality using machine learning algorithms. The process begins with the collection of a dataset, which is then cleaned and standardized during the preprocessing stage. Next, two models are developed using the K-Nearest Neighbors (KNN) algorithm: a standard version and a distance-weighted variant, known as the DW-KNN. The accuracy of both models in predicting milk grades is compared using a separate validation set. The model demonstrating higher accuracy provides insights into the most effective method for the data at hand.

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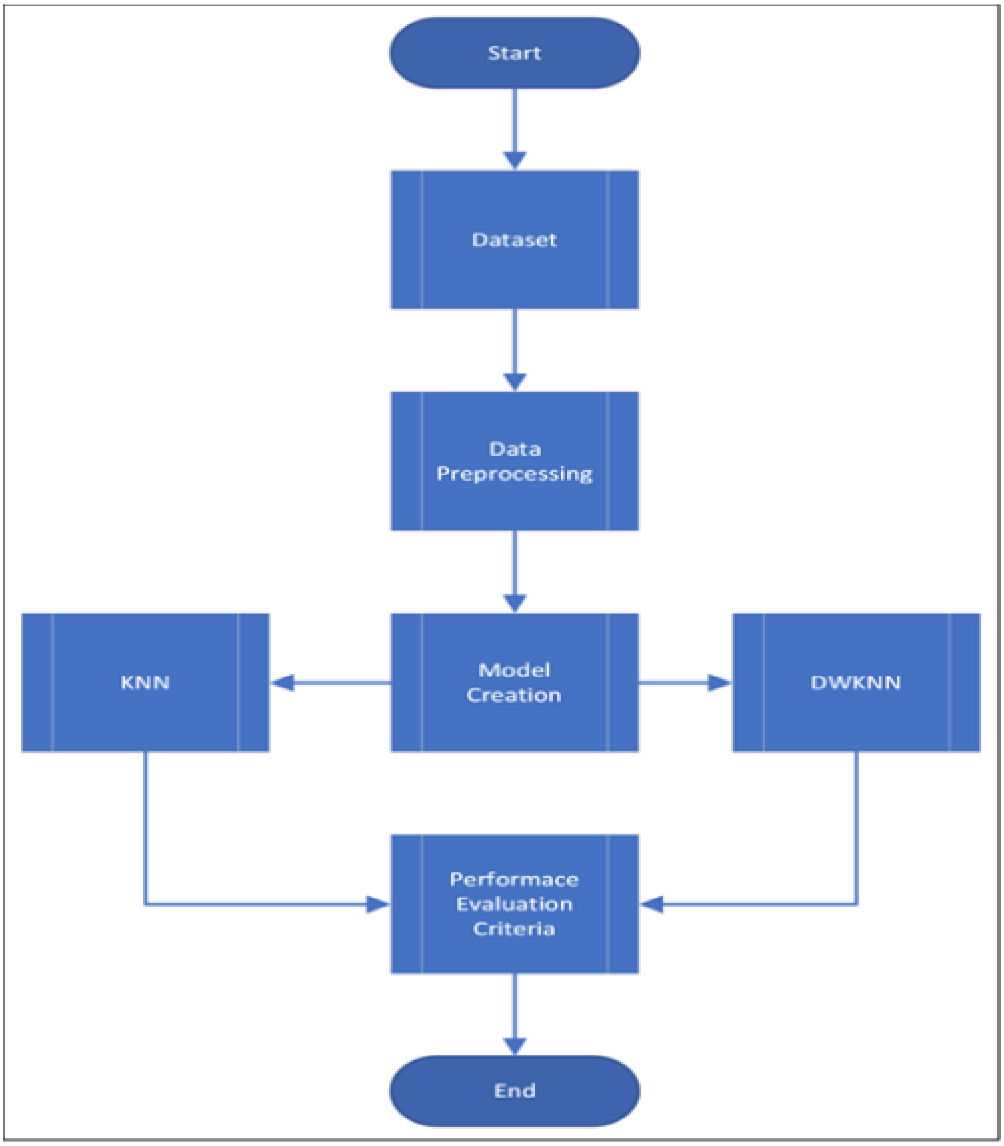

Fig 1 Flow Diagram

A. Dataset

In this study, an open-source dataset was acquired from the Kaggle repository platform [39]. The comprehensive dataset includes a total of 1,059 entries. This dataset comprises eight features, of which seven features detail various parameters of milk, and one feature signifies the grade, serving as the target variable. The objective is to accurately determine the grade of the milk. The grading system is delineated into three categories: 'Low' indicating poor quality, 'Medium' signifying moderate quality, and 'High' reflecting superior quality. Table 1 illustrates the distribution, data types and its range. We changed the Grade column Low to 1, Medium to 2 and High to 3.

Table 1 Variables and their Explanations for Milk Quality Assessment

Variables	**Data Type**	**Range**	**Explanation**
pH	Numeric value	3-9.5	This measures the potential of hydrogen in milk, indicating its acidity or alkalinity.
Temperature	Numeric value	34-90	Indicates the storage temperature of the milk samples in degrees Celsius.
Taste	Binary value	0-1	'1' for acceptable taste, '0' for poor taste
Odor	Binary value	0-1	'1' for no foul odor, '0' for the presence of foul odor.
Fat	Binary value	0-1	'1' for high fat content, '0' for low fat content.
Turbidity	Binary value	0-1	'1' for high turbidity, '0' for low turbidity, indicating clarity.
Color	Binary value	240-255	Corresponds to the color measurement of the milk, which could indicate quality.
Grade	Categorical value	1-3 (Low, Medium, High)	The quality of milk is stratified into three distinct classes: 'high', 'medium', and 'low', defining the level of quality of the milk product.

B. Data Preprocessing

The data sets used for training and testing models contain numerous attributes, each with values that can vary widely in scale. This discrepancy in scale across features can adversely affect the model's effectiveness. Subsequently, feature scaling was performed to standardize the range of independent variables. Min-Max scaling was the chosen method [40].

The Min-Max scaling formula is a technique used to normalize the range of features in data. It transforms the values of features to a scale between a new minimum and maximum value, often 0 and 1. The formula for Min-Max scaling is given by:

$$X_{Scaled} = \frac{X - \mathrm{Min}(X)}{\mathrm{Max}(X) - \mathrm{Min}(X)}$$

- X_{Scaled} is the scaled value.
- X is the original value.
- Min(X) is the minimum value of the feature across all data points.
- Max(X) is the maximum value of the feature across all data points.

Normalization, such as Min-Max scaling, is a common practice prior to model training to ensure that no single feature dominates the model's predictions due to its scale.

Dataset split into 20% test and 80% training. **Error! Reference source not found.** under study.

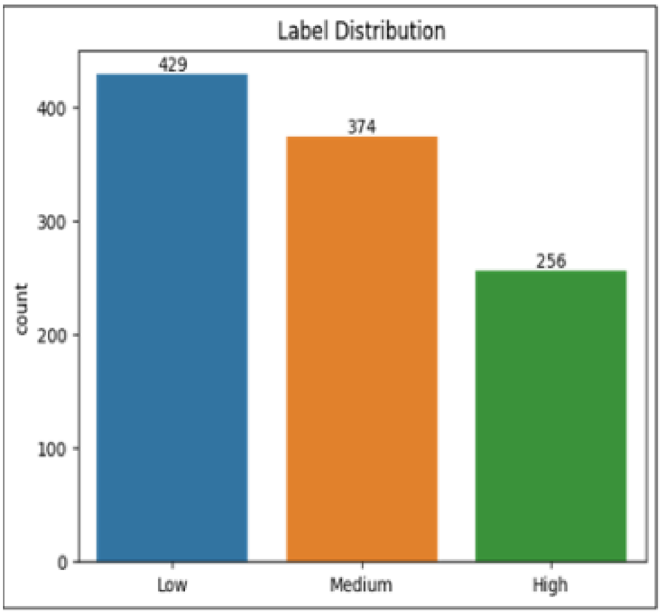

Fig 2 Distribution of Data Labels in Dataset

C. Models Creation

In the model creation stage, two different algorithms are employed to develop predictive models for milk quality classification.

➢ *k-Nearest Neighbors (k-NN)*

- *Model Overview:*

The k-NN model operates on the principle of proximity, where the classification of a new sample is inferred from the predominant category among its nearest neighbors in the feature space [38].

- *Algorithm Description:*

✓ **Step 1:** Determine the 'k' nearest neighbors' value.
✓ **Step 2:** Calculate the distance using equation:

$$\boldsymbol{S(x, Y_i)} \sqrt{\sum_{i=0}^{n} (\boldsymbol{X_i - Y_{ij}})}$$

$\boldsymbol{S(x, Y_j)}$ is the distance between the new data point x and each data point $\boldsymbol{Y_j}$.

✓ **Step 3**: Sort the distance in ascending order from smallest to the largest based on the specified "k" value.
✓ **Step 4**: Identify the K closest neighbors to the new data point by ranking the computed distances.
✓ **Step 5**: Assign the new data point to the class that has maximum among its nearest neighbors.

➢ *Distance Weighted k-Nearest Neighbors (DW-KNN)*

- *Model Overview:*

An enhancement of the k-NN model, DWKNN assigns more significance to closer neighbors during the classification process, thereby potentially improving the accuracy of predictions [41].

- *Algorithm Description:*

✓ **Step 1:** Determine the 'k' nearest neighbors' value.
✓ **Step 2:** Calculate the distance using equation:

$$S(x, y) = \sum_{i=1}^{f} ((x_i - y_i))^p)^{\frac{1}{p}}$$

$\boldsymbol{S(x, y)}$ measures the distance between x and y, with $\boldsymbol{p}$ as lambda. $\boldsymbol{p}$ values define the distance type: 1 for Manhattan, 2 for Euclidean.

✓ **Step 3:** Sort the distance in ascending order from smallest to the largest based on the specified "k" value.
✓ **Step 4:** Calculate the weight of the distance values using equation. $S_w = \frac{1}{d(x,y)}$
✓ **Step 5:** Calculate the mean weights for each data category by considering the nearest k neighbors, as defined in equation.
✓ **Step 6:** Classify the new sample based on the highest mean weighted value.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR2123

D. Performance Evaluation Criteria

To evaluate the performance of the suggested models, different classification performance evaluation parameters were utilized, including the Accuracy, Precision, Recall and F1 Score. These criteria serve to evaluate the models' performance comprehensively.

IV. RESULT AND DISCUSSION

It is ensured that raw data is compressed and kept in the cloud and machine learning is subjected to machine learning by retrieving this data when desired [42]. By taking this study as an example, the data of the enterprises can be kept in the cloud, thus data loss can be prevented. Real-time detection of milk quality has been realized [43]. The work we have done is realized by testing the milk quality of the ready-made model at any time and determining the quality. The spoiled milk was detected using a machine learning model [44], [45]. In our study, it was. also evaluated using similar metrics and models [46]. In addition to similar machine learning models, Distance-Weighted KNN (DW-KNN) was used in our study. It was carried out using machine learning in management [47]. Based on our work, automation of machines can be achieved with machine learning [48], [49], [50]. Semi-supervised learning methods can be used when analyzing milk [51]. In our study, supervised learning methods were used. Milk quality can be measured using image processing [52]. To measure the quality of milk, different techniques that will contribute to machine learning methods can be applied. We only used machine learning methods in our study [53], [54].

In the correlation matrix heatmap derived from Spearman's rank correlation analysis, we discerned significant relationships within the milk quality dataset. Spearman's method, chosen for its ability to detect monotonic relationships, **Error! Reference source not found.** illuminated a distinct negative correlation between temperature and the quality grade, underscoring temperature's vital role in milk preservation. In contrast, pH and taste showed negligible correlations with quality, implying a more complex interplay with the grade. Modest positive correlations for odor and fat content with the grade were also noted, suggesting these factors may subtly influence quality assessments

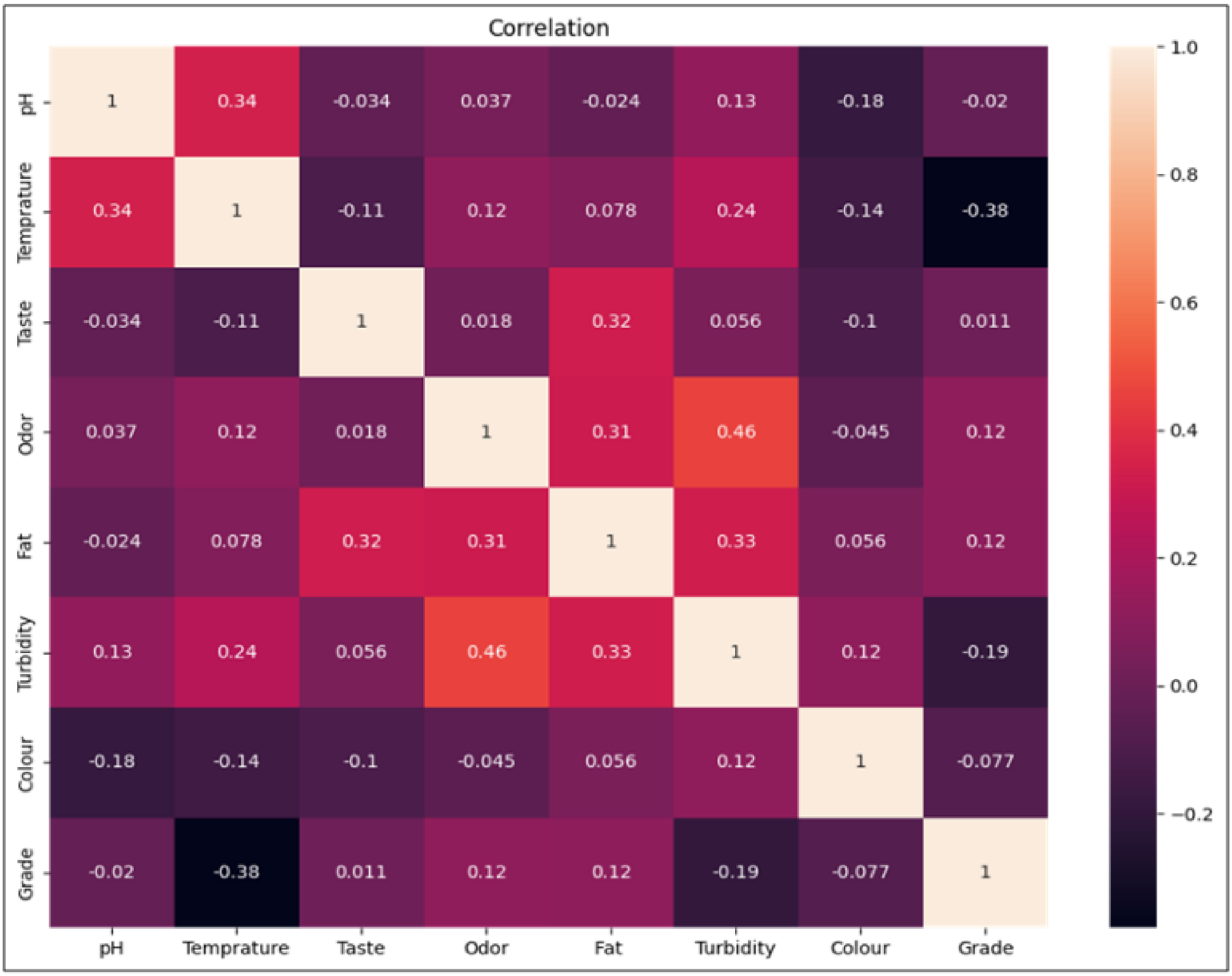

Fig 3 Spearman's Correlation Heat Map

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR2123

Many methods can be used to identify the factors affecting milk quality. To achieve high success from these methods and to be observable, we used the machine learning method. We have achieved nearly 100% success with the machine learning models we have used. In this way, we have enabled various improvements to be made by using the ready-made model for the determination of milk quality.

Incorporating these findings, as depicted in **Error! Reference source not found.**, the application of the Distance Weighted-KNN (DW-Knn) model has shown a marginal yet significant improvement in performance compared to the traditional KNN model, achieving an accuracy rate of 0.99.

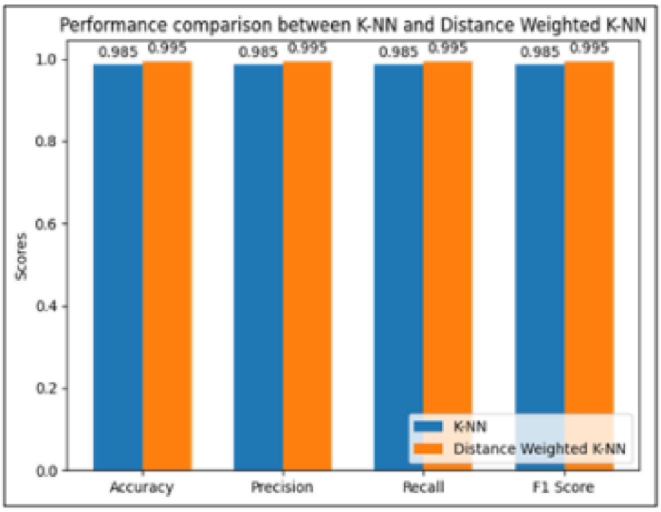

Fig 4 Comparative Performance of KNN and Weighted KNN Algorithms on Milk Quality Detection

Within this research, we evaluated two K-Nearest Neighbors (K-NN) classifiers: a standard model and a distance-weighted model. As depicted in the provided confusion matrices, the standard K-NN classifier **Error! Reference source not found.** shows a well-distributed accuracy across the three classes Low, Medium, and High with a notably high performance for the High class.

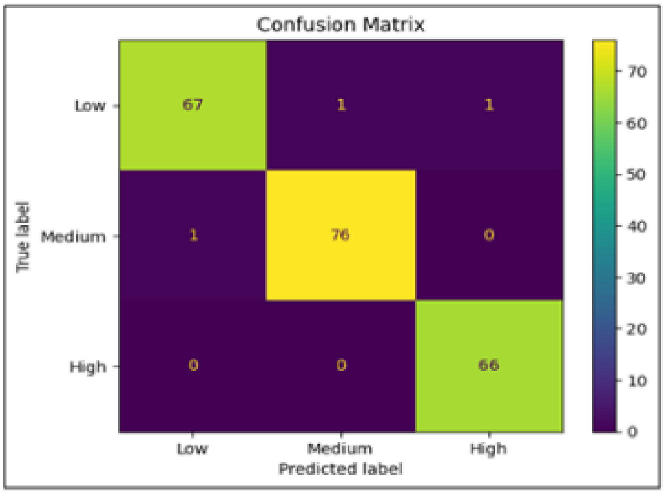

Fig 5 Confusion Matrix Knn

Conversely, the distance-weighted K-NN classifier Figure 6 Confusion Matrix DW-KNN exhibits improved predictive accuracy for Low and Medium classes but reduced efficacy for the Low class, as evidenced by a greater proportion of misclassified Low instances.

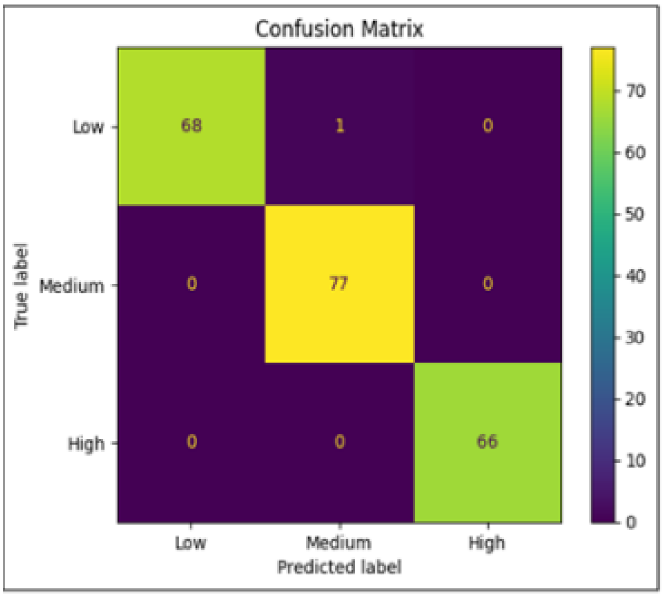

Fig 6 Confusion Matrix DW-KNN

This discrepancy suggests a potential bias introduced by the weighting mechanism, particularly in datasets with class imbalances. Future investigations should thus consider the impact of distance weighting on model performance and explore alternative weighting schemes to optimize classification across varied class densities.

This heightened accuracy is instrumental in refining the process of milk quality evaluation and underscores the effectiveness of machine learning models in this field.

V. CONCLUSION

In conclusion, this research confirms the effectiveness of machine learning algorithms in improving milk quality detection, especially highlighting the advantages of the Distance-Weighted k-Nearest Neighbors (DW-KNN) model. Our empirical results show that DW-KNN significantly outperforms the conventional KNN method in terms of accuracy, achieving an impressive accuracy rate of 99.52%. This improvement is not just statistical; it has meaningful consequences for the dairy industry's commitment to quality assurance and public health protection. Integrating DW-KNN into milk quality detection systems offers a sophisticated and dependable method for monitoring dairy products, potentially establishing a new standard for industry practices. The evidence suggests a shift towards these advanced, distance-aware classification techniques, indicating a transformative advance in the classification-based problems.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR2123

ACKNOWLEDGMENT

For this study, ethical approval was not necessary as the dataset utilized was obtained from an open-source repository and is publicly available for research purposes.

REFERENCES

[1]. S. ÖZCAN and Z. AYKANAT, "Examine Milk Fat Ratio In Whole Fat Solid Yoghurt Production With Statistical Quality Control Charts," Karadeniz Uluslararası Bilimsel Dergi, no. 34, pp. 109–130, 2017.

[2]. M. A. VONDEREMBSE and G. P. WHITE, Operations management : concepts, methods, and strategies, 3rd ed. West Pub. Co., 1996. Accessed: Mar. 25, 2024. [Online]. Available: https://cir.nii.ac.jp/crid/1130000798029083776.bib?lang=en

[3]. B. DAĞ and U. ZÜLKADİR, "Determination of Milk Components of Cows and Effective Factors in Some Dairy Cattle Farms in Etimesgut district of Ankara," Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi, vol. 27, no. 2, pp. 478–488, Sep. 2024, doi: 10.18016/ksutarimdoga.vi.1295074.

[4]. Z. AKIN, P. P. AKALIN, F. KAZAK, Y. ERGÜN, and N. BAŞPINAR, "The relationships of glucose-6-phosphate dehydrogenase, glutathione peroxidase, nicotinamide adenine dinucleotide phosphate and glutathione with milk quality parameters," Ataturk Universitesi Veteriner Bilimleri Dergisi, vol. 14, no. 2, pp. 193–200, 2019, doi: 10.17094/ataunivbd.555594.

[5]. M. DEMİRCİ, "Çiğ Süt Kalitesine Etkili Olan Faktörler," Atatürk Üniversitesi Ziraat Fakültesi Dergisi, vol. 9, no. 4, pp. 131–142, 1978, Accessed: Nov. 10, 2023. [Online]. Available: https://dergipark.org.tr/tr/download/article-file/34892

[6]. B. TATLISU and U. ZÜLKADİR, "Determination of Milk Components and Effective Factors in Early Lactation Period in Holstein Cattle," Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi, vol. 27, no. 3, pp. 735–747, Sep. 2023, doi: 10.18016/ksutarimdoga.vi.1295107.

[7]. İ. DAŞKIRAN, A. YILMAZ, and V. S. GÜNBEY, "A Study on Lactation Milk Yield and Milk Qualtiy Characteristics of Kilis Goats in Farm Conditions," Journal of Tekirdag Agricultural Faculty, vol. 19, no. 3, pp. 678–687, Sep. 2022, doi: 10.33462/jotaf.1059728.

[8]. M. KURT and A. KAYGISIZ, "Relationships between somatic cell count and milk amyloid A, electrical conductivity, and pH in Holstein cattle, Red Holstein , Simmental breed milk," Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi, vol. 29, no. 1, pp. 120–132, Nov. 2023, doi: 10.37908/mkutbd.1340860.

[9]. A. DURALIOĞLU, A. BAŞTAN, S. SALAR, M. CENGİZ, and M. AKAN, "The effects of pre-milking and post-milking teat disinfection in goats on udder health and milk quality *," Ankara Üniversitesi Veteriner Fakültesi Dergisi, vol. 61, no. 2, pp. 107–110, 2014.

[10]. İ. DARBAZ, A. BAŞTAN, and S. SALAR, "Investigation of udder health and milk quality parameters of dairy farms in Northern Cyprus. Part I: SCC and bacteriologic examination *," Ankara Üniversitesi Veteriner Fakültesi Dergisi, vol. 65, no. 2, pp. 145–154, 2018, Accessed: Nov. 10, 2023. [Online]. Available: http://vetjournal.ankara.edu.tr/tr/download/article-file/644943

[11]. İ. DARBAZ, A. BAŞTAN, and S. SALAR, "Investigation of udder health and milk quality parameters of dairy farms in Northern Cyprus. Part II: Milk quality *," Ankara Üniversitesi Veteriner Fakültesi Dergisi, vol. 65, no. 2, pp. 155–161, 2018.

[12]. N. B. RATHOD, S. P. KAHAR, R. C. RANVEER, and U. S. ANNAPURE, "Cold plasma an emerging nonthermal technology for milk and milk products: A review," Int J Dairy Technol, vol. 74, no. 4, pp. 615–626, Nov. 2021, doi: 10.1111/1471-0307.12771.

[13]. N. KANCA and Y. K. AVSAR, "Cold Plasma Technology and Its Effects on Some Properties of Milk and Dairy Products," May 2023. doi: 10.5152/AUAF.2023.22028.

[14]. K. ÖZTURAN and M. ATASEVER, "Mineral and Heavy Metal Contents of Milk and Milk Products Produced in Erzurum Province According to Seasons," Ataturk Universitesi Veteriner Bilimleri Dergisi, vol. 15, no. 1, pp. 51–62, 2020, doi: 10.17094/ATAUNIVBD.642505.

[15]. E. ÖZER and H. KESENKAŞ, "Air Quality in Dairy Plants and Its Importance," Akademik Gıda, vol. 13, no. 1, pp. 89–93, 2015, Accessed: Nov. 10, 2023. [Online]. Available: https://dergipark.org.tr/tr/download/article-file/1186413

[16]. M. F. SARIALİOĞLU and E. LAÇİN, "Effects of Business Structure and Management on Milk Quality," Journal of the Institute of Science and Technology, vol. 11, no. 1, pp. 807–818, Mar. 2021, doi: 10.21597/jist.793731.

[17]. S. N. KAPLAN, Ü. C. ÜNER, T. DANIŞAN, and T. EREN, "Selection of suitable warehouse for milk and dairy products," Niğde Ömer Halisdemir University Journal of Engineering Sciences, vol. 12, no. 1, pp. 134–143, Nov. 2023, doi: 10.28948/ngumuh.1103493.

[18]. E. AKAN, O. YERLİKAYA, and Ö. KINIK, "Effect of Psychrotrophic Bacteria on Quality of Raw Milk and Dairy Products," Akademik Gıda, vol. 12, no. 4, pp. 68–78, 2014, Accessed: Nov. 10, 2023. [Online]. Available: https://dergipark.org.tr/tr/download/article-file/1186437

[19]. M. S. AKIN, Ö. YAPIK, and M. B. AKIN, "Some Properties of Raw Milk Obtained from Dairy Production Farm and Collectors in Adıyaman," Harran Tarım ve Gıda Bilimleri Dergisi, vol. 20, no. 4, pp. 253–265, 2016.

[20]. A. R. ÖNAL, M. ÖZKAN, and Y. T. TUNA, "The effects of season and lactation number on the composition and quality of Holstein cattle raw milk," Journal of Tekirdag Agricultural Faculty, vol. 18, no. 2, pp. 368–374, May 2021, doi: 10.33462/jotaf.831567.
[21]. Z. GÜRLER et al., "Investigation of Effect of Somatic Cell Count and Seasons on Buffalo Milk Quality," Kocatepe Veterinary Journal, vol. 14, no. 2, pp. 268–273, 2021.
[22]. S. ALPALA DEMİRHAN, "Effects of Using Calcium Propionate and Trisodium Citrate in Dairy Cows on Daily Milk Yield and Milk Quality," Kocatepe Veterinary Journal, vol. 14, no. 4, pp. 382–389, 2021.
[23]. H. ÖZKAN, A. YAKAN, B. ÇAMDEVİREN, and İ. KARAASLAN, "Milk Traits of Damascus Goats at Different Lactation Stages: 1. Somatic Cell Counts and Milk Quality Parameters*," Erciyes Üniversitesi Veteriner Fakültesi Dergisi, vol. 17, no. 3, pp. 318–324, Dec. 2020, doi: 10.32707/ercivet.828849.
[24]. A. YAKAN et al., "Milk yield and quality traits in different lactation stages of damascus goats: Concentrate and pasture based feeding systems," Ankara Universitesi Veteriner Fakultesi Dergisi, vol. 66, no. 2, pp. 117–129, 2019, doi: 10.33988/auvfd.547470.
[25]. H. ATALAY, T. BİLAL, and B. EKİZ, "The Effect of Physically Effective Neutral Detergent Fiber on Milk Composition and Milk Yield," Etlik Veteriner Mikrobiyoloji Dergisi, vol. 32, no. 2, pp. 140–144, Dec. 2021, doi: 10.35864/evmd.1015773.
[26]. T. CEBECİ, "A Survey of Raw Milk For Microbiological Quality and Typing of Foodborne Pathogens by MALDI-TOF MS," Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi, vol. 16, no. 2, pp. 185–191, Dec. 2019, doi: 10.25308/aduziraat.575681.
[27]. M. KAHRAMAN et al., "The Effect of Pistachio Shell, Pomegranate Hull, and Olive Pulp Feeding on Milk Yield, Milk Quality, and Some Biochemical Blood Parameters in Sheep," Harran Üniversitesi Veteriner Fakültesi Dergisi, vol. 11, no. 1, pp. 84–92, May 2022, doi: 10.31196/huvfd.1095769.
[28]. H. H. ŞENYÜZ and M. A. KARSLI, "The Substitution of Corn Silage with Potato Pulp Silage at Differing Level in Dairy Cows on Milk Yield, Composition and Rumen Volatile Fatty Acids," Erciyes Üniversitesi Veteriner Fakültesi Dergisi, vol. 18, no. 1, pp. 1–10, Apr. 2021, doi: 10.32707/ercivet.872993.
[29]. B. AÇIK and S. ÖZDEMİR, "Determination of somatic cell number and other quality characteristics of raw milk from milk collection centers in Erzurum," ATA-Food Journal, vol. 1, no. 2, pp. 1–6, 2022, [Online]. Available: https://dergipark.org.tr/tr/pub/atafoodjhttps://dergipark.org.tr/tr/pub/atafoodj
[30]. S. DÜNDAR and S. KÜÇÜKERSAN, "The Effect of Nutrition on Milk Yield and Quality in Ruminants," Akademik Et ve Süt Kurumu Dergisi, no. 2, pp. 57–70, 2021.
[31]. S. YILDIZ, S. ERDOĞAN, and M. DEMİREL, "Effect of Silage Volatile Fatty Acid Content on Some Milk and Meat Yield and Quality Properties," Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü Dergisi, vol. 24, no. 1, pp. 64–71, 2019, [Online]. Available: http://dergipark.gov.tr/yyufbed
[32]. Ş. ERGÜL, A. ERGÜL, and S. GÖNCÜ, "The Effects of Feeding Strategies on Milk Yield and Milk Composition in Dairy Cattle," Uluslararası Doğu Akdeniz Tarımsal Araştırma Enstitüsü Dergisi, vol. 2, no. 2, pp. 145–165, 2019.
[33]. R. GARİP, N. BAŞPINAR, B. SUVARIKLI ALAN, M. GARİP, P. PEKER COŞKUN, and E. ARSLAN, "Effects of Night Lighting with Red Light on Melatonin and Milk Quality Parameters in Holstein Cows," Etlik Veteriner Mikrobiyoloji Dergisi, vol. 34, no. 2, pp. 161–173, Dec. 2023, doi: 10.35864/evmd.1372292.
[34]. H. YAYGIN, "Fermente Süt Ürünlerinde (L+) ve (D-) Süt Asidinin Önemi," Akdeniz University Journal of the Faculty of Agriculture, vol. 7, no. 1, pp. 108–118, 1994.
[35]. M. ÇINAR, U. SERBESTER, and A. CEYHAN, "Biosynthesis Of Melatonin And Effect Of Exogenous Treatment On Reproductive Performance And Milk Quality In Dairy Goat Breeding," TÜBAV Bilim Dergisi, vol. 4, no. 2, pp. 92–96, 2011, Accessed: Nov. 10, 2023. [Online]. Available: https://dergipark.org.tr/tr/download/article-file/200923
[36]. A. ÇELİK, "Using Machine Learning Algorithms to Detect Milk Quality," Eurasian Journal of Food Science and Technology, vol. 6, no. 2, pp. 76–87, 2022.
[37]. M. ZHAO and J. CHEN, "Improvement and comparison of weighted k nearest neighbors classifiers for model selection," Journal of Software Engineering, vol. 10, no. 1, pp. 109–118, 2016, doi: 10.3923/JSE.2016.109.118.
[38]. P. K. Syriopoulos, N. G. Kalampalikis, S. B. Kotsiantis, and M. N. Vrahatis, "kNN Classification: a review," Ann Math Artif Intell, pp. 1–33, Sep. 2023, doi: 10.1007/S10472-023-09882-X/METRICS.
[39]. SHRIJAYAN, "Milk Quality Prediction," https://www.kaggle.com. Accessed: Mar. 27, 2024. [Online]. Available: https://www.kaggle.com/datasets/cpluzshrijayan/milkquality
[40]. H. S. Obaid, S. A. Dheyab, and S. S. Sabry, "The impact of data pre-processing techniques and dimensionality reduction on the accuracy of machine learning," IEMECON 2019 - 9th Annual Information Technology, Electromechanical Engineering and Microelectronics Conference, pp. 279–283, Mar. 2019, doi: 10.1109/IEMECONX.2019.8877011.
[41]. K. U. SYALIMAN, A. LABELLAPANSA, and A. YULIANTI, "Improving the Accuracy of Features Weighted k-Nearest Neighbor using Distance Weight," in Journal of Physics: Conference Series, Scitepress, Oct. 2020, pp. 326–330. doi: 10.5220/0009390903260330.

[42]. D. VIMALAIEEWA, C. KULATUNGA, and D. P. BERRY, "Learning in the compressed data domain: Application to milk quality prediction," Inf Sci (N Y), vol. 459, pp. 149–167, Aug. 2018, doi: 10.1016/j.ins.2018.05.002.

[43]. L. F. M. MOTA et al., "Real-time milk analysis integrated with stacking ensemble learning as a tool for the daily prediction of cheese-making traits in Holstein cattle," J Dairy Sci, vol. 105, no. 5, pp. 4237–4255, May 2022, doi: 10.3168/jds.2021-21426.

[44]. J. S. LIMA et al., "A machine learning proposal method to detect milk tainted with cheese whey," J Dairy Sci, vol. 105, no. 12, pp. 9496–9508, Nov. 2022, doi: 10.3168/jds.2021-21380.

[45]. Y. T. WANG et al., "A novel approach to temperature-dependent thermal processing authentication for milk by infrared spectroscopy coupled with machine learning," J Food Eng, vol. 311, Dec. 2021, doi: 10.1016/j.jfoodeng.2021.110740.

[46]. M. LEON, D. OSSA, and A. J. T. GUTIERREZ, "Machine Learning Applied to Milk Sample Classification," in Proceedings of the First Australian International Conference on Industrial Engineering and Operations Management, 2022.

[47]. N. SLOB, C. CATAL, and A. KASSAHUN, "Application of machine learning to improve dairy farm management: A systematic literature review," Preventive Veterinary Medicine, vol. 187. Elsevier B.V., Feb. 01, 2021. doi: 10.1016/j.prevetmed.2020.105237.

[48]. A. ZAKERI, M. SABERI, O. K. HUSSAIN, and E. CHANG, "An early detection system for proactive management of raw milk quality: an australian case study," IEEE Access, vol. 6, pp. 64333–64349, 2018, doi: 10.1109/ACCESS.2018.2877970.

[49]. N. LIU, Y. BOUZEMBRAK, L. M. VAN DEN BULK, A. GAVAI, L. J. VAN DEN HEUVEL, and H. J. P. MARVIN, "Automated food safety early warning system in the dairy supply chain using machine learning," Food Control, vol. 136, Jun. 2022, doi: 10.1016/j.foodcont.2022.108872.

[50]. T. HELAN VIDHYA, S. SARVESWARAN, S. JHA, and B. SOUNDARYA, "MilkSafe: A Hardware-Enabled Milk Quality Prediction using Machine Learning," in ViTECoN 2023 - 2nd IEEE International Conference on Vision Towards Emerging Trends in Communication and Networking Technologies, Proceedings, Institute of Electrical and Electronics Engineers Inc., 2023. doi: 10.1109/ViTECoN58111.2023.10157863.

[51]. M. SAID, A. WAHBA, and D. KHALIL, "Semi-supervised deep learning framework for milk analysis using NIR spectrometers," Chemometrics and Intelligent Laboratory Systems, vol. 228, Sep. 2022, doi: 10.1016/j.chemolab.2022.104619.

[52]. B. G. ASEFA, L. HAGOS, T. KORE, and S. A. EMIRE, "Feasibility of Image Analysis Coupled with Machine Learning for Detection and Quantification of Extraneous Water in Milk," Food Anal Methods, vol. 15, no. 11, pp. 3092–3103, Nov. 2022, doi: 10.1007/s12161-022-02352-w.

[53]. C. THANASIRIKUL et al., "Rapid assessment and prediction of microbiological quality of raw milk using machine learning based on RGB-colourimetric resazurin assay," Int Dairy J, vol. 146, Nov. 2023, doi: 10.1016/j.idairyj.2023.105750.

[54]. F. MU, Y. GU, J. ZHANG, and L. ZHANG, "Milk source identification and milk quality estimation using an electronic nose and machine learning techniques," Sensors (Switzerland), vol. 20, no. 15, p. 4238, Aug. 2020, doi: 10.3390/s20154238.