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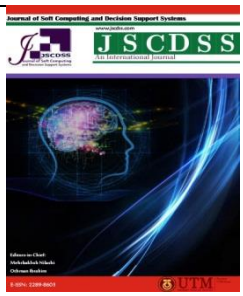

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Revealing the Effectiveness of Turmeric for COVID-19 through Analysis of Consumer' Reviews Using Clustering, Text Mining and Deep Learning

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Abstract

Understanding COVID-19's nature along with clinical features will be essential in dealing with the outbreak of this virus. As the immune response of COVID-19 patients is found to be similar to the immune response of patients with MERS and SARS, those Complementary and Alternative Medicines (CAMs) are potential sources of bioactive compounds with antimicrobial activity can be beneficial in the prevention and treatment of COVID-19 virus infection. This paper investigates the role of curcumin, as an active component of the spice turmeric, in infectious diseases such as COVID-19. In addition, this paper provides some results from the WebMD data for the consumers' satisfaction of turmeric consumption. The data analysis is performed using clustering, text mining and prediction techniques. The results show that the majority of consumers find turmeric as a useful CAM in improving their general health and well-being. Overall, the advantages of turmeric to infectious disease in the early stage of infection for prevention and treatment need additional evaluation. Nevertheless, because some clinical studies show turmeric effectiveness in infectious disease prevention and treatment, further clinical and consumer analysis should be conducted to reach robust conclusion on the benefit of turmeric beneficial for COVID-19 treatment. The outcome of this paper demonstrates the health benefits of turmeric and its effectiveness in immune system enhancement and protection against infectious diseases.

Keywords: Curcumin, Turmeric, COVID-19, Immune Response, Consumer Experience, Clustering, Text Mining

1. Introduction

Coronavirus is an enveloped RNA virus (Cao et al., 2015; Du et al., 2020; Rhodes et al., 2020; Rosa and Santos, 2020) whose distribution among mammals such as humans and birds is extensive and significantly fast, with resulting respiratory, enteric, hepatic, as well as neurologic complications (Huang et al., 2020; Li et al., 2020; Zhu et al., 2020). This virus was incorporated to the diseases list by World Health Organization (WHO) in its 2018 yearly review of the Priority Diseases Blueprint List.

COVID-19 which is an official name for a respiratory infection caused by a 2019 new coronavirus started first in Wuhan, China and widely spread worldwide (Abumalloh et al., 2021b; Asadi et al., 2022; Kavanagh, 2020; Rupani et al., 2020; Wu et al., 2020; Zhu et al., 2020). According to World Health Organization (WHO), the new coronavirus or COVID-19 is a major global epidemic (Ahani and Nilashi, 2020; Nilashi et al., 2022a; Nilashi et al., 2022c; Nilashi et al., 2021d; Nilashi et al., 2021e; Zheng et al., 2020; Zibarzani et al., 2022). National and international spread of the disease has threatened people's lives all around the world since then (Abumalloh et al., 2021a; Nilashi et al., 2021a; Nilashi et al., 2021b; Nilashi et al., 2022b; Nilashi, Mehrbakhsh et al., 2020b; Nilashi et al., 2021f; Wu et al., 2020). COVID-19 infection has caused SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) (Prompetchara et al., 2020; Zheng et al., 2020). SARS-CoV-2 is a beta-coronavirus (Naveja et al., 2020).

Understanding COVID-19 nature along with clinical features will be essential in dealing with the outbreak of this virus (Hassan et al., 2020; Liu et al., 2020; Nilashi, Mebaksh et al., 2020; Nilashi, Mehrbakhsh et al., 2020c; Shereen et al., 2020; Taheri et al., 2021). As immune response of the patients with COVID-19 is found to be similar to the immune response of patients with other infection diseases such as MERS and SARS, the Complementary and Alternative Medicines (CAMs) which are potential sources of bioactive compounds with antimicrobial activity may be helpful in the prevention and treatment of COVID-19 virus infection. To understand how they may be beneficial to the new outbreak, it is important

to learn from previous similar infectious diseases prevention and treatment through the CAMs. It has been previously demonstrated that CAMs are beneficial in boosting immune response vs. diseases, especially infectious diseases (Chen et al., 2010). This paper investigates the role of curcumin, as an active component of the spice turmeric, in infectious diseases such as COVID-19. In addition, this paper discusses on the previous research on immune system, COVID-19 and CAMs provides some results from the WebMD data for the consumers' satisfaction of turmeric consumption. WebMD is a public and well-known Internet site that provides information and services on a variety of health-related issues for both medical professionals and patients (Blank et al., 2010; Buis and Carpenter, 2009; Introne and Goggins, 2015). The data analysis is performed using clustering, text mining and prediction techniques. The results are presented and discussed.

The reminder of this paper is organized as follows. In Section 2, an overview of CAMs is provided. In Section 3, the methodology of this research is provided. In Section 3, we provide the results of the data analysis. In Section 5, the discussions are provided. Finally, this work is concluded in Section 6.

2. Complementary and Alternative Medicine (CAM)

As medicines and health practice, CAMs are not part of mainstream medicine but through a variety of treatment approaches are used alongside conventional medical treatments. Recently, interest in CAM has grown much (Borm et al., 2020; Konakci et al., 2020; White, 2020). CAM modalities are widely used in many Western and Eastern nations (Barnes et al., 2008; Tan et al., 2004). Such growth has been linked to lower prices of CAMs, immediate care in relation to the traditional medicine, improved health and quality of life, fewer side effects of cure and/or disease recovery (Ameade et al., 2015; Bakker et al., 2020). It has been shown that the use of CAM can produce mental health and physical benefits and have a major impact on the quality of life (Medeiros et al., 2019). The recent study by (Dehghan et al., 2020) reveals that there is a significant relationship between CAMs usage and quality of life in patients under hemodialysis.

A study by (Pfalzgraf et al., 2020) shows that approximately 66% of the fibromyalgia patients have used complementary and alternative therapies such as massage therapy, vitamins, and meditation. The use of CAMs in children with atopic eczema was examined by (Kaitian et al., 2020). The results through a cross-sectional survey conducted at a tertiary care centre reveal that nearly half of all parents used complementary and alternative medicine for their child's atopic eczema in the past 12 months and atopic eczema severity from parental perspective was a major predictor of complementary and alternative medicine use. The study by (Erdem et al., 2020) showed the importance of CAM among Turkish pediatric oncology patients. The importance of CAMs among women with breast cancer in Saudi Arabia was found by (Alsharif and Mazanec, 2019). (Orhan et al., 2003) investigated the CAM use in a group of Turkish children with asthma and found that significantly high percentage of the study' respondents have aimed to use CAM for their child's asthma in the future. (Chiru et al., 2020) also found that medicinal plants have been effective in the treatment of the common cold and influenza in Moldova and Romania. The study by (Guo et al., 2007) provide a compressive investigation on the use of CAMs for preventing or treating influenza or influenza-like illness. (Nilashi, Mehrbakhsh et al., 2020c) have further investigated the role of CAMs on infectious diseases. They investigated the beneficial role of CAMs in improving immune system function. From a comprehensive review on CAMs, they concluded that, as immune response of COVID-19 patients is found to be similar to the immune response of patients with MERS and SARS, those complementary and alternative medicines are potential sources of bioactive compounds with antimicrobial activity can be beneficial in the prevention and treatment of COVID-19 virus infection.

3. Method

Beside the analysis of previous studies on health benefits of turmeric, this study aims to investigate the health beneficial of turmeric from consumers' perspective. Accordingly, the consumers' reviews on this CAM from a health and medical website, WebMD, are collected and analyzed using machine learning techniques. For the aim of data analysis, this study develops a new method using text mining, clustering and prediction machine learning techniques. We use Self-Organizing Map (Kohonen, 2001) for data clustering (Nilashi, Mehrbakhsh et al., 2020a; Nilashi et al., 2021c; Nilashi et al., 2017; Nilashi et al., 2014a), Latent Dirichlet Allocation (Blei et al., 2003) for text mining (Ahani et al., 2021; Nilashi et al., 2022d; Nilashi et al., 2022e; Nilashi et al., 2021g) and Deep Neural Networks (Hinton and Salakhutdinov, 2006) for prediction tasks. These approaches are introduced in the following sections. The methodology is presented in Fig. 1. As seen from Fig. 1, the data collection is performed from WebMD for consumers' reviews on turmeric. The data is in the forms of numerical reviews and textual reviews. After data pre-processing, the textual data is analyzed using LDA. Then both data are used in SOM for data clustering. Every cluster in SOM is then used in DNN to construct the prediction models. The prediction models are then used to predict the consumers' satisfaction level.

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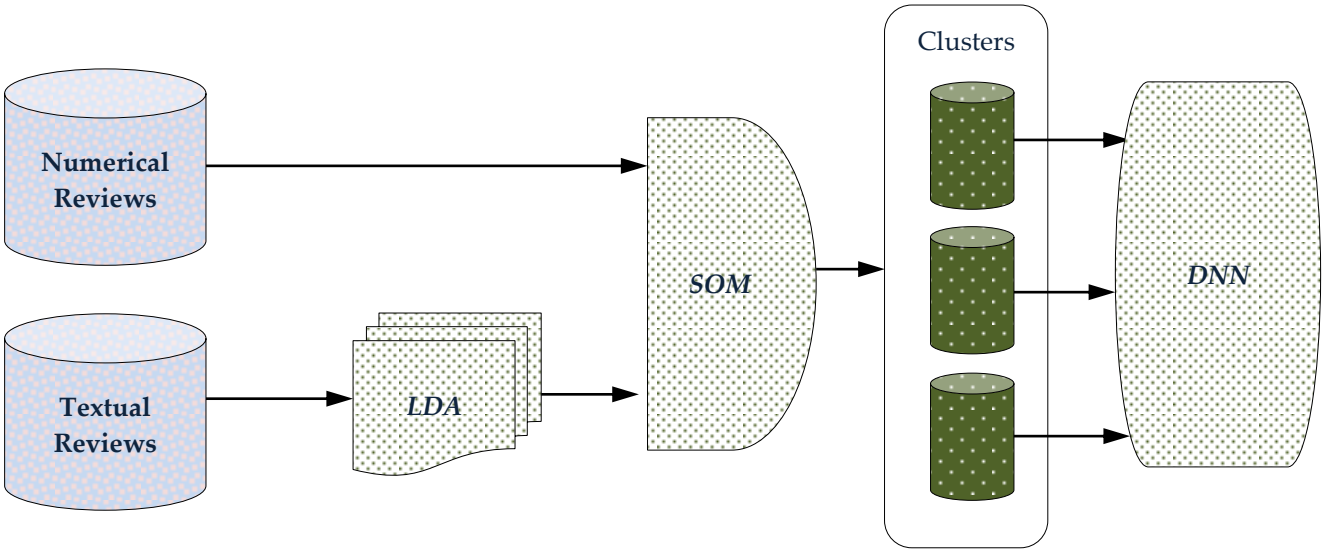

Fig. 1. Research method

4. Results

44.1 Data Analysis

The data is crawled from WebMD which is a platform to share the news and information pertaining to human health and well-being. This website provides the information on the diseases, drugs and supplements (Connelly et al., 2018; Hoover et al., 2016; Udayanga et al., 2020). In addition, the consumers are able to provide their experience on the use of these drugs and supplements in two forms, textual reviews and numerical reviews. The consumers evaluate the drugs and supplements from three perspectives, effectiveness, satisfaction and ease of use (Ru, 2018; Ru et al., 2015). Totally, 398 records were crawled from WebMD. The findings from data analysis show that the majority of consumers are female (52.3%). In this study, SOM clustering is used for data segmentation. Three clusters were retrieved from the data through SOM3 × 1. The results for three clusters are presented in Fig. 2. It is found that the majority of consumers in first, second and third segments have used turmeric for less than 1 month and 1 to 6 months. In the first segment, the majority of consumers have been female. In addition, the consumers with the age of 55-64 and 65-74 have been more in the first and second segments.

Regarding the assessment criteria, as shown in Table 1, consumer' satisfaction, ease of use and effectiveness of turmeric have been high in the first segment. In the second segment, it is found that the satisfaction level is relatively high, but the majority of consumers are not satisfied with the use of turmeric. Overall, from this result is can be concluded that the majority of consumers is satisfied with the use of turmeric and found it effective as an alternative and complementary medicine for health issues. In Fig. 3, the main reasons for taking turmeric in each segment are presented. It is found that in all segments, turmeric has been beneficial for arthritis, general health and well-being, joint pain, pain and diabetes. In addition, general health and well-being is one of the main reasons for consuming turmeric in all segments.

Table 1. Results for consumer' satisfaction, ease of use and effectiveness of turmeric

Assessment Criteria	Assessment Levels	Segment 1	Segment 2	Segment 3
Effectiveness	High	242	46	2
	Moderate	0	49	3
	Low	0	24	32
Ease of Use	High	242	87	0
	Moderate	0	31	8
	Low	0	1	29
Satisfaction	High	240	57	2
	Moderate	1	28	3
	Low	1	34	32

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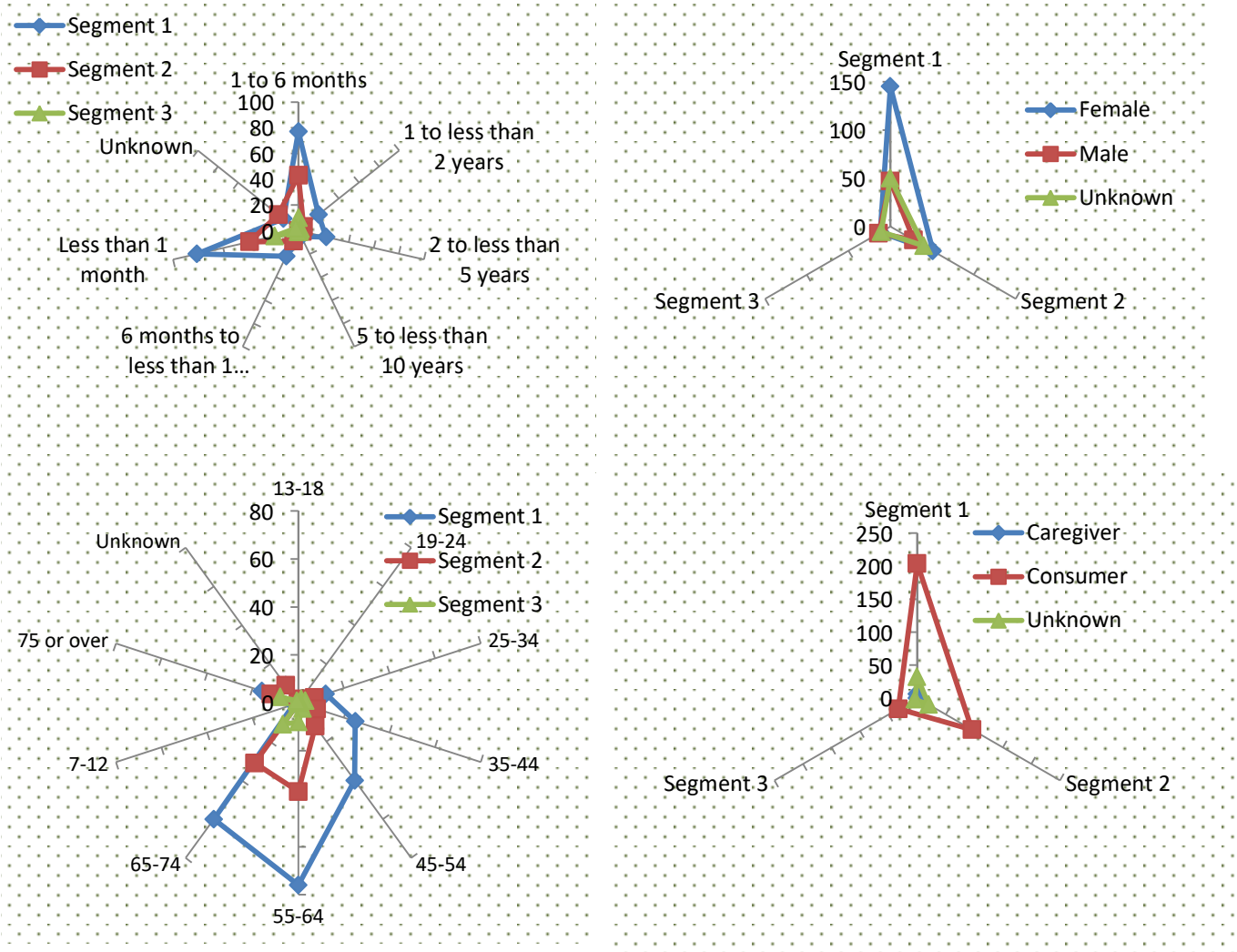

Fig. 2. Consumers' demographic results in each segment

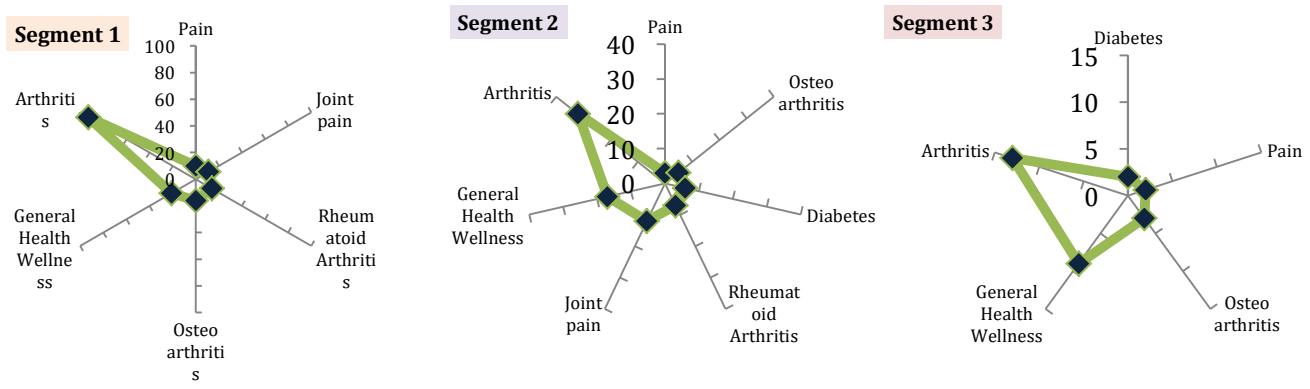

Fig. 3. Results for reason for taking turmeric in each segment

4.2. Evaluation Metrics

We use precision, recall and F-measure (Bagherifard et al., 2017; Nilashi et al., 2014a, b; Nilashi et al., 2015; Nilashi et al., 2018) to assess the accuracy prediction of the proposed method. The confusion matrix is used for the calculation of AUC-ROC as well as AUC-PR. AUC-ROC indicates the area under the curve for the sensitivity. In Eq. (1), the F-measure formula is presented as a weighted harmonic mean recall and precision. In this equation, $\beta=1$ is considered for the F1 score.

An International Journal JSCDSS E-ISSN: 2289-8603

$$F = \frac{1}{\frac{\beta^2}{1+\beta^2} \times \frac{1}{Precision} + \frac{1}{1+\beta^2} \times \frac{1}{Recall}} = \frac{(1+\beta^2).Precision \times Recall}{\beta^2.Recall + Precision} \quad (1)$$

The method was implemented in Matlab software. We used Softmax as an activation function in DNN. The method was trained and the optimal architecture for DNN was determined after several repeated experiments. The results showed that the average DNN' classification accuracy by the use of ReLU for test dataset was about 96.2%. The result was also compared with the other classifiers. All methods were trained for 100 trials. We selected Support Vector Machine (SVM) (Vapnik, 1995), Naïve Bayes (NB) (McCallum and Nigam, 1998) and Neural Network (Horiguchi and Ishioka, 2001). In Support Vector Machine, Radial Basis Function (RBF) was considered as a kernel function. The results of method comparisons are presented in Fig. 4.

The results show that DNN (F1=0.91; AUC=0.96; Accuracy=0.958) provides better results compared to the NB (F1=0.86; AUC=0.93; Accuracy=0.891), SVM (F1=0.84; AUC=0.92; Accuracy=0.852) and NN (F1=0.81; AUC=0.91; Accuracy=0.81). The results also show that Naïve Bayes also provide good accuracy which compared to SVM and NN which can suggest its ensemble learning with DNN for further accuracy improvements.

5. Discussion

Immune response is widely investigated in patients with COVID-19 (Ahmadpoor and Rostaing, 2020; Nilashi, Mehrbakhsh et al., 2020c; Prompetchara et al., 2020; Qin et al., 2020; Tufan et al., 2020). Through ACE2 (Angiotensin-Converting Enzyme 2) receptors, SARS-CoV-2 infects host cells which lead to COVID-19 related pneumonia (Shi et al., 2020; Zheng et al., 2020). It is found that an immune response of COVID-19 patients may be similar to the immune response of patients with MERS and SARS (Nilashi, Mehrbakhsh et al., 2020c; Prompetchara et al., 2020). The previous research shows that the SARS-CoV-2 infection produces immune responses clinically in two main stages. A specific immune response is necessary to prevent the virus and preclude the disease progression to severe stages during incubation and non-severe stages (Shi et al., 2020). Accordingly, strategies such as anti-sera or pegylated IFNα for enhancing immune responses at this stage are definitely important (Shi et al., 2020).

The use of CAMs is growing in the general population (Nilashi, Mehrbakhsh et al., 2020c; Sinha and Efron, 2005; Skouteris et al., 2008). For many years, CAM treatments have mainly been used for general well-being or particular illnesses along with standard medical treatments (Dehghan et al., 2020; Kaitian et al., 2020; Park et al., 2020). As a CAM, curcumin is a hydrophobic polyphenol and an active component of the spice turmeric (Ohno et al., 2017) in enolic and keto forms (Manolova et al., 2014; Zheng et al., 2018). This CAM has demonstrated to be effective in preventing or treating diseases such as viral infections (Mounce et al., 2017; Shome et al., 2016). It has gained much attention due to its antitumor, anticarcinogenic, anti-inflammatory (Morita et al., 2010), antibacterial, antioxidant properties, anti HIV, and nematocidal activities (Araujo and Leon, 2001; Kuttan et al., 1985). To date, numerous studies for different biological activities of powder and crude turmeric extracts have been performed. Antimycobacterial activity of turmeric has been approved in the previous research. Curcumin has immune-enhancing properties (Kuttan et al., 1987; Nagabhushan and Bhide, 1992). In addition, curcumin antiviral activity against a variety of viruses has been observed, including Zika virus, Chikungunya virus, hepatitis viruses, human papillomavirus, human immunodeficiency virus, herpes simplex virus-2 as well as respiratory influenza virus (Praditya et al., 2019).

In a study by (Abdel-Tawwab and Abbass, 2017), the authors evaluated the effect of turmeric powder on the innate immunity of common carp. The results of their study showed that turmeric powder supplementation is a promising immunostimulant. They found that, turmeric powder can improve fish performance and innate immunity. (Boonjaraspinyo et al., 2011) found that the properties of curcumin are antioxidant and anti-inflammation. The study by (Amalraj et al., 2017) on the biological activities of curcuminoids, the authors comprehensively reviewed the previous works and concluded that curcuminoids have extensive biological activity as an antioxidant, anti-inflammatory, neuroprotective, antitumor, arthritis, radioprotective and anti-acidogenic. The study by (Gupta et al., 2020), the authors investigated potential use of turmeric in COVID-19. They concluded that turmeric has a promising efficacy against influenza A viral infections. In addition, they suggested well-defined randomized studies for the evaluation of turmeric derivatives efficacy against SARS-CoV-2. From investigating previous studies, (Babaei et al., 2020) concluded that curcumin may have a potential role to treat COVID-19. The study conducted by (Shankhdhar et al., 2020) revealed the effectiveness of curcumin for psychological well-being and boosting immunity.

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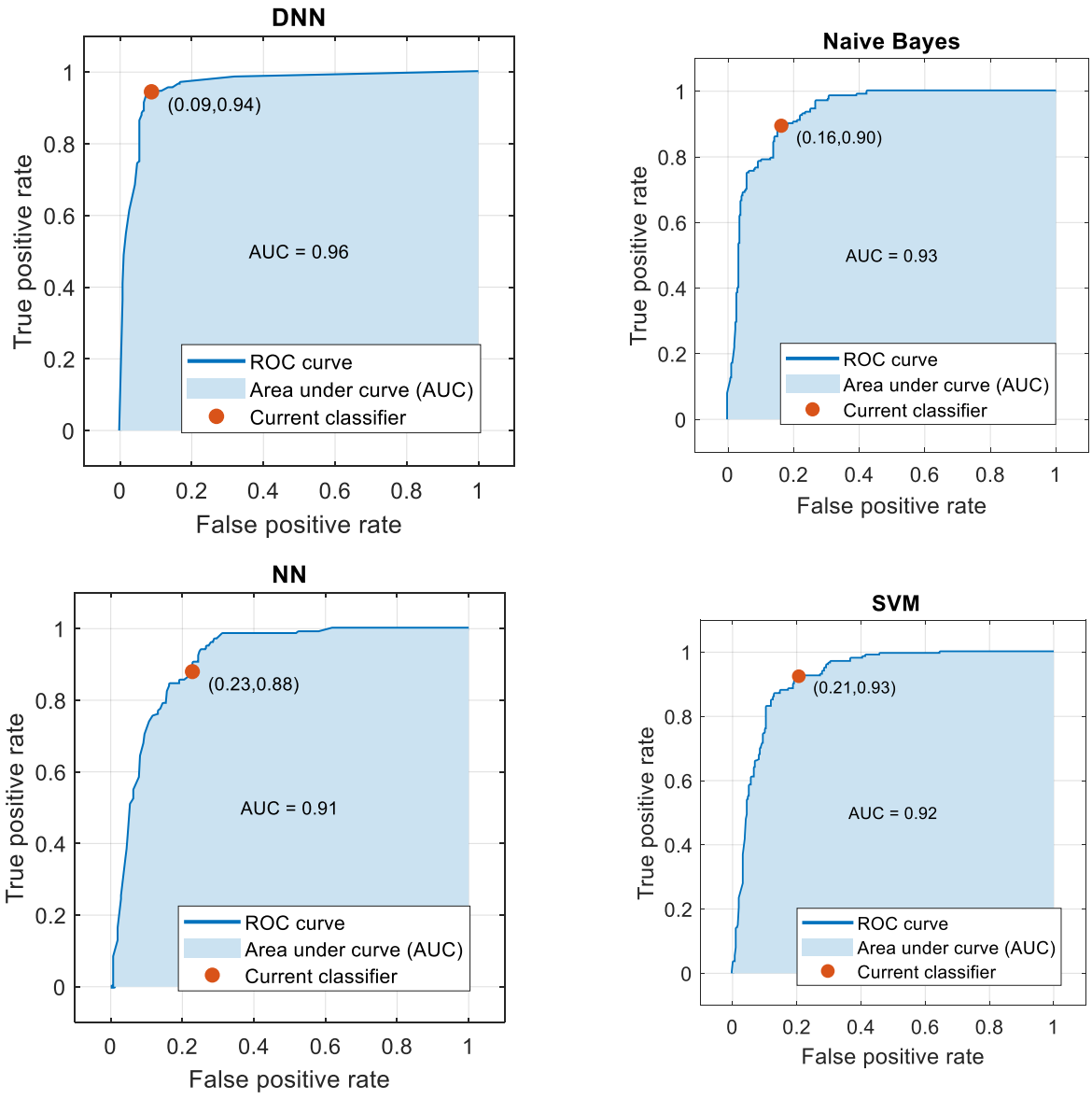

Fig. 4. The ROC results of the methods

In the recent study on the COVID-19 depression with immunity booster, (Soni et al., 2020b) suggested from the previous studies that nutraceuticals like curcumin can be a promising option as immunity boosters and antidepressants for pyschoneuroimmune response. Curcumin has also been effective in hindering SARS-coronavirus replication (Wen et al., 2007). According to (Lu et al., 2020) cited by (Soni et al., 2020a), the effectiveness of curcumin against COVID-19 can be due to the genomic similarity of severe acute respiratory syndrome coronavirus 2 with SARS-coronavirus (>80%) and MERS-CoV. According to (Soni et al., 2020a), the experimental results from previous research show the potential of curcumin in the prophylactic management as well as the therapeutic of respiratory infections and pathophysiology. This recommends the curcumin implementation in COVID-19 (Soni et al., 2020a).

6. Conclusion

The use of CAMs is growing in the general population. As a CAM, curcumin is a hydrophobic polyphenol and an active component of the spice turmeric. The effectiveness of turmeric has been extensively investigated in the context of boosting immune response to infectious diseases. This paper investigated the role of curcumin in infectious diseases such as COVID-19. The previous studies on this context were explored and their results were provided. In addition, this paper also provided some results from the WebMD data for the consumers' satisfaction of taking turmeric. We performed the data analysis using clustering, text mining and prediction techniques. Two types of data, numerical reviews and textual reviews, were considered for consumers' satisfaction in taking turmeric. The textual reviews were analyzed through a text mining approach,

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Latent Dirichlet Allocation. SOM clustering was used for the data clustering. Deep Neural Networks was used to finally predict the satisfaction level of consumers in taking turmeric. The outcome of this paper through literature reviews demonstrated the health benefits of turmeric and its effectiveness in immune system enhancement and protection against infectious diseases. The immune system has an important protective role against most infectious diseases like SARS-CoV-2, according to previous research. The discussion on the previous works on the antimicrobial activity of turmeric shows that improving immune system function through curcumin is possible and this directly impacts on the management of infectious diseases such as COVID-19. In addition, from data analysis, it was found that the consumers use turmeric for different health issues, specially the majority have used it for general health and well-being. The results show that the majority of consumers find turmeric as a useful CAM in improving their general health and well-being. Overall, the advantages of turmeric to infectious disease in the early stage of infection for prevention and treatment need additional evaluation. Nevertheless, because some clinical studies show turmeric effectiveness in infectious disease prevention and treatment, further clinical and consumer analysis should be conducted to reach robust conclusion on the benefit of turmeric beneficial for COVID-19 treatment. In addition, further studies are needed to show improvement in COVID-19' clinical symptoms such as fever, dyspnea, cough, expectoration, and myalgia or fatigue as a result of taking turmeric.

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