Digital Agriculture Food and Wine

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Digital Agriculture, Food, and Wine deals with the implementation and integration of digital data, sensors, technology, and tools on agricultural applications from the farm to consumers. These technologies can range from big data, sensor technology, sensor networks, remote sensing, robotics, unmanned aerial vehicles (UAV). Data processing is performed using new and emerging technologies, such as computer vision, machine learning, and artificial intelligence, among others. The latest advances made by the Digital Agriculture Food and Wine Sciences group (DAFW) from The University of Melbourne deals with crop monitoring/decision making, assessment of quality of produces, non-invasive sensory analysis for consumer perception assessment, and animal stress and welfare assessments.

Artificial intelligence | Food Science | Vineyard of the Future | Robotics | Machine learning

1. Introduction

The increasing demand from consumers for more premium/high-quality food and beverages, and the fact that the traditional methods to assess these products tend to be time-consuming, not affordable especially for small producers and, in some cases, their need for large laboratory space, raise the need for the development of novel techniques based on emerging technologies to ease the assessment of food and beverage quality traits from farm to consumers. The application of emerging technologies related to artificial intelligence has shown to be effective in the reliable, cost-effective, and rapid prediction of the most critical quality traits to offer products that may satisfy consumers needs.

2. Datas

Traditional methods to assess different quality traits in food and beverages from farm/vineyard to palate such as physicochemical parameters, sensory profile, and consumer acceptability tend to be costly with equipment that requires large space and special installation as well as specialized personnel to operate it. Hence, the results are not readily available to producers, which hinders the ability for near real-time decision making for the management of crops, raw material, or processing methods to improve the quality of final products [1][2][3].

For the viticulture and winemaking industries, despite keeping records from past vintages and accumulating data from operations and management practices plus physicochemical parameters and sensory descriptors of berries and wines [4], there have been minimal attempts to analyze these records using emerging technologies such as data mining and machine learning [5]. The majority of recent studies have focused on the use of robotic platforms

and unmanned aerial and terrestrial vehicles to acquire remote sensing data to gather information to be used for decision-making related to irrigation scheduling, pest, and disease detection or yield estimation, among others [6][7][8][9][10]. Examples of some studies on wine are the implementation of machine learning modeling in a vineyard from vertical vintages and weather and water balance data to obtain aroma profiles and physicochemical parameters [11] and sensory profile according to changes in seasonality, showing that quality traits from wines can be characterized and modeled [5]. Near-infrared spectroscopy has been used to measure berries and used to develop machine learning models to predict berry cell dead and living tissue as well as sensory descriptors of the final product (wine) [12].

At the farm level, in the animal industry, emerging technologies such as machine learning have been implemented in a robotic dairy farm, by analyzing and modeling data from four years of weather parameters including temperature-humidity index to assess milk productivity/yield and quality traits such as fat and protein content [13].

In the brewing industry, the quality of beers produced in every batch is usually assessed using traditional techniques that provide results days or even weeks later, and by a master brewer tasting the product and confirming if it has the same sensory characteristics as usual [14][15][2][16]. However, this is not efficient and does not provide reliable, objective, and accurate results. Therefore, artificial intelligence techniques have been developed to assess beer quality within minutes by using an electronic nose to detect volatile compounds translated into aromas using machine learning, in any stage of the brewing process [3], and an automatic robotic pourer, RoboBEER (The University of Melbourne, Parkville, Vic, Australia), coupled with computer vision analysis to assess color and foam-related parameters in bottles beers [17]. Data obtained from the latter has been used to develop machine learning models to predict the type of fermentation [17], sensory profile [15], physicochemical parameters, aromas [18], consumers acceptability [19], and proteins [20] of the final product.

Other emerging technologies such as the use of remote/non-invasive biometrics to acquire more information from consumers by assessing physiological and emotional responses when evaluating the acceptability of food and beverages have been developed along with a Bio-Sensory Application (The University of Melbourne, Parkville, Vic, Australia) to display the sensory questionnaire and record videos to capture the consumers responses, which are then analyzed using computer vision algorithms [21][22]. These techniques have been applied to assess different products, such as beer [14][23], chocolate [24], labels [25], and insect-based snacks [26]. Similar techniques to assess physiological responses have been adapted to assess any signs related to stress that may be associated with the end products (i.e., milk, meat).

3. Applications

Emerging technologies based on artificial intelligence can be applied to any field. In the food and beverage industry, techniques based on robotics, sensors, supervised machine learning modeling, and computer vision have been applied [2].

Specifically, in viticulture and enology, these technologies have been developed to aid in the assessment and prediction of wine quality traits to satisfy consumers demands. Among the approaches that have been developed to assess or predict wine, quality is the construction of artificial neural network models using weather and water balance data until harvest to predict the wine aroma profile, physicochemical components [11], sensory profile, and color with high accuracy [5]. Furthermore, near-infrared (NIR) spectroscopy data from berries has been used to predict berry cell dead and living tissue, and sensory profile of wines [12]. NIR has also been used to develop models to predict smoke contamination in berries and wine. On the other hand, an electronic nose has been developed to detect smoke taint in berries and wines and predict specific glycoconjugates related to smoke [27].

These modeling techniques have also been applied i) to assess aroma profiles in cocoa plantations based on aerial photogrammetry, canopy architecture and machine learning [28]; ii) to assess big data related to environmental factors affecting dairy cow stress and milk productivity and quality [13]; iii) use of remote sensing and machine learning to assess crop water status [6]; iv) use of robotics and remote sensing to assess the intensity of beer sensory descriptors [15], consumers acceptability [19], type of fermentation [17], proteins [20] and other physicochemical parameters [18], v) use of biometrics (physiological and emotional responses) from consumers to assess acceptability of beer [14][23], and insect-based snacks [29], vi) use of a portable electronic nose coupled with machine learning to assess aromas in beer [3], and vii) use of near infra-red spectroscopy and machine learning to assess physicochemical parameters and sensory descriptors of beer [18][30], and physicochemical parameters in chocolate [31], among others.

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