IT SUPPORT FOR EXPLORING SENSORY QUALITY OF SUSTAINABLY GROWN APPLE VARIETIES

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Abstract: Sustainable and environmentally-conscious fruit growing is a main concern in European agriculture. Using modern breeding technologies, several disease-resistant apple varieties have been developed in recent years. These varieties can be grown with low pesticide use, which means not only sustainable fruit growing, but lower production costs. Before these varieties are used in orchards, it is essential to explore the fruits' quality as pertains to sensory characteristics. Sensory quality involves all attributes percieved through the human senses. Sensory testing data might be influenced by the subjective character of the assessors taking part in the evaluation. However, several techniques are known which reduce bias to an acceptable level. Information Technology (IT) is a great help in designing and performing sensory tests in accordance to the relevant ISO standards. Our research team has developed a VBA software supporting sensory profile analysis of disease-resistant apple varieties [1,2]. This software can be used to explore and monitor the sensory quality of apples, from harvest through the length of the storage period. This system may be used for online testing (LAN) or with printed score sheets, if network solutions are not provided. The results of these tests are highly valuable, because each country has a different climate. Therefore, the same variety might have a different perceived quality in different countries. The feedback of these results, together with the results of our Internet-based questionnaires [3,4], can help fruit breeders to explore in more detail the sensory quality of apples grown in different regions of Europe.

1. Introduction

Sustainable agriculture is a feasible way of providing the population with nutritional resources while preserving the natural state of our environment. Several European agricultural sectors suffer from overproduction (especially in the European Union), and this problem led researchers and growers to search for adequate solutions. In a narrowing market – as in the case of apple – the regulatory system should prefer and support those production strategies which show the most value. Throughout the process of apple production, the critical point concerning the environment is pest management. This concern also influences the economic indices of apple growing, since pesticides constitute a relatively large part of the total production costs. Modern breeding technologies have provided several so-called 'resistant' apple varieties. The term 'resistant' refers to genetic resistance against several plant diseases. This genetic resistance is usually transferred from the genome of wild apple species. The fruit of the wild apple species are not only resistant to disease, and their fruit quality is poorer than that of cultivated trees. These natural conditions usually result in somewhat lower fruit quality in the resistant apple varieties. However, research studies have shown that resistant varieties are still suitable for canning and fresh consumption. To assess the market potential of such varieties, it is essential to explore their sensory quality. Information Technology has a huge impact on sensory testing, since it provides effective and fast methods for almost every part of the testing process.

2. Sensory testing

Sensory testing is a relatively new, emerging field of research. Sensory quality is an important part of product potential. Since sensory quality is perceived by human assessors, its subjective character cannot be totally eliminated. However, several testing techniques can be applied to improve the reliability of sensory data.

Basically, there are two types of sensory testing regarding the assessors involved:

- *Consumer tests:* untrained (naïve) assessors take part in the test. The number of respondents is preferably high, to ensure a given market representative results. The test procedure should be easy and transparent, since most consumers have no experience in such testing. The number of samples (in our case apple varieties) should be limited, as long tests involving many samples usually do not provide reliable data. The target of consumer tests is primarily preference. The respondents give a hedonic evaluation, based on overall impression.
- *Laboratory tests:* trained assessors and/or experts are needed (preferably a product specific panel). The reliability of these methods is based on the training of the assessors. Tests take place in a specially designed sensory laboratory (ISO). The test structure is much more detailed than in the case of consumer research. The number of samples might be higher, but it should still be reasonable, since several sensory properties are evaluated during the tests. The target of such evaluations is a detailed sensory description of the samples.

Both these approaches are necessary to completely explore the sensory quality of an apple variety. The consumer tests refer to the degree of satisfaction. Such tests are essential when introducing a variety to a new market. Several conclusions might be drawn from previous experience on foreign markets, but consumer preference usually varies to a great extent from market to market.

Descriptive tests are more replicable over different panels (countries). If the applied descriptive terminology is standardized, then differences in the results between regions or countries will refer mainly to the differences among the samples. The same apple variety grown in Germany and Hungary is very likely to have differences in its sensory character.

3. Sensory testing and Information Technology

Designing and implementing sensory tests can be effectively aided by the application of IT tools. Depending on available resources, different levels of computerization are possible:

1. *Basic level:* the test design and questionnaires are created on a single PC. Sheets and sample codes are printed. Test is implemented on hardcopy forms. Data collection is performed by the means of manual coding and data input.
2. *Intermediate level:* Test is designed and implemented, as above. Data input is computerized with the application of OCR (Optical Character Recognition) technology. Special software is needed for the design of the test sheets. Not all types of data can be processed (e.g., handwriting might cause problems). Precision printing and copying are essential. High performance scanner with ADF (Automatic Document Feeder) is necessary.

3. *High level:* Test design and questionnaires are designed on the panel leader's PC. The questionnaire files are copied to the computers in the sensory booths. Test is performed with the electronic forms. Data collection is real time through the network. Data analysis is fast and convenient. Full computerization of the sensory lab is needed (PC to every booth + LAN).

In some cases, the highest level of computerization is either not always feasible, or it can be implemented only through very large investments. Consumer tests involving hundreds of respondents are usually performed on paper ballots. There are mobile solutions for this purpose (e.g., palmtop, PDA, tablet/touch screen-based computers) but their application in Hungary is not typical.

The efficiency of test design and test implementation depends considerably on the specialization of the software. The more specific the software, the easier the testing is. Usually, this means higher development costs as well. Such specialized software systems are sold in a moderate number of copies, so their prices are relatively high. This was one of the motivating factors for our developing a new software system tailor-made to the objectives of our research [2].

4. Sensory testing of resistant apple varieties

Apple is the most important fruit produced in Hungarian horticulture. In the past 15 years, many changes took place in the structure of apple growing. Large orchards were usually split into smaller parts, with the owner no longer the state, but private smallholders. The formerly largest markets of Hungarian apple (parts of the former the Soviet Union) practically no longer exist. New orchard establishments are relatively rare, due to high investment costs.

Among the circumstances mentioned above, several factors should be considered before introducing a new variety to the Hungarian market. In Eastern Hungary (one of the main apple growing regions), a new apple growing structure began to form under the investment of Wink B. Ltd. Several resistant apple varieties were brought from Germany, where these varieties are grown for the canning industry. Due to climatic differences between Eastern Hungary and Germany, initial experiences showed better parameters during laboratory measurement of processed apples. These results initiated the evaluation of the market potential of the varieties.

We applied both consumer tests and sensory laboratory tests. Since software development is connected to the lab tests, these will be explained in more detail. During the laboratory tests, descriptive sensory profiling was applied. Several versions of this approach are known, in this present research we used a special version of profile analysis: Q.D.A. Quantitative Descriptive Analysis provides a detailed sensory description of the apple varieties tested. The method consists of 3 main steps:

Step #1: Generating the terminology of descriptors: The assessors are introduced with the samples to be tested. They define those sensory attributes, which are the most characteristic to the samples. Each sensory attribute has to be clearly defined and understood by all panel members. The panel leader helps to manage the process of generating the terminology. Once a sensory attribute is defined, the panel chooses an evaluation method (e.g., unstructured scale, category scale).

Step #2: Implementing the test: During Step #1, the panel leader creates the structure of the score sheet on the basis of the panel's decisions. Once consensus has been reached among panel members, the panel leader customizes the score sheets according to the test design. Sample codes and a presentation order are generated for each assessor, to provide a balanced test environment. Assessors work separately in the sensory booths. The personalized score sheets are copied to the booth PC's. Panellists evaluate the samples according the defined terminology.

Step #3: Evaluating the data: After score sheets have been filled out, they are first checked for missing data in the presence of the panellists. In the case of any missing data, the assessor can complete the evaluation. Once all sheets are confirmed, the panel leader adds them to the parent directory. Data analysis protocols begin to explore differences among the tested samples. Statistical evaluation can be performed with built-in modules or sheets can be exported to several statistical applications.

5. Main features of the software created

Our VBA software consists of 5 modules, 6 userforms, and works on 4 Excel worksheets, as shown in Fig.1. Among the modules, those marked a1, a2, and a3 create the score sheets for the assessors, including the protection of the cells, which should remain unchanged during the sensory testing procedure. The subroutines of these modules call up the forms, and they fill out the first two worksheets (Basic_data and Scoresheet). The b1 and b2 marked modules supervise the data collection from the filled out scoresheet-files, make statistical evaluation in the third worksheet (Stat_eval) and create the diagrams in the fourth worksheet.

The application of the software we show in the next section, on a real apple profile analysis. In the first step of profile analysis, the assessors decide which attributes should remain in the final evaluation system. The discussion is supervised and assisted by the panel leader. For each sensory attribute, the group has to choose an evaluating method (e.g. unstructured scale, category scale, descriptive evaluation). Our software makes it easy to choose the evaluating method and specify the further details (Fig 2-5.). In this step, the screen can be projected to help the work of the group.

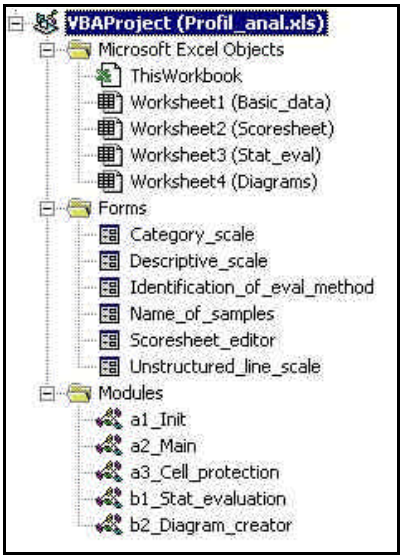

Fig. 1.: Main parts of the profile analysis supporting VBA software

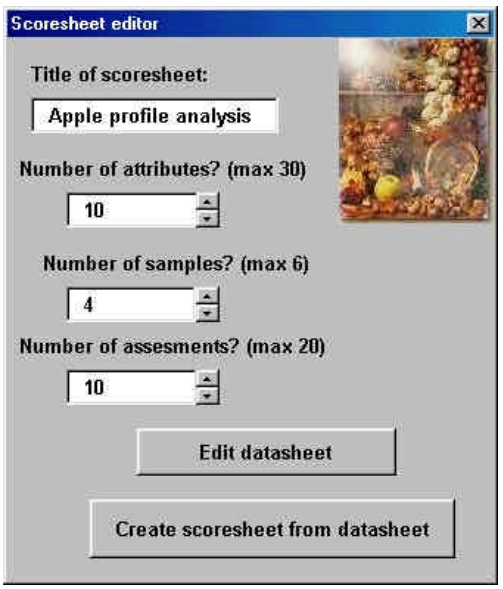

Fig.2: The Scoresheet editor

Using the Scoresheet editor form (Fig. 2.), the assessors specify the title of the score sheet, and the number of attributes, samples and assessments.

Each attribute has a sequence number and a code corresponding to type (evaluation method). On Figs 3-4, we show how to set up the evaluation method and scales. As an example, in the case of an unstructured line scale we specify attribute's name, give the legends at the start and at the end of the scrollbar belonging to the unstructured line.

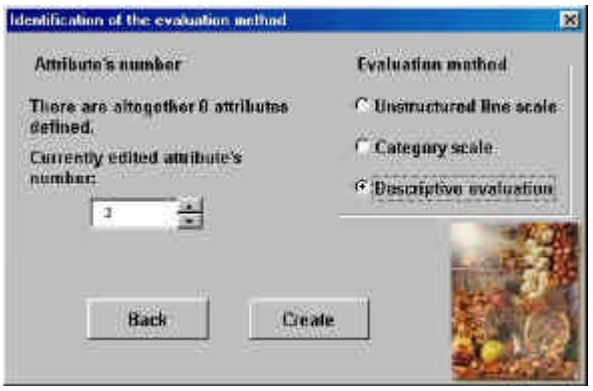

Fig. 3: Setting the evaluation method

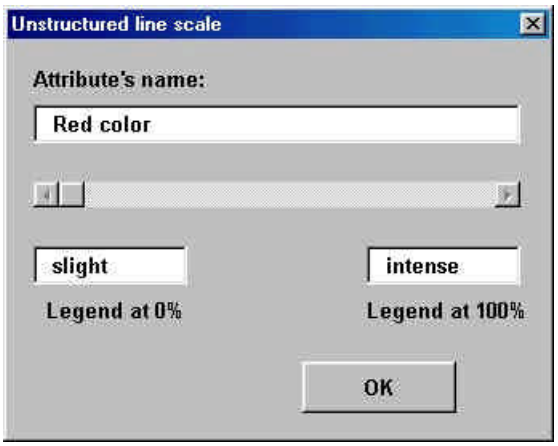

Fig. 4: Unstructured line scale

When all the attributes are defined and the evaluation methods are specified, the software asks to type in the name of the samples (varieties) into a form, and thereafter creates a block design for the presentation sequence of the samples. A randomly generated, three digit number code is also assigned to each sample (Fig. 5.). These techniques are essential to avoid psychological faults during testing.

By choosing 'Create score sheet from datasheet' (see Fig. 1.), the software creates the score sheets for each assessor. Then the score sheets are copied to the PCs in the sensory booths, and the assessor is ready to test (Fig. 6.).

When the testing session is finished, the data are collected from each PCs. The online filling of the questionnaires means, that the time consuming data input from paper based questionnaires can be skipped. By the VBA macros of the module b1_Stat_evauationl (see Fig.1) the individual data are collected in one worksheet (Stat_eval), and statistical analysis takes place. Every attribute is analysed for significant differences, and for the better understanding, the results are represented in diagrams (Figs. 7 and 8.).

Sample's name	Idared	Jonathan	Topred	Golden				
sample ID	A	B	C	D	3-digit samplecodes			
1	B	A	D	C	584	182	356	289
2	C	D	A	B	351	217	675	967
3	D	C	B	A	396	934	167	342
4	A	B	D	C	609	307	861	796
5	B	A	C	D	219	829	718	492

Fig. 5: Creating the test design automatically

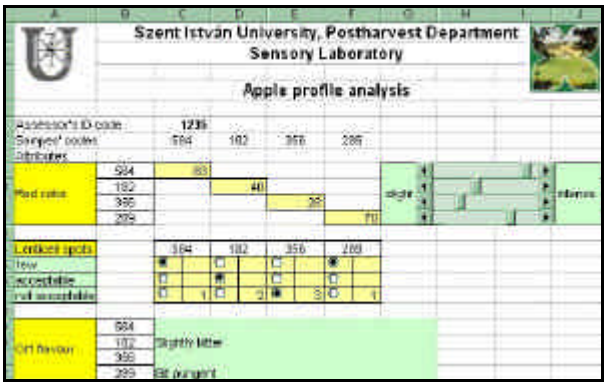

Fig. 6: Filling out the score sheets

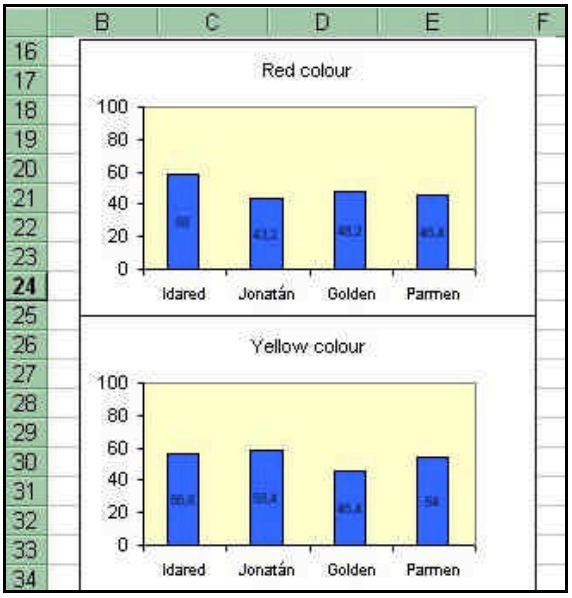

Fig. 7: Graphical presentation of the results, according to the properties

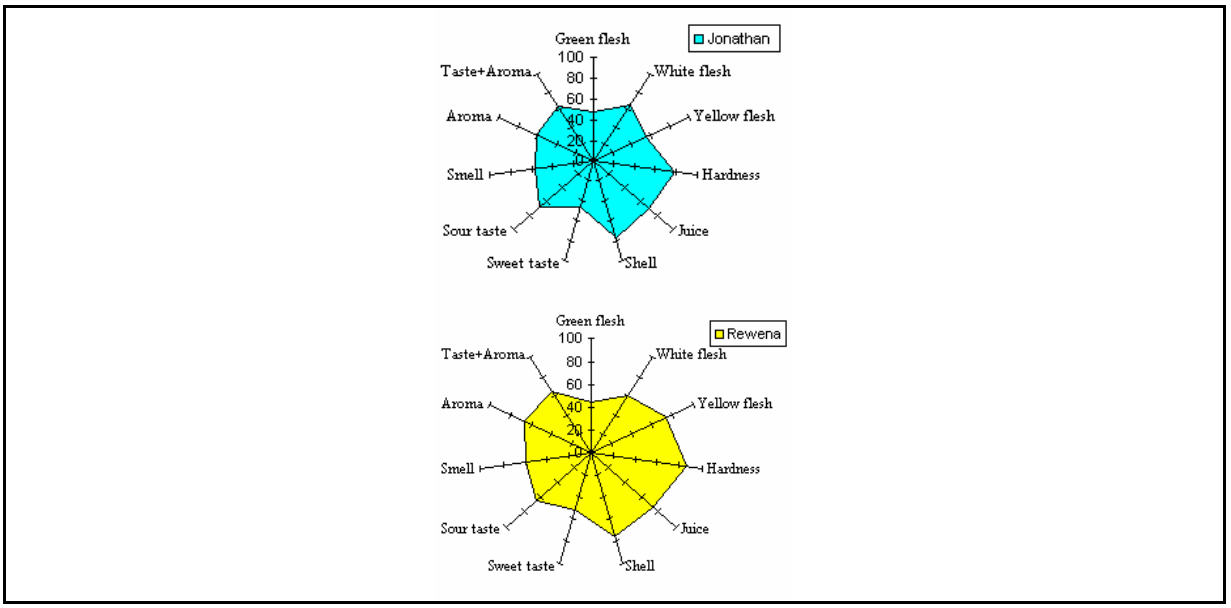

Fig. 8: Comparison of apples' sensory profiles

Jonathan (top) and Rewena (below)

6. Internet based questionnaires

To measure the demographic patterns and customer attitude towards the new apple varieties, an Internet-based questionnaire system is under development. The experiences of previous studies seems to show that the following structure is suitable for our objectives.

A CGI program is utilised for data acquisition from the questionnaires. The process of this type of data collection and evaluation is shown on Fig 9. and 10. Throughout the process, a QD file(questionnaire description) is generated from the Web-form. Since the QD file is generated from the HTML source, it is possible to collect not only electronic forms, but also hardcopy sheets, in a separated, but very similar file.

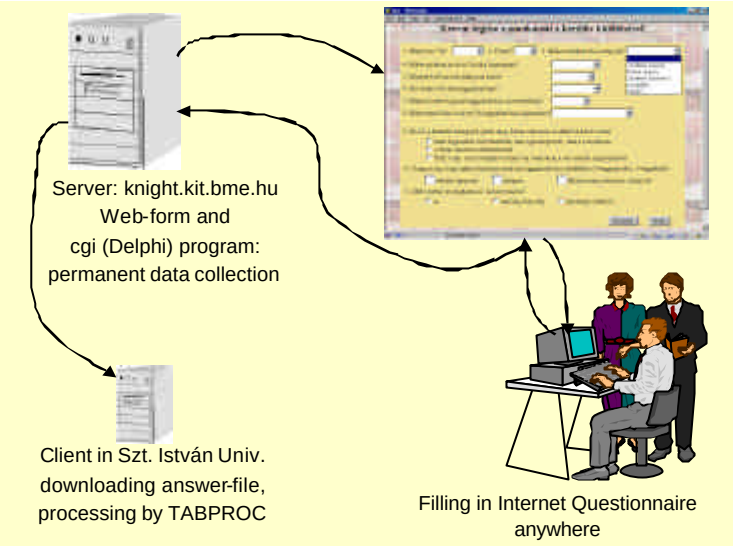

Fig 9. Internet data collection using CGI program

In 2002, after evaluating several online Internet-data questionnaires, we used our Web-forms and CGI program to process consumers' questionnaires about resistant apple varieties. The questionnaire included questions about the representativeness of the assessors, with respect to the Hungarian apple-consumers, too. On Fig. 11., we show the response patterns in 2 different regions of Hungary (Hortus Expo near Budapest, and Nyíregyháza, in Eastern Hungary).

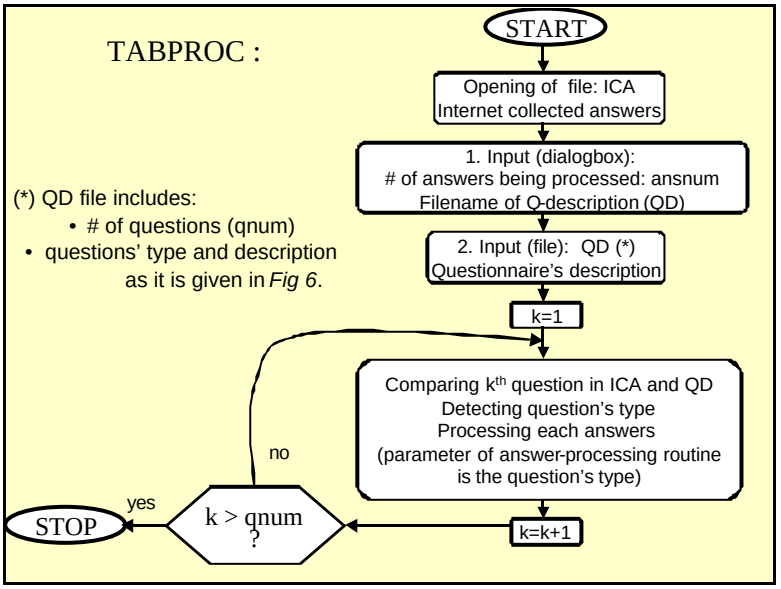

Fig 10. Steps of processing CGI program-collected answers

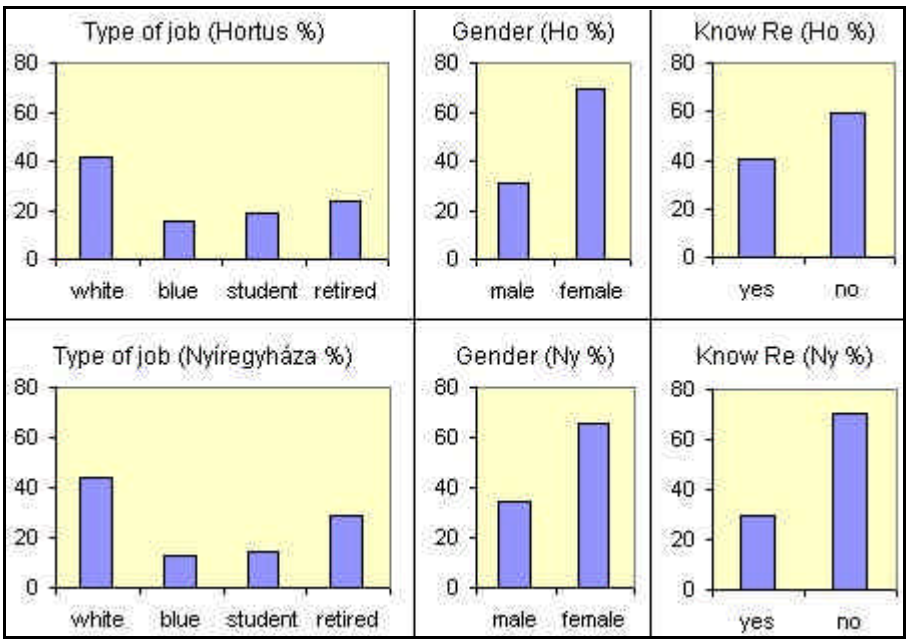

Fig.11. Results of Internet-based data processing consumer questionnaire of Re-apples

7. Discussion

Initial experiences with the VBA-based sensory analysis supporting software showed that the time demand of both the preparation and testing steps can be considerably reduced. Online forms mean no data input is necessary from paper-based questionnaires. Data analysis and report making is almost real time. In the future, we plan to develop similar software modules for other testing methods (difference testing, ranking and other descriptive methods). A database system managing the different data structures is also planned. The resistant apple varieties tested (Releika, Remo, Resi, Rewena and Reglindis) performed well, comparing to the control variety Jonathan M41.

The applied IT tools improved the efficiency of research concerning the market potential of the new varieties. The structure of the developed methodology will be tested in further studies in the coming years. These results can facilitate the more widespread growing of disease-resistant apple varieties. Thus, apple growers might meet both economical and ecological goals in the European market.

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