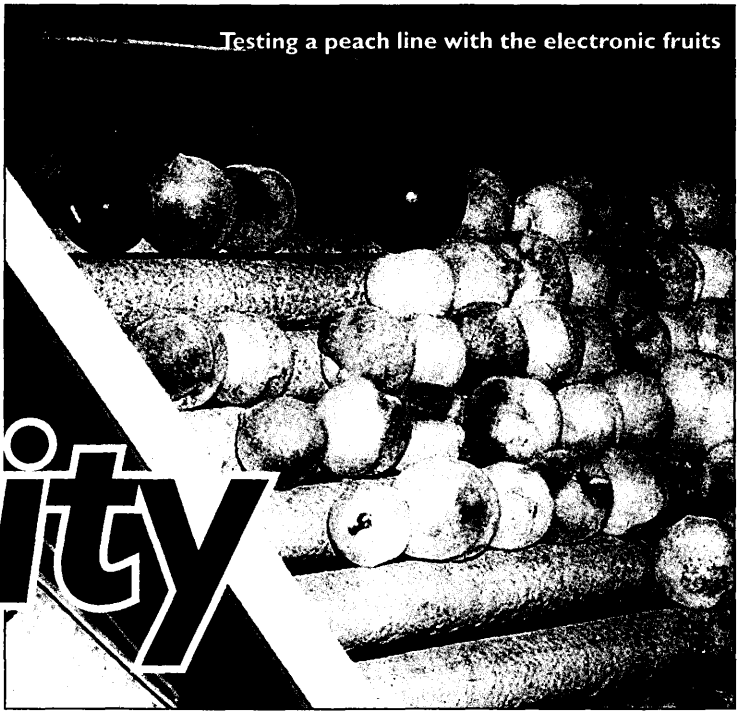
Consumers demand high quality fruit. But how do farmers, wholesalers and retailers assess quality non-destructively? A multi-national team of researchers believe that they can provide the answers.

Engineering research to improve fruit quality


Testing a peach line with the electronic fruits

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Participating on the European project for the past four years are six leading Agricultural Engineering organisations: *Polytechnical University Madrid (UP); Katholieke Universiteit Leuven (ULEU); Scottish Centre of Agricultural Engineering (SAC); Biotechnologisk Institute Kolding (BI); Silsoe Research Institute (SRI); and Centre National du Machinisme Agricole, du Genie Rural, des Eaux et des Forets (CEMAGREF).* The aim of the study is to improve the quality of fruit (apples, peaches, pears, and apricots) by:

- reducing losses due to damage susceptibility
- minimising damage incidence
- enhancing quality grading procedures
- monitoring surface appearance
- assessing internal quality non-destructively.

Detecting damage

Mechanical damage to fruits is mainly inflicted during field harvesting operations, but it also occurs in grading and packing lines, during transport, and in handling at the end of the supply chain during produce display and selection by retailers and consumers. A significant variation in damage is observed when comparing different procedures and different equipment. Most of the bruising damage, however, can and should be avoided by good management and attention to detail in handling processes.

Electronic fruits, already commercially available, are convenient devices for assessing potential damage in fruit handling operations. Damage is typically due to impacts, and is proportional to the applied loads and drop heights. With the appropriate testing protocols, such as those proposed in the study, the electronic fruit can pinpoint exactly where damage is occurring in a handling system. These damage points can be eliminated or reduced by better handling during the picking activity (specific recommendations are being developed), elimination of rough loading and unloading of boxes, and by padding or elimination of transfers in fruit sorting lines. In addition, a new device has been developed to measure the *static compressive forces* on fruit in containers, as well as new models of electronic fruits.

Fruit-by-fruit assessment is essential in an effort to maintain uniformity of appearance and consistency of internal quality. This is very labour intensive and a high level of operator efficiency on a grading line is difficult to sustain over the normal working period. There is real scope for the introduction of objective measurement techniques and equipment on grading lines.

Such monitoring devices are being developed for firmness, appearance and internal quality (sugar content).

Monitoring firmness

Firmness can be measured by contact (impact and compression) and by resonant frequency techniques. Both manual and automatic laboratory devices

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Contractors of the CAMAR project participating in a collaborative testing campaign in Madrid. Left to right: Andrew Muir [UK], Quingseng Yang [UK], Calum Dewar [UK], Vincent Steinmetz [F], Josse De Baerdemaeker [B], Pilar Barreiro [ES], Liesbet Verstreken [B], Jose Briz [ES], Jose Luis Garcia [ES], Margarita Ruiz-Altisent [ES], Jesper Kamp[DK], Robin Tillet [UK].

Innovative development of slurry injection equipment.

are now in use to measure *impact and compression* firmness of apples, pears and peaches, and the prototypes under evaluation have potential as on-line equipment. Within the project, the development of firmness measurement by *resonant frequency* offers the important advantage of a softer and simpler way of "touching" the fruit. The outcome of the three measurement procedures for firmness have been compared with the destructive Magness-Taylor penetration test for firmness and with the degree of ripening in peaches, apples and pears. Firmness is related to *colour* in fruit development during post-harvest ripening, data on colour and on colour uniformity having been analysed in combination with firmness. These two factors and other quality attributes, such as *external appearance* and *sugar content*, can be integrated by sensor combination procedures into a unique fruit classification system.

Imaging blemishes and sugar

The external appearance is evaluated by means of a *defect recognition technique* which can discriminate between the common external blemishes in fruit. Images of each fruit are captured sequentially and analysed immediately using image analysis techniques similar to those already applied to size and partially to colour measurement. *Insect holes, diseases* and *wounds* are the easiest ones to detect, whilst *bruises* are more difficult. In order to achieve a feasible procedure, complex algorithms have been developed to interpret the data collated from the optical scanning equipment. Further, a *portable detector* for recognising diseases and defects in fruit and in other agricultural produce has been demonstrated as a first prototype.

Light reflectance in the near infra-red range is used for the *measurement of sugar content*. A camera image is also captured for this purpose and specific data analyses can predict the sugar content of apples with a precision of 1.4° Brix. On the basis of these results, a device for on-line mounting is well advanced ■

General Information

The sector consists of some 300 companies of which 140 have over 10 employees. There are three bigger companies of which two belong to the same concern. In all, about 5000 employees work in the industry. The great majority of these companies are members of NATI. The Dutch manufacturers specialise in light machinery, installations and equipment. The products vary from simple implements to manure processing systems, harvesting machines, complete barn installations and computer-controlled systems.

In their specialist fields the companies are among the international leaders, a position which has been achieved by continuously improving equipment and techniques. Machines are being developed to operate both more efficiently and at a higher quality standard. The strict specifications in the Netherlands make agrarian Holland an ideal testing ground. In addition, there is a very close co-operation between the manufacturers, the users, and the agricultural institutes and universities. These links enable the manufacturers of agricultural machinery and equipment to react quickly and effectively to new trends in this sector. Currently, more than 65% of the total production of the sector is being exported.

Activities

•Protecting the techno-economic interests of the Dutch agricultural industry.
•Conducting research and market investigations.
•Influencing international standardisation.
•Providing information about guidelines, standards, regulations and legislation.
•Undertaking joint projects regarding quality assurance, etc.
•Introducing micro-electronics to the sector.
•Promoting exports through joint presentations at foreign exhibitions and by trade initiatives.
•Discussing price structures.
•Regulating exhibitions both at home and abroad.
•Informing users and dealers and responding to their queries.
•Functioning as an intermediary for international supply and demand.

Participation

NATI is among others represented in:

CEMA (Comité Européen des Groupements de Constructeurs du Machinisme Agricole), an European association of manufacturers' organisations, which protects the international interests of the manufacturers;

Federatie Agrotechniek, a federation involved in the exhibition policy in the Netherlands and in taking care of the common interests (for example, legislation) of all parties in the manufacturing and trading of equipment;

SAP (Stichting Agrotechnisch Platform), a foundation promoting efficient mechanisation in Dutch agriculture;

NNI (Nederlands Normalisatie Instituut), the committee Agricultural Implements of this National Standardisation Institute judging, among others, ISO and European standards for agricultural implements.

The Future

Characterised by a high degree of flexibility, the progressive agricultural machinery industry has good prospects, despite the worsening position of the agricultural sector. Signals from the market in the field of mechanisation, automation and new crops are promptly converted into a product modifications or new machinery. The same response is applied to public perceptions regarding environmental care. As a result of this approach, rapid developments are visible concerning:

- slurry storage, handling and injection systems
- crop protection techniques
- automation of milk and feeding systems
- automation of registration and identification systems
- quality improvement of harvesting equipment
- mechanical weed control equipment
- business management systems

Changing mechanisation trends and the open European market, together with the high quality standard and the flexibility of the Dutch agricultural machinery industry, offer positive opportunities for the inventive entrepreneur ■

Ing R Westerbeek is Secretary of the Nederlandse Agro Technische Industrie (NATI), is a joint branch group of the Metaalunie and the FME for manufacturers of agricultural machinery and equipment.