CHAPTER 18

QUALITY CONTROL IN THE PRODUCTION CHAIN OF HERBAL PRODUCTS

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Abstract. Quality control is an important tool in the production of high-quality herbal products, while lack of control can result in inferior products that may lead to health problems in the consumers. A quality system is described using Enterprise Resource Planning (ERP) software in a fully integrated herbal production process in The Netherlands. For each production process all success and failure factors were determined and monitored with forms that the users filled out on the computer. All data were integrated and the ERP system linked quality and knowledge management regarding traceability, cultivation and processing (including advisory capacities) and research. Although the system was only partly implemented, the results were satisfactory and suggest that this could be an important tool for sustainable high-quality production systems of herbal products.
Keywords: enterprise resource planning; success and failure factors; traceability

INTRODUCTION

Herbs are produced in two main ways: collection of wild-crafted plants from their natural habitats in the wild and cultivation of herbs that are grown using commercial farming techniques. Plants from cultivated sources provide better guarantees that the plant collected is the one that is desired, while in wild-crafted herbs there is a chance that the wrong herb has been picked, which could lead to serious consequences. Analytical techniques are needed to confirm the identity of the plant.

Many herbs are sold via brokers where the material can change hands several times. This means that the original identity of the crop in terms of where and by whom grown, along with the method of production, can be lost by the time the plant reaches the extraction or manufacturing company.

Raw materials can be obtained in a variety of ways. Fully integrated businesses grow, process and extract everything in-house, and by doing so have full control over the quality of the products they sell. Other companies concentrate on their core business of extraction or product development, whereas cultivation or collection of medicinal plants is outsourced. This way they retain all the benefits of quality

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control, leaving the mechanics of it to experts in this particular field. Lastly, companies simply buy their requirements on the open market. The latter bears the highest risk as the source of the herb may not be known, storage conditions may have been poor, adulteration with other material may have occurred, and records detailing agronomic inputs, including pesticides, are rarely available (Green 2001). No matter which manner of production has taken place, quality control is an important issue.

The rising popularity of herbal products, both as food and feed supplements and as phytotherapeutic drugs, has also given rise to many reports describing adverse health effects and variable quality, efficacy and contents of herbal products (Taylor 2004).

Side effects of herbal products may consist of allergic reactions, interactions with conventional drugs or intrinsic toxicity. Other reasons are related to preparation and manufacturing of the herbs, such as misidentification of plants, lack of standardization, contamination, substitution and adulteration of plants, failure of good manufacturing practice, and incorrect preparations and/or dosages (Calixto 2000).

In this paper, the quality system that was used for the commercial production of herbs in The Netherlands a few years ago is described (Flevo Herb). The research project (BIOHERB) aimed at an optimal recovery of bioactive compounds from medicinal herbs in a fully integrated business. For this we investigated: optimization of the activities of seeding, cultivation, cultivation measures, harvesting, drying, extraction, quality analyses, formulation of dry extract, and integral quality control (IQC; Dutch: IKB = Integrale KwaliteitsBeheersing).

In this project, research institutes from Wageningen (RIKILT, PRI, DLV and ATO), Lelystad (PAV), Dronten (agricultural college CAH) and Leiden University worked together with a group of farmers financed by a fund from the European Commission for development of new enterprises in the province of Flevoland.

PRODUCTION CHAIN

A fully traceable crop production protocol is essential for a quality product. Before the plant is sown in the field, properties of the plant should be identified and measured against the target profile of the ultimate product. Plant breeding can help to create different strains of a species that have more suitable characteristics, both in terms of chemical profile and agronomically, and these strains can increase yield and reduce cost.

The production chain starts with the selection of the seeds and the availability of seeds from specified origins, breeds and cultivars. The seed must meet quality parameters, such as those related to levels of infection (fungi), foreign material, moisture content, germination rate, and purity and viability.

During cultivation the growth, weed control and cultivation measures need to be monitored. Time of harvest depends on plant development, weather and available equipment. Drying conditions depend on the moisture content of tissue at harvest, the plant parts used, and the temperature best suited for preservation of the requested

ingredients. Extraction methods must be certified using standardized methods, and extracts must meet standards related to levels of active ingredients and the absence of toxic and undesirable products.

The European Herb Growers' Association (Europam 2003) introduced Good Agricultural Practices – a code of conduct that indicates the methods by which crops should be cultivated to ensure that the quality of the product is not compromised. For example, guidelines state that the use of pesticides and herbicides has to be documented, that fertilizer use should be minimized, and that human sewage sludge must not be used on fields. All starting materials and processing steps must be documented so that the final customers can audit the production method employed in producing the crop. This requirement is absolutely essential for pharmaceutical businesses and is a prerequisite to manufacturing a pharmaceutical-grade product.

For optimal adjustment of methods to systems, the production chain can be linked to the knowledge chain (Figure 1).

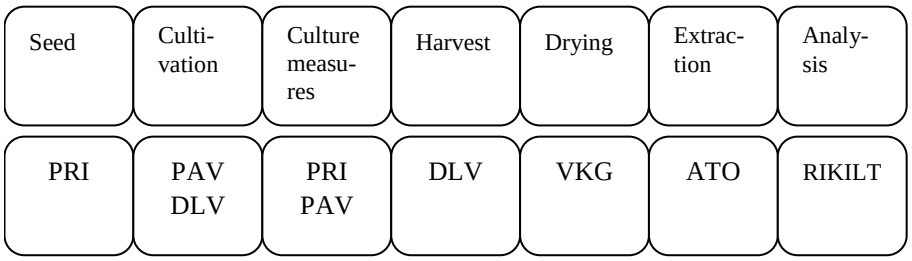

Figure 1. *Production chain and corresponding knowledge chain*

Specific knowledge is linked to the different chains of the production, but a central point that connects all these segments is necessary. This point is formed by the integral quality control that collects the information from each point and makes the information available for the whole system, as is illustrated in the knowledge mill (Figure 2).

To develop such a system, an integral quality control system has to be built and managed. Managing an integral quality system implies: 1) a build-up in phases (product, process, service); 2) starting with basic supplies (baseline measurement); 3) filling-in specific supplies (bottlenecks); 4) registration, control and assurance (procedures); 5) documentation in a quality manual (binder).

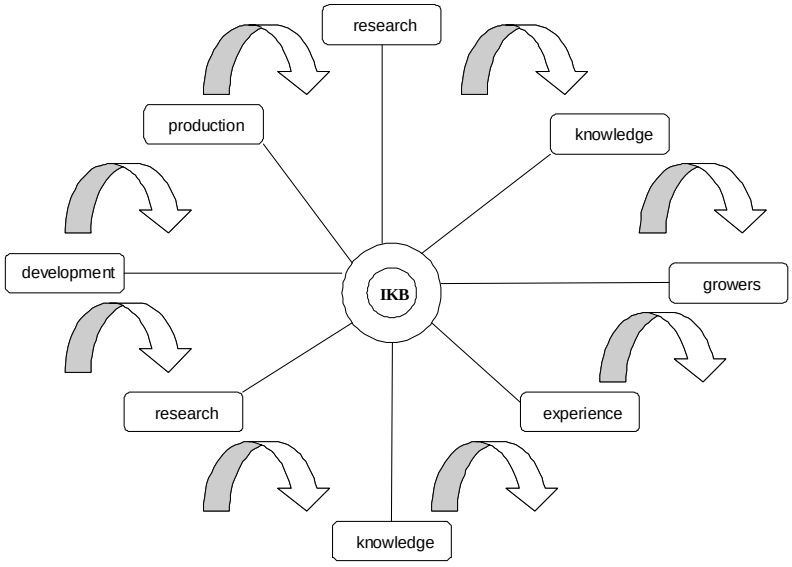

***Figure 2**. Integral Quality Control (IQC; Dutch: IKB = Integrale KwaliteitsBeheersing) linking all information together*

BENEFITS OF INTEGRAL QUALITY CONTROL

An Integral Quality Control (IQC) system has many benefits, such as providing insight into company management, improvement in the efficiency and effectiveness of the production process, provision of products with constant quality, economic methods for production, and demonstrable activities. Moreover, quality control provides a guarantee for the customer, means cost reduction for the supplier and, maybe most important, leads to identification and traceability of errors.

While quality can be defined in many ways, all measurements share the common assumption that 'quality is defined by the customer'. The most used definition is 'fitness for use' (Juran and Godfrey 2002). Other quality experts emphasize particular aspects, such as W. Edwards Deming who calls for 'continuous improvement', whereas Philip Crosby uses the phrase 'conformance to requirements'. In contrast, the Japanese quality expert, Kaoru Ishikawa, combines several aspects and thinks in terms of a product that is 'most economical, most useful, and always satisfactory to the consumer'.

Quality, which has a direct impact on product performance and hence on customer satisfaction, thus begins with customer needs and ends with customer satisfaction (Cortada 1993). Quality refers to the product in terms of technical specifications and to the organization of the production process and the continuity of service. The know-how and control of the production process and the coordination

of all links are essential for good quality. Monitoring should be done at selected steps in production process (Figure 3).

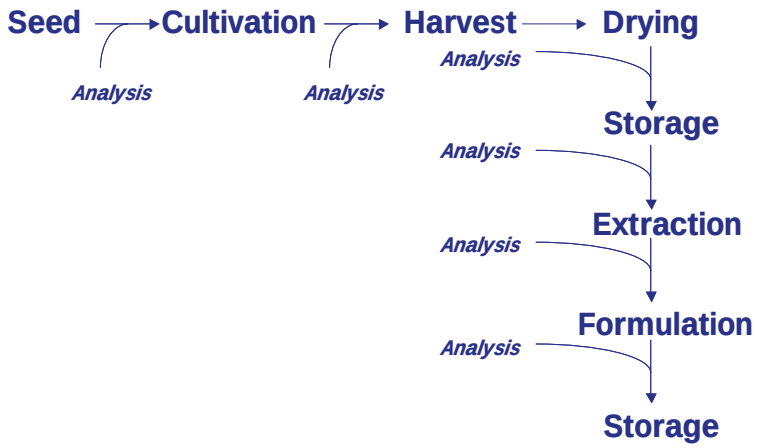

***Figure 3**. Quality control points in the production chain*

Quality control at the farm level is concerned with sampling, specifications and testing, while quality control at the supply-chain level is concerned with organization, documentation and release. These procedures serve to ensure that the necessary and relevant tests are actually done and that materials are not released for use and products not released for sale until the product quality has been judged to be satisfactory.

The basic requirements of quality control for herbal production are that:

- adequate facilities, trained personnel, and approved procedures are available for sampling, inspecting and testing of starting materials, packaging materials and intermediate, bulk and finished products;
- samples of starting materials, packaging materials and intermediate, bulk and finished products are taken by personnel and by methods approved by quality control;
- test methods are validated;
- records, made manually and/or by recording instruments, demonstrate that all the required sampling, inspecting and testing procedures were actually done and any deviations are fully recorded and investigated;
- the finished products contain active ingredients complying with the qualitative and quantitative composition of the Marketing Authorization, are of the purity required, and are enclosed within proper containers and correctly labelled;
- records of results from inspection, material testing and intermediate, bulk and finished products are formally assessed against specification, including a review and evaluation of relevant production documentation and an assessment of deviations form specified procedures;

- no batch of product is released for sale or supply unless certified by a qualified person that all material is in accordance with the requirements of the Marketing Authorization;
- sufficient reference samples of starting materials and products are retained to permit future examination of the product if necessary, and the product is retained in the final pack unless exceptionally large packs are produced (www.pharmacos.eudra.org).

INFORMATION MANAGEMENT

To manage the information from all the processes in the BIOHERB project a software system, known as Enterprise Resource Planning (ERP), was implemented. In this system all data were collected, structured and controlled and the information was made available for the users. Within the ERP system, the main processes of a business or a consortium are combined, including production, planning and logistics; purchase and sale; financial administration; supply control and quality assurance; and knowledge management. Users concerned in the BIOHERB project were the farmers, processors and sales managers, and the management of the Flevo Herb Company. At the primary-process level, the farmers have insight into time of delivery and sale price, while the sales managers have detailed information about supply, delivery time and cost price, and on land area and cultivation plan for the next year.

The ERP system links quality and knowledge management on traceability, cultivation, processing (including advisory capacities) and research. From this perspective, businesses are able to formulate company objectives with the aid of information technology (ERP). The most important company objectives to be fulfilled with ERP are (Bothof and Götte 1998):

- Cost control
- Quality improvement of product and services
- Customer-friendly operations
- Innovation of products and services
- Market development.

Subsequent beneficial objectives of ERP are improvement of:

- cooperation among internal production processes, tasks and functions
- internal and external communication structures
- real-time information to support decision-making.

PRACTICAL IMPLEMENTATION OF THE ERP SYSTEM

In the BIOHERB study, all farmers were equipped with a computer with the ERP software and all information about the crops, seeding time, seed number, weather conditions, weed control measurements and crop development was documented using the ERP system. The system, which made results of crops available for the whole organization, required each farmer to complete forms on the computer, making all information available for monitoring (Table 1).

Table 1. *Forms used in ERP system*

Form	Subject
Grower	Harvest of fresh herbs
Harvest	Storage of dried herb
Registration form	Grower
Registration form	Cultivation advisor
Registration form	Processing company
Registration form	Handler combine harvester
IQC program	Field areas
IQC program	Grower
IQC program	Cultivation advisor
IQC program	Processing company
IQC program	Main management program
Cultivation manuals	For each herb grown

To determine critical success and failure factors in the process specific steps were identified. From grower to fresh herb the first factor identified was the grower with the knowledge and experience of the individual farmer as a main success or failure factor. The next critical factor was the information about the soil and plot on which the herb was grown. The third step was identifying the preparation measures necessary for the soil. The fourth step was sowing and planting of the herbs, required seed, seedlings planted per row, and time of year planted. The fifth step was assessment of necessary crop protection measures. The sixth step was to determine the amount and type of fertilizer needed. The seventh step was to determine the amount of rain or irrigation needed. The last step, the time of harvest, was related to suitable weather and the crop development at harvest time. This latter step also included the plant part to be collected, the type of machine to be used, and the technical data for adjustment of the machine to the crops to be harvested.

Similar analyses were made for the processes of drying, storage, extraction and formulation of the herbs. For each process the critical success and failure factors were determined and forms developed.

DISCUSSION

Quality control systems are important for the production of high-quality herbal products. Lack of quality control may lead to problems due to unidentified problems in the production process that can lead to inferior or inconsistent products or even accidents due to intoxication or allergic reactions. The rising popularity of herbal products as food and feed supplements and as phytotherapeutic drugs has also given rise to many reports describing adverse health effects and variable quality, efficacy and contents of herbal products (Taylor 2004).

The European Herb Growers' Association (Europam 2003) introduced Good Agricultural Practices – guidelines that designate the method by which crops should be cultivated to ensure the quality of the product is not compromised.

Good Manufacturing Practices are required for medical herbs, as stated in Annex 7 of Eudralex (the Rules Governing Medicinal Products in the European Union) for herbal medicinal products (European Commission 1998). Most herbs, however, are sold as food or feed supplements and regulations for these products differ per state and country (Barnes 2003; Calixto 2000). These differing regulations mean that the implementation of quality control systems is more or less determined by the manufacturers of herbal products.

In this paper we have shown an example of the implementation of an Enterprise Resource Planning system in the Dutch BIOHERB project. In the project, a fully integrated business was established in which the production chain from seed to formulated product was examined. Integral quality control was central to collect data from all processes involved and for each process, the critical success and failure factors were determined and forms developed to monitor all steps in the production process.

Since this was a scientific project of a limited period of time, many applications were only theoretical. For the primary sector, the farmers, the program was fully implemented and worked satisfactorily. Using this system, we discovered that certain infections occurred only in some specific areas and were mostly related to the presence of more sandy soil.

Although much effort is needed to determine all success and failure factors of every process in the production chain, we believe that in this way the highest quality can be sustained and the production process can be optimized.

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