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Cost factors of decentralised potato starch production

Large amounts of potato starch are utilised for technical purposes. The separation of starch corn from peel and tissue mix is dispensed with in order to reduce the high cost of the production process through lowering quality to the standard required for the determined use. This would allow an on-field process directly linked with harvesting. A calculation on the cost of raw starch production follows based on procedural-technical investigations and on the basis of a detailed estimation of the expected price for such complex harvesting machinery and technological chain

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According to the German Starch Association current starch production in the country is around 1.5 m t annually. From this a good 0.6 m t, or more than 40%, is potato starch. The industrially prepared and modified starch is used in increasing proportions for chemical and technical products. In 1998 43% of total starch production was used in paper and corrugated cardboard production and in the chemical industry. Increasingly, starch is also used in the manufacture of biologically degradable plastics such as throwaway eating utensils in the fast-food sector, compostable rubbish sacks and carrier bags or horticultural plastic sheeting.

Starch production from potatoes represents an especially involved multi-step process because starch content is only a maximum 20% along with 75% liquid. A closer look is therefore required as to whether this process, concentrated just now in a few starch factories, can be shortened and decentralised for the avoidance of, among other things, huge transport operations. The normal food-quality pure potato starch is not necessary for many chemical and technical applications.

Bernhardt et al. [1] have investigated how far this shortened production technology is practicable for the production of a raw starch from potatoes.

Below, the cost questions of such a technology in the direct production of potato starch during the mobile harvesting are looked at.

A short description of the method

The functional component groups for starch production are for fitting onto a conventional harvester taking the place of the large-volume bunker and a part of the mechanical separation equipment. Before the otherwise-usual bunkering of the harvest occurs, the potatoes are processed by cleaning, chopping and dewatering component groups. A circulating waterbed softens adhering soil and allows separation of remaining stones and clods and this should be attached as part of the currently existing cleaning equipment of layered brush rollers. Reduction of potatoes is a three-step process comprising chopper, cracker and milling rollers. The subsequent mechanical dewatering is by auger-centrifuge also known as a decanter. Naturally, the bunker has to be rebuilt to cope with the milled ware. Where appropriate, the bunker could be part of a replaceable container system.

The resultant moist starch-fibre mix from now on described as potato substrate and with temporary stabilising substances added is then transported directly to further processing or for drying as a long-term stabilisation measure.

The following economic observations will show that this shortened production method can be economically viable.

Cost calculations for the harvesting section

Within this new potato starch production method the key position is held by the above-described harvester. Additionally required for harvesting are a suitably-powerful tractor, a driver and a monitoring person on the machine.

Estimation of machine price

The price shown in *table 1* (cost value) which is given as machine price in the total, was calculated from comparative analyses and this covers the most important functional groups with the necessary drive element.

Useful is the estimation within two limit values. The variant described as „optimistic“ uses a technical development level for com-

Table 1: Cost estimation of main functional groups

Construction group	Pessimistic variant in TDM	Optimistic variant in TDM
Basic machine with bunker	80	60
100% non-potato const. (NPC) separation	30	25
Brush cleaning	20	}
Cracker and mill	30	25
Decanter	150	100
Total	**310**	**210**

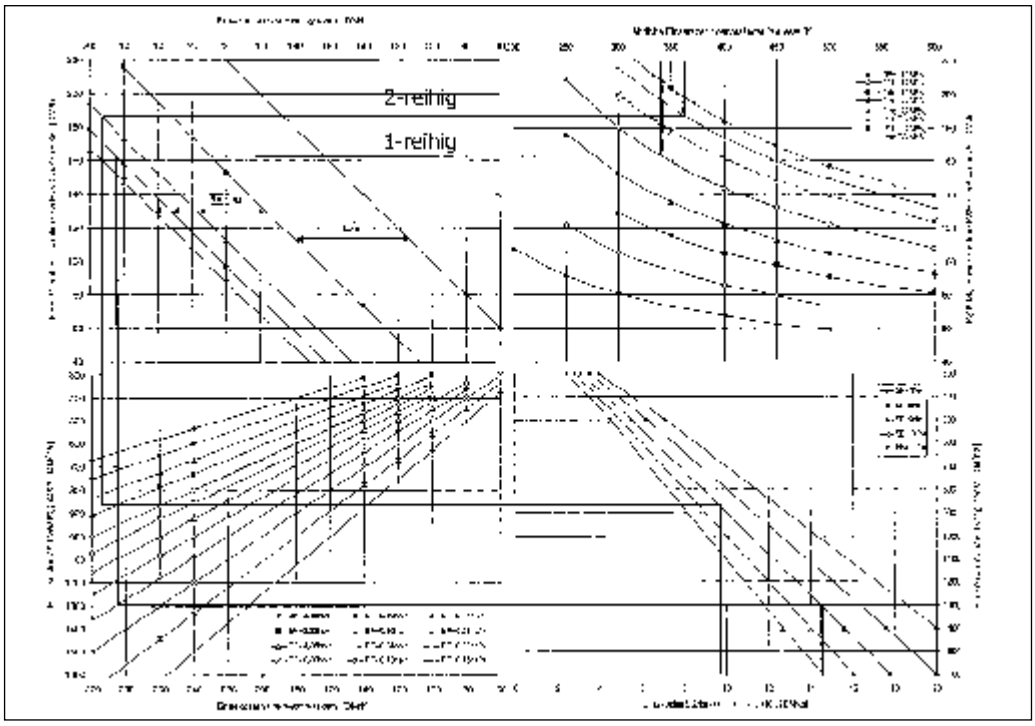

Fig.1: Nomogramm for assessing harvesting costs

ponent groups precisely dimensioned at constructed for the specific application and therefore the price of this sort of machinery is decided by the level of technical development.

Machinery costs
With the price of the substrate harvester determined in this way the hourly costs of running the machine were calculated through a KTBL calculation programme [2].

To be observed here in particular are utilisation time and annual area covered as well as a residual value with its influence on the depreciation costs. A capital interest charge of 8% was applied as notional loss. The annual fixed costs also include charges for garaging, general business costs, taxes and insurance. To these come variable costs, especially for repairs and lubrication. Fuel costs are taken as part of the tractor expenses. So calculated, machinery can be based on the working hour as a function of the annual utilisation time as shown in the nomogramme above, right in *figure 1*.

As additional parameter the machinery price has been varied in order to stress to the potential machine manufacturer or future user the effect of these prices on production costs of usable potato starch.

The bringing together of the influential factors in a nomogramme proved to be a very useful and easily understood measure.

Wage costs
Wage costs are put at 35.00 DM/h for the tractor driver and 30.00 DM/h for the machine minder (fig. 1 above, left).

In that it is also attempted here to compare the situation with that in a traditional potato harvest, costs have to be added for two or three sorters on the harvester in particular for separating-out stones and clods.

Tractor costs
Using the above-mentioned calculation scheme, costs of the tractor used in powering the starch-substrate harvester can be determined. For a single-row substrate harvester a 110 kW tractor would be required with an average purchase price of 125000 DM. The tractor as universal energy source and work machine is substantially more intensively applied than special farm machinery and for this reason retains a favourable cost rate of 55.00 DM/working hour. (fig. 1 above, left). Verified values for tractor costs are naturally available in technical data collections.

Area-based harvesting costs
From the sum of machinery, tractor and wage costs one can, by bringing-in the technical performance data for the harvester, calculate the costs for each harvested hectare. As mentioned before, the aim is to construct this starch aggregate harvester from a conventional harvester so that then comparable performance data can be established, below, left in nomogramme. These performance values in ha/h are given consideration of so-called „help times“ and loss periods and represent 55% to 65% of the possible performance simply calculated from working sped and working width (number of rows) [3].

Substrate harvesting costs
These costs are based on the amount of harvested aggregate in terms of pure starch. In moist starch-fibre substrate this represents 35% of the mass at 60% moisture content. For normally harvested potatoes this depends on the starch content of respective varieties, e.g. less than 14% with eating ware or up to 23% (in 1999) with industrial potatoes.

On the nomogramme below, right, the cost per 1 kg starch can be seen. From the marked example for a single-row substrate harvester costing around 210 TDM and for a two-row variant costing around 245 TDM with working times of 350 h/year and 77 ha, respectively 126 ha, harvested potato fields:
- 0.14 DM/kg starch for singe-row, and
- 0.09 DM/kg starch for the two-rower.

If one puts the normal harvesting costs for starch potatoes at 700 DM/ha, this would, with the starch available in these potatoes (20%, i.e. 9 t/ha) lead to 0.08 DM/kg harvesting costs.

It is then clear that the extra input for raw starch production on the field costs less – maximum 0.06 DM/kg – than the usual harvesting process which costs at least 0.08 DM/kg. Also the comparison for transport costs for delivery to the starch factory at 15 DM/t of potatoes with the site more than 80 km away means this starch would face costs of 0.075 DM/kg!

Table 2: Cost of potato substrate harvest and postharvest processing

	DM/t Potatoes	DM/t Starch
Cultivation (390/550 dt/ha)	72.20 / 51.20	267.40 / 189.60
Harvest	24.70 / 17.30	91.50 / 64.00
Transport	6.00	11.00
Preparation		
- Drying		345.00…185.00
- Milling, classifying		20.00…15.00
Sub total		**734.90…464.50**
Gross margin (2000, DM/ha)		51.30 / 36.40
Required price		**786.00…501.00**

Cost elements of the total procedure

After the determined limits to the expected costs of potato starch substrate production, their relation to the other cost elements of the total procedure is of interest.

The main sections of the procedure are:
- the cultivation and, with that, all work towards production on the field
- the above-mentioned harvest
- the transport of harvested material from the field for further
- processing and storage

Table 2 indicates the cost framework for a substrate harvest and processing The product-linked costs also depend on the yield (39 or 55 t/ha), i.e. all costs from ploughing the field through to the last crop care action are first of all counted as preparation. These costs then require a minimum yield currently of 39 t/ha in order to break even.

Such a cost input can then be based on the solid material content of the potatoes, i.e. the actual starch substrate (27% of solid material with starch potatoes). With a balanced moisture content of 17%, this is 31% of the grown potato mass.

Based on these cultivation costs the costs of the substrate harvest represents only one third. The costs for the subsequent sector transport including transfer and drying are deduced from a rougher calculation. It was assumed that this raw starch could in the main be used in a dry condition in the processing procedure.

This thermal dewatering can represent up to 40% of total costs. Thus more rational methods of drying should be developed or special utilisation lines for moist substrate be introduced.

Summary

The authors are convinced that from the cost observations shown here, reliable information for economical evaluation of a new system for potato starch production can be taken and offer the following key conclusions:

1. The application of this research work as part of a financial calculation is absolutely justifiable.
2. The financial inputs able to be calculated for the necessary system steps indicate the points where special research and development work is still necessary,
3. This also means that all research and development work is justified where it follows-up an utilisation of this raw starch as industrial material and products.
4. Also the constructors and machinery manufacturers are shown within which cost limits the technical solutions must move in order to give an economically viable system.

The methods shown here should give cause for reflection and also offer in themselves concepts towards the improvement in method application. The parallel technical and procedural-technological research which can be seen here on the example of potato starch as regenerative raw material led to better results and to more precise use of research results.

Literature

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