Cost of GMO-related co-existence and traceability systems in food production in Germany

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Abstract:

In contrast to the increasing use of GM plants in world-wide agriculture, the acceptance of GM food is still low in the European Union (EU). In order to ensure freedom of choice for consumers and users of GM and non-GM products, GM food and feed products have to be labeled in case a tolerance threshold of 0.9 % is exceeded for EU authorized GMOs. This paper aims to quantify the cost of traceability and co-existence systems for GM food from the seed to the food level for sugar, wheat starch and rapeseed oil for human consumption in Germany respecting the 0.9 % threshold for labelling of GM food. The cost calculation for traceability and co-existence measures follows the principle of aggregating all incurred cost on the different levels of the value chain and to increase the price of the final product at each level. Altogether the measures to ensure co-existence and traceability lead to 5 % to 13 % higher price for GMO-free rapeseed oil, to 2 % to 5 % higher prices of GM-free sugar and to 8 % price increase for GMO-free wheat starch.

Keywords:
Co-existence, traceability, food production

1 Introduction and regulatory framework

The worldwide acreage of genetically modified (GM) plants is continuously growing and amounted to 114 million ha in 2007. More than 10 million farmers in 23 countries have grown GM plants - mainly GM soybean, GM maize, GM cotton and GM rapeseed (ISAAA, 2007). In contrast to the high penetration of GM crops in Northern and Latin America, Bt maize is the only GM crop that is commercially grown in the EU. In 2007 GM maize was cultivated on 75,000 ha in Spain and additionally 35,000 ha in France, Czech Republic, Portugal and Germany (GMO Compass, 2007). Furthermore, the EU imports around 40 million t of soybeans and maize and derived products mainly from USA and Latin America, which are at least partly GM.

In contrast to the increasing use of GM plants in world-wide agriculture, the acceptance of GM food is still low in the European Union (EU) (Gaskell et al, 2006; Costa Font et al, 2008). In the opinion of most EU consumers there is nothing to gain by applying GM ingredients but serious disadvantages may occur like negative long-term health and/or environmental impacts, difficulties of reversing GMO technology as it becomes widespread used, monopolization tendencies in the seed and food industry as well as ethical concerns (Menrad and Hirzinger, 2005). Furthermore, the share of people thinking that it is useful to apply biotechnology to food production decreased in the recent years (Gaskell et al, 2006).

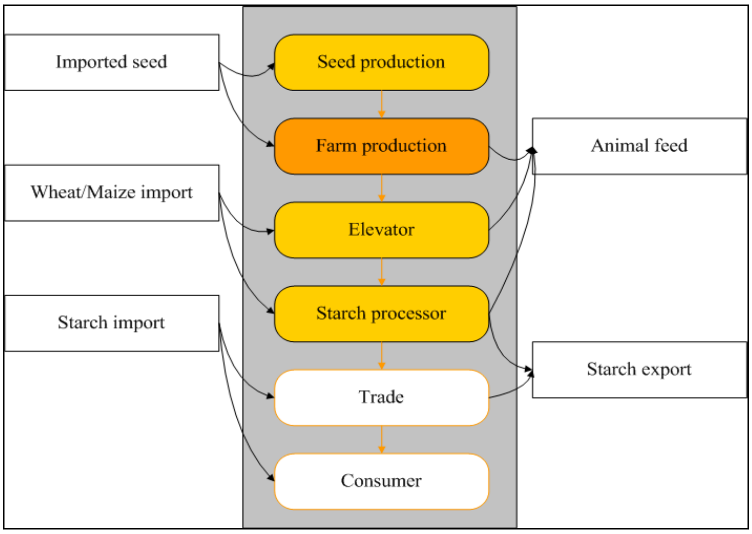
In recent years the EU adopted a series of regulations related to GMOs of which the regulations (EC) No 1829/2003 and 1830/2003 (dealing with the admission, labelling and traceability of GMOs) have special impact on the food and feed industry. Important targets of these regulations are to ensure freedom of choice for consumers and users of GM and non-GM products as well as to avoid environmental and health risks associated to the commercial use of GM products. Food and feed products have to be labelled to contain GMOs or GM material in case a tolerance threshold of 0.9 % is exceeded for EU authorized GMOs and 0.5 % for unauthorized GMOs if they already have received a favourable EU risk assessment. Products containing traces of GMOs below the appropriate regulatory thresholds are exempt from labelling, provided that compliant traceability systems are in place and traces of GMOs are adventitious and technically unavoidable. Also animal products which were produced with GM feed compounds do not have to be labelled. Products containing GMOs above the threshold must be labelled, even if the GM material is undetectable by analytical tests (European Parliament and the Council of the European Union, 2003a, b).

Since several years there is an intensive discussion how to ensure freedom of choice between farmers in differing agricultural production systems within the EU as well as for consumers who might be willing to buy and consume GM foods or not. Several studies analyzed the possibilities of co-existence schemes and its economic effects on crop production in Europe (e. g. Bock et al, 2002; Tollstrup et al, 2003; Messéan et al, 2006), but a lot of questions are still intensively discussed in this field not least the threshold level of GM adventitious presence in EU seed production. Due to the low consumer acceptance in most EU member states the European food industry has taken a "wait and see"-position with respect to introducing GM food which needs to be labelled. With the exception of a few EU member states (e.g. the Netherlands) hardly any GM foods can be found on retail shelves of the EU (Transgen, 2007). The German food industry nearly totally applies a prevention-strategy with respect to GMOs which can be used in food production and require labelling (Hirzinger and Menrad, 2007). Against this background this paper aims to analyse the required measures as well as associated cost to ensure co-existence and traceability between GM and non-GM products in selected value chains of food production in Germany.

2 Methodology

It is the target of this paper to quantify the cost of traceability and co-existence systems for GM food from the seed to the food level in Germany respecting the 0.9 % threshold for labelling of GM food. Thus each level of the value chain has to be taken into account as illustrated in figure 1 for the value chain of wheat starch. While the yellow-underlayed parts of the value chains are included in the cost calculations, imports and exports of products, the situation in food retail shops and at the home of consumers are excluded from the cost calculations. The analyses are carried out for the value chains of sugar, wheat starch and rapeseed oil for human consumption. While GM oilseed rape is cultivated on around 6 million ha in particular in Canada (ISAAA, 2007), there is no commercial planting of GM wheat or sugar beet varieties so far. Thus the value chain of rapeseed oil represents a case of an already existing problem of ensuring traceability of GM and non-GM food due to imports e. g. of rapeseed and derived products into the EU although no GM varieties are grown in the EU. The value chain of sugar is selected to analyse the situation in a contract-based value chain with close links between growers of agricultural crops and the processing companies as well as a regionally concentrated cultivation of sugar beets in the neighbourhood of the processing plants. In contrast the value chain of wheat starch represents a case with no strong links between growers of agricultural crops and the subsequent processing steps. Furthermore wheat is traded internationally in substantial amounts and has not to be grown in the neighbourhood of the wheat starch plant.

Figure 1: Value chain of wheat starch production in Germany



Source: Hirzinger, 2008.

The cost calculation for traceability and co-existence measures follows the principle to aggregate all incurred cost for cultivating and transportation of crops or processing of the raw material crop on the different levels and to increase the price of the final product at each level: the commodity price e. g. for wheat is increased by the cost of co-existence measures on the farm level in order to comply with the threshold of 0.9 % for adventitious presence of GM material. The resulting price for non-GM wheat on farm level is automatically the non-GM commodity price in the next level of the value chain (i.e. the elevator). This principle is used at all stages of the value chain thus aggregating the additional cost for respecting the 0.9 % threshold of GM adventitious presence on all levels and setting the price for the non-GM product at the end of the value chain. In general the additional co-existence and traceability cost are referring only to the final food product of the value chain and do not consider any by-products which might be produced (e. g. rapeseed meal when processing rapeseed oil, or gluten in wheat starch production).

For calculating the traceability and co-existence cost an Excel-based simulation model has been developed which includes the potential cost categories on each level of the value chain. In order to ensure co-existence (on defined thresholds) between GM and non-GM seeds or agricultural crops the following measures (and resulting cost positions) have been taken into account (Messéan et al, 2006; Menrad and Reitmeier, 2006; Tollstrup et al, 2003; Bock et al, 2002):

- Cleaning of machinery and equipment when shifting from GM to non-GM fields
- Increasing isolation distances between GM and non-GM crops

- Time isolation: Separating flowering times by providing a choice of varieties, some flowering earlier than others
- Non-GM buffer zone: Sowing an area of non-GM crops all around the GM field
- Discard width: The discard width on a non-GM field is an area of variable size around the edge of the field that is not included in the final harvest.
- Monitoring activities of fields can include testing of the seeds or agricultural crops (via PCR or protein-based quick tests)
- Cost of administration and certification or additional efforts for organising seed multiplying
- Building of additional storage facilities
- Additional transportation costs (e. g. due to increased transport distances for agricultural crops)
- Other cost (e.g. for training or stewardship programmes of farmers).

On the elevator, crusher or processor level the main risks are admixture of GM and non-GM commodity or derived products mainly due to human errors (Hirzinger, 2008). In this context it has to be taken into account that Regulation No. 178/2002 of the EU requires the traceability of food ingredients in the German food industry since 2005. Thus food industry companies have already installed general documentation and traceability systems which can be used for traceability of GMOs as well without causing additional significant cost for documentation (Hirzinger, 2008; BLL, 2006). Thus the following measures (and resulting cost positions) have been considered in the calculation of traceability and co-existence cost for elevators, crushers or processors:

- Higher commodity cost representing the accumulated co-existence and traceability cost of the previous levels of the value chain
- Testing programmes for incoming commodity and/or the produced goods
- Mode of transport of commodities and produced goods (e. g. via ship or truck) which influences the testing regime and cost of testing programmes
- In case GM and non-GM commodities are handled or processed in the same factory, measures have to be taken for cleaning (manually) or flushing of the repositories and adjustment of the production
- Building of additional storage facilities, investments in other additional equipment or building of a complete second production line in an existing plant
- Education and training programmes, e. g. for workers
- Other cost (e.g. for external audits, modifications in organisation).

In order to specify and quantify the different cost categories numerous data and information sources have been used. The cost of co-existence measures in seed production and for farming have been calculated according to the methodologies used in previous studies or using a methodological guidebook for calculating cost of co-existence measures which was developed in the context of the EU-funded SIGMEA project (Reitmeier et al, 2006). Data from scientific literature or previous research projects have been used to quantify the co-existence cost in seed and agricultural production or appropriate co-existence measures have been defined (e. g. use of a buffer zone of a certain width) and the cost calculated according to the methodology suggested by Reitmeier et al, 2006.

Concerning co-existence and traceability cost on elevator, crusher or processor level hardly any studies are available for European countries which quantify the cost on the different levels of the value chain. Thus we developed specific formula for each relevant cost position in order to quantify the respective position and finally sum up the cost per unit (in general ton of product produced) in order to get a price loading for the respective level of the value chain. In the following example the formula for commodity, certification and extra transport cost on the elevator, crusher or processor level is presented:

$$PK_A = (p_{Non-GM} - p_{GM})*Mp_{Non-GM} + (t_{GM} - t_{Non-GM})*Mt_{Non-GM} + K_Z$$

PK_A	GM prevention cost commodity, extra transport and certification
Mp_{Non-GM}	Amount of processed non-GM commodities in tons
Mt_{Non-GM}	Amount of transported non-GM commodities in tons
p_{non-GM}	Price of non-GM commodity in €
p_{GM}	Price of GM commodity in €
t_{GM}	Transport cost due to co-existence in €
t_{non-GM}	Transport cost without segregation in €
K_Z	Facultative cost of certification in € (per year)

Data to empirically specify and quantify the cost positions have been gathered using published scientific reports and literature as well as carrying out expert interviews using a semi-structured interview guide. In 2006 expert interviews have been carried out with 13 representatives of the analyzed value chains. In case relevant information are lacking in the data set, meaningful assumptions are made based on the situation either in other countries or in comparable value chains. In order to consider the variety of the differing situation in the single companies of the analysed value chain, several 'adjustment screws' (like e. g. the threshold of GM adventitious presence in non-GM seed, penetration of GM varieties in agriculture, the strategy to ensure co-existence adopted by an elevator, crusher or processor) have been included in the simulation model which allow to simulate the cost depending on the assumptions made for the respective factor. These factors can be modified according to the given situation and the impact of such changes on the overall traceability cost at the level of the final product can be simulated.

3 Co-existence and traceability cost in selected value chains

The following paragraph deals with the necessary measures to ensure a threshold of GM adventitious presence below 0.9 % at the different levels of the value chain of the analysed products.

3.1 Rapeseed oil

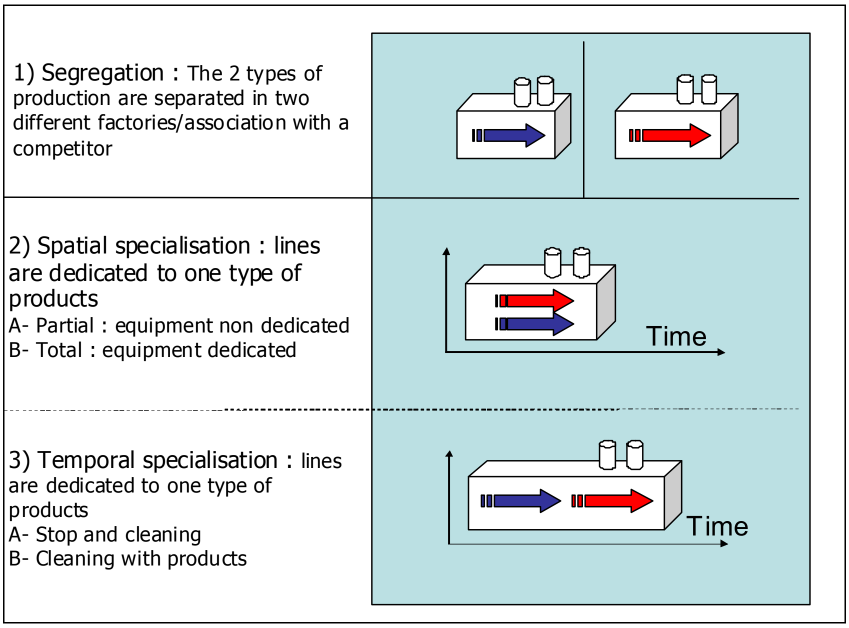
The necessary measures and corresponding cost to ensure traceability and co-existence between GM and non-GM rapeseed oil for human consumption are shown in table 1. Due to the lacking threshold only very few information exist concerning the necessary measures and additional cost of co-existence in certified rapeseed production. Bock et al, 2002 estimate a

10 % increase of non-GM certified seed cost in rapeseed production mainly due to increasing isolation distances and cleaning of machinery. So far legally binding regulations are lacking for commercial cultivation of GM rapeseed in Germany. A recently published literature review concerning the pollen flow distances in rapeseed indicates “that the bulk of outcrossing occurs within very short distances, less than 10 m from the source” (Hüsken and Pfeilstetter, 2007), but also cases of up to 100 m (and more) of outcrossing distances are reported. In order to comply with this “open” situation, a 100 m buffer zone around a GM rapeseed field was considered as appropriate measure to keep GM adventitious below the 0.9 % threshold in order to take into account the low consumer acceptance and political sensitivity of this issue in Germany. In addition, cleaning of machinery, monitoring of fields and insurance was seen as necessary resulting in cost of 21.25 €/t rapeseed or a 6.4 % price increase based on the rapeseed price end 2007 in Germany (table 1).

As mostly in particular large elevators have several locations to collect oilseed rape in Germany, it was assumed that an elevator will locally separate the GM and non-GM collection places of rapeseed since this represents the cheapest option to implement a prevention strategy with respect to GMOs (Hirzinger, 2008). Nevertheless, elevators have to test the incoming commodity which is generally transported by truck with protein-based quick tests and parts of the crop with PCR tests resulting in cost of more than 17 €/t (equivalent to a price increase of 4.6 %) for non-GM rapeseed on the elevator level (table 1) of which around 90 % are caused by higher commodity cost.

The situation of a large crusher (with production capacities of at least 0.3 million t) is considered in the cost calculation. These companies have three different options to ensure co-existence of GM and non-GM rapeseed processing (figure 2) namely the local segregation, i.e. defining one plant to process solely GM rapeseed and another plant to only process non-GM rapeseed. The spatial specialisation strategy requires the building of new registration, transport and storage facilities to ensure a parallel processing of GM and non-GM rapeseed on different production lines within one plant as well as permanent GMO-testing. The temporal specialisation means the temporally separated use of one production line for GM and non-GM rapeseed, i.e. firstly non-GM varieties are processed followed by GM commodity interrupted by a flushing process to clean the processing equipment (Hirzinger, 2008).

Figure 2: Possible options to manage co-existence in oilseed rape processing at the level of the oil mill



Source: Hirzinger, 2008.

The option of locally separating plants for processing of GM and non-GM rapeseed is the most cost-efficient strategy to ensure co-existence and traceability on the crusher level. If the co-existence cost caused at the elevator level are totally shifted to the oil mill cost of around 53 €/t can be estimated (equalling to 5.2 % of the price of rapeseed oil of 895 €/t in 2007). In contrast the temporal segregation strategy causes cost of around 74 €/t what equals to 8.3 % of the price of rapeseed oil. The higher cost are mainly due to testing necessities of the produced rapeseed oil (due to potential admixture) and depreciation of necessary investments in storage facilities and other equipment. In addition, flushing of the repositories and adjustment of the production requires additional personnel, cleaning and a downgrading in quality of the produced rapeseed oil during the flushing process. Spatial specialisation represents the most cost-intensive co-existence and traceability strategy which results in cost of around 114 €/t rapeseed oil (equivalent to 12.8 % of the price of rapeseed oil). These additional cost compared to the temporal segregation are mainly due to capital cost for building a new production line which was calculated to cause investment cost of 14 million €.

Table 1: Cost of traceability and co-existence measures for non-GM rapeseed oil for human consumption on the different levels of the value chain in Germany

Level of the value chain	**Measures to ensure co-existence and traceability**	**Additional costs: total costs (costs per ton)**	**Cost increase (% of product price on this level)**	**Additional remarks**
Seed multiplier	▪ Increasing isolation distance ▪ Cleaning of machinery		**+ 10.0 %**	▪ Bock et al, 2002 estimated this cost increase for a 0.3% threshold in certified rapeseed seed
Farmer	▪ Cleaning of machinery ▪ Buffer zone of 100 m ▪ Monitoring and insurance	74.28 €/ha (21.25 €/t)	**+ 6.4 %**	▪ Yield: 3.5 tons/ha ▪ Herbicide resistant oilseed variety ▪ GM-adoption rate in region: 50 % ▪ Additional monitoring on field
Elevator	▪ Higher commodity prices ▪ Longer transport distances ▪ Cleaning of transport equipment ▪ Testing of incoming commodities (PCR, quick test)	6,915,600 € (17.29 €/t)	**+ 4.6 %**	▪ Turnover with purified rapeseed: 412 Mio. € ▪ Proportion of GM commodity: 50 %, local separation
Oil mill	▪ Higher commodity prices ▪ Testing of incoming commodities and online process (PCR, quick test) ▪ Investment in additional registration, transport and storage facilities (for 2) and 3)) ▪ Flushing of the repositories (2)) ▪ Building new production line (3))	1) 3,362,993 € (52.70 €/t) 2) 5,334,218 € (74.10 €/t) 3) 8,222,391 € (114.20 €/t)	**+ 5.2 %** **+ 8.3 %** **+12.8 %**	▪ Turnover with purified rapeseed: 64.4 Mio. € ▪ Proportion of GM commodity: 30 %
1) Local separation 2) Temporal specialisation 3) Spatial specialisation				

Sources: Hirzinger, 2008; Hirzinger et al., 2008; Daems et al, 2007; Kasamba and Copeland, 2007; KTBL, 2007; Messéan et al, 2006: Bock et al, 2002; data of expert interviews

3.2 Sugar

The necessary measures and corresponding cost to ensure traceability and co-existence between GM and non-GM sugar are shown in table 2. A first risk factor for GM admixture in the sugar supply chain is the contamination of certified hybrid beet seed. In order to keep a 0.3 % threshold of GM adventitious presence in non-GM sugar beet seed measures like e. g. isolated fields, monitoring of fields and harvest have to be adopted in sugar beet seed production (Messéan et al, 2006) resulting in costs of 246 €/ha (or 7.7 % of the price of sugar beet seed). Farmers face additional cost for destructing adventitious weed beets by hand pulling and cleaning of the truck (Menrad and Reitmeier, 2006) causing cost of 132 €/ha or 6.7 % of the sugar beet price in 2005/06 (table 2).

As sugar beets are grown in the regional neighborhood of sugar processing plants the farmers deliver the beets directly to the plants. The main additional cost for sugar processing companies is the higher price for non-GM sugar beet. In case of a temporal segregation every incoming truck has to be tested with a quick test and every 10th truck is tested with a quantitative PCR-test summing up to cost of 4.69 €/t sugar. Additional cost refers to depreciation of investments in storage facilities, cost for flushing the processing equipment and training of the workers. Altogether the price loading of non-GM sugar using a temporal segregation co-existence strategy will be 14.39 €/t sugar or 2.3 % of the EU-reference sugar price of 631.90 €/t in 2005/2006.

In Germany sugar production is dominated by three companies which separate their production on multiple plants. Thus a segregation of GM and non-GM production on two sites would be reasonable, when the processing capacity and quantities are well distributed and the logistic is economic. For this local separation strategy, it is assumed that no investments in processing, storage and infrastructure of the second site have to be done and that the regional supply radius of beets for the sugar plants has to be doubled (due to a 50 % adoption of GM sugar beets). If truck transport cost of about 0.1 € per ton and km are considered, the transportation cost increase from 5 €/t (50 km distance) up to 10 €/t (100 km distance) resulting in significantly higher cost for non-GM sugar beet (including transportation cost) which overcompensate the fact that e.g. no additional storage facilities are required for implementing this strategy. Altogether cost of more than 31 €/t sugar (equalling to 4.9 % of the 2005/06 price of sugar) have to be calculated in case of a local separation strategy in sugar production (table 2).

Table 2: Cost of traceability and co-existence measures for non-GM sugar on the different levels of the value chain in Germany

Level of the value chain	**Measures to ensure co-existence and traceability**	**Additional costs: total costs (cost per ton)**	**Cost increase (% of product price on this level)**	**Additional remarks**
Seed multiplier	▪ Isolated fields ▪ Monitoring of current and previous production sites ▪ Cleaning of machinery ▪ Control of harvest	246.42 €/ha (126.37 €/t)	**+ 7.7 %** (of gross margin)	▪ Yield: 2.0 tons/ha ▪ Required threshold: 0.3 % ▪ Isolated seed production fields
Farmer	▪ Higher seed costs ▪ Cleaning of trucks ▪ Destruction of weed beets	132.15 €/ha (2.20 €/t)	**+ 6.7 %**	▪ Yield: 60 t/ha ▪ Proportion of GM crop: 50 % ▪ Benefits GM beet: Lower production costs, 5 % higher yield
Sugar processor	▪ Higher costs for crop ▪ Testing of sugar beet ▪ Investment in storage facilities (1))	1) 4,676,500 € (31.16 €/t) 2) 2,158,495 € (14.39 €/t)	**+ 4.9 %** **+ 2.3 %**	▪ Turnover of sugar for human consumption: 78.55 million € ▪ Proportion GM commodity: 50 %
1) Local separation 2) Temporal specialisation				

Sources: Hirzinger, 2008; Messéan et al, 2006; Menrad and Reitmeier, 2006; data of expert interviews.

3.3 Wheat starch

Table 3 summarizes the cost of traceability and co-existence measures for the value chain of non-GM wheat starch in Germany. Due to the self-fertility of wheat relatively limited additional co-existence measures (like isolating fields, additional certification and cleaning of the machinery) are required in order to fulfil a 0.5 % threshold for certified seed production in this crop (Tollstrup et al, 2003) resulting in additional cost of around 1.75 €/t or 2.5 % of the price of wheat seed. On the farming level the example of a *Fusarium* resistant GM wheat was taken into account for which yield increases of 1.5 t/ha have been reported for Germany thereby reducing the cost of insecticide treatment (Goltermann, 2006), but farmers have to accept higher cost of GM wheat seed. In order to ensure co-existence at the 0.9 % threshold level buffer zones of 20 m, cleaning of machinery and additional monitoring activities of the fields (Tollstrup et al, 2003) were assumed resulting in cost of around 10.8 €/t or 7.2 % of the wheat price in autumn 2007. It was assumed that elevators have to test the incoming wheat which is delivered by truck and ship in order to ensure the separation of GM and non-GM commodity. This testing cost amount to 1.30 €/t so that the highest proportion of the additional cost of 13.7 €/t (table 3) are due to higher commodity prices for non-GM wheat by applying local segregation as the most economic strategy. For wheat starch processing all three separation strategies with one or more existing plants were simulated. In order to guarantee a GM-free production within the local segregation strategy the starch processor tests the incoming commodity using quick tests and quantitative PCR resulting in annual testing cost of 151,000 €. Together with higher commodity prices for non-GM wheat a total of almost 21 €/t wheat starch (equalling to 8.3 % of the wheat starch price in 2007) have to be calculated for traceability using the local separation strategy. Applying however the temporal specializstion strategy total cost for traceability of about 33.36 €/t wheat starch occur. Cost are highest for the spatial specialisation strategy (39.17 €/t).

Table 3: Cost of traceability and co-existence measures for non-GM wheat starch on the different levels of the value chain in Germany

Level of the value chain	**Measures to ensure co-existence and traceability**	**Additional cost: total cost (cost per ton)**	**Cost increase (% of product price on this level)**	**Additional remarks**
Seed multiplier	▪ Isolating fields ▪ Cleaning machinery ▪ Certification	9.35 €/ha (1.75 €/t)	**+ 2.5 %**	▪ Yield: 5.4 t/ha ▪ GM threshold 0.5 %
Farmer	▪ Buffer zone of 20 m ▪ Cleaning of machinery ▪ On-field monitoring	85.61 €/ha (10.85 €/t)	**+ 7.2 %**	▪ Higher seed costs ▪ *Fusarium* resistant GM wheat ▪ Yield: 9.36 tons/ha (15 % yield increase) ▪ GM adoption rate: 50 %
Elevator	▪ Higher costs of non-GM wheat ▪ Testing of incoming commodity	[1) 4)] 17,064,500 € (13.65 €/t) [3) 5)] 202,056 € (16.09 €/t)	**+ 8.3 %** **+ 9.8 %**	▪ Turnover with wheat: 711 Mio. € ▪ Proportion GM commodity: 50 % ▪ No imports of GM wheat
Wheat starch processor	▪ Higher costs of non-GM wheat ▪ Testing of incoming commodity	[1)] 2,583,590 € (20.84 €/t) [2)] 3,917,330 (39.17 €/t) [3)] 3,335,900 € (33.36 €/t)	**+ 8.3 %** **+ 12.5 %** **+ 10.7 %**	▪ Turnover with wheat starch: 35.4 Mio. € ▪ Proportion GM commodity: 50 % ▪ Assumed 2 existing plants
1) Local separation 2) Spatial specialisation 3) Temporal specialisation 4) Big-sized company 5) Small-sized company				

Sources: Hirzinger, 2008; Goltermann, 2006; Tollstrup et al, 2003; data of expert interviews.

4 Conclusions

In order to ensure freedom of choice of farmers, processors and consumers in the EU additional measures have to be taken to respect the 0.9 % threshold of GM adventitious presence in non-GM food products. This paper summarizes the necessary co-existence and traceability measures and the corresponding cost for three selected value chains namely oilseed rape for human consumption, sugar and wheat starch in Germany.

Additional cost for co-existence arise at the seed and farming level mainly due to changing agricultural practices (e. g. increasing isolation distances, establishing non-GM buffer zones, border management), cleaning of machinery, and monitoring or certification activities. Depending particularly on the biology of the crop concerned this cost sum up to 2 % (wheat) up to 10 % (rapeseed seed) of the current price of seeds and around 6-7 % of the price of the agricultural commodity.

On the elevator, crusher and processor level co-existence and traceability cost result from higher prices of non-GM crops, testing cost for incoming commodities as well as output testing, investment cost e. g. for new storage or handling facilities (or building a new production line if required), flushing or cleaning the processing plants, certification activities or longer transport distances e. g. of agricultural crops. In most cases a significant proportion of the additional co-existence and traceability cost are caused by higher prices of non-GM commodities. Depending on the specific situation, the length and organisation of the value chain, local segregation of the plants used for GM and non-GM production or a temporal specialisation in one plant might be the most economic strategy to ensure co-existence and traceability between GM and non-GM food products. Nevertheless, additional aggregated cost between 2 % and 5 % of the sugar price, 8 % to 13 % of the price of wheat starch, or 5 % to 13 % of the price of rapeseed oil for human consumption has to be calculated to implement and realise the necessary measures. In contrast, a spatial segregation strategy causes substantially higher co-existence and traceability cost – as shown for rapeseed oil and wheat starch – mainly due to the investment in a second production line.

In future it can be expected that additional branches of the food industry in Germany will be faced with the challenge of an increasing risk of GMO-admixture mainly due to the globally growing cultivation area of GM crops. This will lead to additional and increasing cost to further realise the "prevention-strategy" which is currently adopted by the food industry in Germany even if very few GM plants are cultivated in Germany and the EU.

References

BLL (2006): Leitfaden Rückverfolgbarkeit; Die Organisation der Rückverfolgbarkeit von Produkten in der Lebensmittelkette. In: www.bll-online.de.

Bock, A.; Lheureux, K.; Libeau-Dulos, M.; Nilsagard, H.; Rodriguez-Cerezo, E. (2002): Scenarios for co-existence of genetically modified, conventional and organic crops in European agriculture. Seville: IPTS.

Costa Font, M.; Gil, J. M.; Traill, B. (2008): Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. Food Policy 33, No. 2, p. 99-111.

Daems, W.; Demont, M.; Sausse, C.; Tollens, E. (2007): Economics of spatial co-existence of transgenic and conventional crops: oilseed rape in central France. Katholieke

Universiteit Leuven, Faculty of Bioscience Engineering; Working paper SIGMEA project

European Parliament and the Council of the European Union (2003a): Regulation (EC) No 1829/2003. Official Journal of the European Union.

European Parliament and the Council of the European Union (2003b): Regulation (EC) No 1830/2003. Official Journal of the European Union.

Gaskell, G.; Allansdottir, A.; Allum. A. et al (2006): Eurobarometer 64.3 – Europeans and biotechnology in 2005: Patterns and trends. Report to DG Research of the European Commission.

GMO Compass (2007): GM maize growing in five EU member states. http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/191.eu_growing_area.html.

Goltermann, S. (2006): Pilzbekämpfung im Getreide. Ergebnisse und Empfehlungen zum integrierten Pflanzenschutz im Ackerbau. Landesamt für Landwirtschaft, Lebensmittel-sicherheit und Fischerei Mecklenburg-Vorpommern – Pflanzenschutzdienst. Landwirtschaftsministerium Mecklenburg-Vorpommern.

Hirzinger, T.; Menrad, K. (2007): Konsequenzen der weltweit zunehmenden Verbreitung gentechnisch veränderter Pflanzen in der Nahrungs- und Futtermittelproduktion in Deutschland. In: Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaus e. V. (2007): Good Governance in der Agrar- und Ernährungswirtschaft. Vol. 42, p. 395-404.

Hirzinger, T. (2008): Auswirkungen der EU-Gentechnikgesetzgebung auf die Lebensmittelindustrie in Deutschland - eine ökonomische Analyse. PhD thesis at the Faculty of Economics of the Technical University of Munich.

Hirzinger, T.; Menrad, K.; Bez, J. (2008): Organisation und Bewertung des erweiterten Qualitätsmanagements bei der Herstellung Gentechnikfreier Produkte am Beispiel der Raps- und Sojaverarbeitung. In: Schriften der Gesellschaft für Wirtschafts- und Sozial-wissenschaften des Landbaus e. V. (2008): Agrar- und Ernährungswirtschaft im Umbruch. Vol. 43, (forthcoming).

Hüsken, A.; Pfeilstetter, A. D. (2007): Pollen-mediated intraspecific gene flow from herbicide resistant oilseed rape (Brassica napus L.). Transgenic Research 16, p. 557-569.

ISAAA (2007): Global status of commercialized biotech/GM crops 2007. Executive summary. ISAAA Brief 37-2007.

Kasamba, E.; Copeland, J. (2007): Economics of co-existence measures of GM and conventional crops: oilseed rape in Fife (Scotland). Central Science Laboratory York. Working paper SIGMEA project

KTBL (2007): Betriebsplanung Landwirtschaft 2006/2007. Kuratorium für Technik und Bauwesen in der Landwirtschaft, Darmstadt.

Menrad, K.; Hirzinger, T. (2005): Akzeptanz gentechnisch veränderter Lebensmittel in der EU - Allgemeine Betrachtung. In: Gassen, G.; Hammes, L. (Ed.) (2005): Handbuch Gentechnologie und Lebensmittel. 8. Aktualisierungs-Auflage, Behr’s Verlag, Hamburg, III.5.1.1 - III.5.1.9.

Menrad, K.; Reitmeier, D. (2006): New case studies on the co-existence of GM and non-GM crops in European agriculture. Economic assessment of co-existence schemes and measures. Science Centre Straubing.

Messéan, A.; Angevin, F.; Gomez-Barbero, M.; Menrad, K.; Rodriguez-Cerezo, E. (2006): New case studies on the co-existence of GM and non-GM crops in European agriculture. Final report to the European Commission.

Reitmeier, D., Menrad, K., Demont, M., Daems, W., Turley, D. (2006): Methods for calculating co-existence costs in agriculture. Report of Science Centre Straubing supported by Catholic University of Leuven and Department of Environment Food and Rural Affairs (DEFRA).

Tollstrup, K.; Bode, S.; Boelt, B. et al (2003): Report from the Danish Working Group on the Co-Existence of genetically modified crops with conventional and organic crops, Tjele: DIAS-Verlag.

Transgen (2007): Meldungen aus der Europäischen Union, In: http://www.transgen.de/aktuell/meldungen_europa/200701.doku.html#435.