Biofortification: Consumer Surplus derived from Experimental Auctions

Biofortification: Konsumentenrente aus experimentellen Auktionen

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Summary

To combat vitamin A deficiency in Kenya, a "biofortified" maize variety, i.e. one with a higher content of beta-carotene, is being bred. The benefits of the biofortified variety is evaluated ex-ante, based on data from an experimental auction. Necessary assumptions include well informed participants, constant price relations, a representative sample and non-diminishing marginal utility of vitamin A. Results show that if the biofortified maize costs the same as the standard plain-white maize, the consumer surplus increases by 4 to 14% of the average maize consumption.
Keywords: consumer surplus, experimental auction, biofortification

Zusammenfassung

Für die Bekämpfung des Vitamin-A-Mangels in Kenya wird eine Maissorte mit höherem Beta-carotin-Anteil („biofortified") gezüchtet. Um den Nutzen der Biofortifikation ex-ante zu bewerten, wird in diesem Artikel die Konsumentenrente aus Daten von experimentellen Auktionen berechnet. Die Ergebnisse bedingen u.a. gut informierte Teilnehmende, konstante Preisverhältnisse, eine repräsentative Stichprobe und ein nicht abnehmender Grenznutzen. Wenn der biofortifizierte Mais gleich viel wie der normale Mais kostet, dann ist die geschätzte Erhöhung der Konsumentenrente Äquivalent zu 4 bis 14% des durchschnittlichen Maiskonsums.
Schlagworte: Konsumentenrente, experimentelle Auktion, Biofortifikation

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1. Introduction

Major staples like rice, maize, cassava and sweet potato are being modified to contain more beta-carotene, which the human body can convert to vitamin A. It is hoped that these "biofortified" varieties will reduce vitamin A deficiency which causes night-blindness and weakens the immune system. Affected are mainly poor lactating women and children in Africa, Asia and Latin America. In Kenya, for example, 24% of the pre-school children suffered from vitamin A deficiency according to the last national survey of 1999 (WHO, 2006).

Because the development of biofortified varieties is expensive, ex-ante studies on their impact are necessary. In this paper we discuss the possible impact of biofortified maize in Kenya as an example. In Kenya the major staple food is plain-white maize meal, but the biofortified variety will, due to the higher beta-carotene content, be yellow. Unfortunately, many Kenyans associate yellow maize with food aid for the poor. One concern about biofortified maize is thus that Kenyans will value the biofortified-yellow maize less. This concern was addressed by experimental auctions to measure the willingness to pay for plain-yellow and fortified-white maize (DE GROOTE et al., 2011). The data from this study is used to discuss how to calculate, ex-ante, the change in consumer surplus due to the introduction of biofortified maize.

It is not the first time the potential of biofortification is analyzed: MEENAKSHI et al. (2010) did a cost-effectiveness analysis of biofortification for a variety of crops in 12 countries. Their analysis is based on DALYs (Disability-Adjusted Life Years) – a weighted sum of accumulated life improvement and life extension achieved through biofortified crop varieties. MEENAKSHI et al. (2010) estimate the costs per DALY to be between US$ 18,- and US$ 113,- for biofortified maize in Kenya. This is cautiously compared to the estimated costs of the provision of vitamin A capsules of US$ 12,- per DALY and fortification (artificial vitamin A addition to industrially processed food) of US$ 20,- to US$ 55,- per DALY. Which approach is more cost-effective is thus unclear for maize in Kenya. These cost-effectiveness studies are top down approaches which are built on scientific results. Their aim is to measure the change in DALYs instead of measuring the preferences of the population.

Other studies focused on the preferences of the target population and use sophisticated elicitation mechanisms, such as experimental auctions, to determine consumers' choices (DE GROOTE et al., 2011). They estimated the willingness to pay (WTP) for plain-yellow and fortified-white maize meal, but did not proceed to estimate the change in consumer surplus. LUSK and MARETT (2010) demonstrated that consumer surplus estimates from experimental auctions are possible. But they derived it only for a ban of hazardous technologies and labeling, but not for the introduction of a new variety.
In what follows it is assessed which assumptions are necessary to calculate consumer surplus changes from experimental auction data. Improvements in the data collection are proposed and first estimates of the consumer surplus change through biofortification based on revealed behavior are given.

2. Conceptual Framework

Experimental auctions are used extensively by researchers to elicit the willingness-to-pay (WTP) for food which has been genetically modified, organically produced, or irradiated. The popularity of experimental auctions is likely to be related to their straightforward interpretation: the bids collected from the participants are interpreted as the maximum marginal WTP.
Estimation of consumer surplus changes are hardly ever part of the experimental auction studies. This issue has been taken up, among others, by LUSK and MARETT (2010) and they estimate consumer surplus changes from a ban and labeling of methylmercury fish and cloning technology in beef production. They define $WTP_{i,R}$ as the WTP of consumer i for the regular product and $WTP_{i,N}$ as the WTP for the new product. Their prices are P_R and P_N, respectively. Before the introduction of the new product, the consumer surplus from one unit of the regular product for consumer i is

$$(1) \qquad CS_i^{before} = max\{WTP_{i,R} - P_R \, , 0\}$$

The surplus is thus the difference between the WTP and the price if it is positive, or alternatively, if it is negative it is zero because the product is not bought.

After the introduction of the new product, the consumer can decide between the regular product, the new product and neither of them. The consumer surplus is thus

$$(2) \quad CS_i^{after} = max\{WTP_{i,R} - P_R \,, WTP_{i,N} - P_N \,, 0\}.$$

The consumer is assumed to choose the product which yields the highest surplus if at least one of them is positive. Otherwise none of them is consumed and the consumer surplus for these products is zero. The change in consumer surplus for the average of the total L persons of which each consumes N_i goods is

$$(3) \quad \Delta CS = \frac{1}{L}\sum_{i=1}^{L} N_i\{CS_i^{after} - CS_i^{before}\}\,.$$

Clearly, the change in consumer surplus cannot be negative through the introduction of a new product. Possible negative externalities, such as soil degradation from an increased maize cultivation, are not considered.

The calculation of the average change in consumer surplus from experimental auction data rests on several critical assumptions. The main concern in most experimental auctions is the internal validity of collected bids[1]. The external validity, i.e. how well the elicited preferences can be generalized to populations at different places, times and circumstances is rarely discussed.

For the calculation of consumer surplus four assumptions are particularly relevant. First, consumers must rationally consider all impacts of the consumption of a product when bidding and their preferences must be stable. For example, participants have to be able to determine whether the consumption of more beta-carotene increases health. Similarly, uncertainty in the effectiveness of biofortification and discounting of future benefits is part of the evaluation process. Second, the price relations assumed for the products already in the market are assumed not to change when the new food variety is introduced,

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[1] For a discussion of the internal validity of experimental auctions in the African context see MORAWETZ et al. (2011).

because the WTP for a characteristic of a new product, depends on the price of substitutes. If, for example, vitamin A capsules are freely distributed, the WTP for fortified maize meal will be reduced, thus reducing the consumer surplus from the fortified maize meal. Third, for a prediction of the change in consumer surplus for the population, the sample must be representative for the population over space, time and circumstances. Fourth, marginal utility of the product characteristic of interest does not decrease with repeated consumption or it must be measured and accounted for.

3. Method and Data

The consumer surplus is calculated with data collected by a variant of the BDM (Becker-DeGroot-Marschak) mechanism to measure the WTP for plain-white, fortified-white, and plain-yellow maize in Kenya as described in DE GROOTE et al. (2011). The data were collected in the years 2005/06 and 2009 in the provinces Siaya and Vihiga in Western Kenya and Machakos and Makueni in Eastern Kenya. The first two provinces were selected because yellow maize is regularly consumed there. The two provinces in Eastern Kenya due to good accessibility, and because they allowed to collect data from an urban environment. In 2005/06 a total of 100 persons were surveyed in Siaya and Vihiga, 200 in rural Machakos and Makueni, and 200 in Machakos Town. In 2009 another 151 consumers were surveyed in Machakos Town.

The market prices used in the analysis were collected during the surveys. For plain-white maize meal, the price was 10% lower in Western Kenya than in Eastern Kenya. In 2009 the price for plain-white maize meal in Eastern Kenya was 60% higher than in 2005/06. Yellow maize meal was only available in Western Kenya where it costs as much as plain-white maize.

The bids from the BDM mechanism revealed a premium for fortified-white maize of up to 30% (see Figure 1 which is based on data from DE GROOTE et al. (2011)). In Eastern Kenya there was a discount for plain-yellow maize between 11 and 15%. In Western Kenya, in contrast, there was a much smaller discount (5%) or even a premium (4%) for the plain-yellow maize. The increase in food prices in 2009 was reflected in generally higher bids in 2009 (between 67% for fortified-white and 84%

for plain-yellow maize). The average consumption of maize is assumed to be 103 kg/person per year as reported by (PINGALI, 2001).

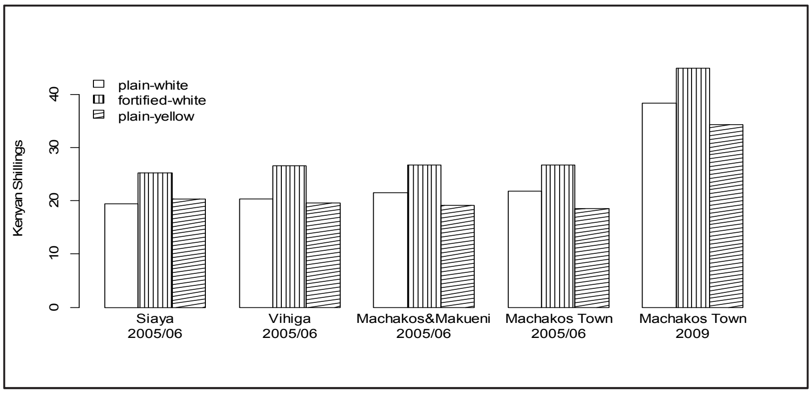

Fig 1: WTP for 1 kg of different maize meal varieties.
Source: Data from DE GROOTE et al. (2011)

To calculate the change in consumer surplus through the introduction of biofortified-yellow maize, it is assumed that the WTP for biofortified-yellow maize is a combination of the WTP for plain-white, fortified-white and plain-yellow maize. Then, the WTP for biofortified maize is the WTP for plain-white maize, reduced by the WTP discount for the color yellow and increased by the premium for fortification. Based on this WTP for biofortified-yellow maize, the scenarios discussed in this paper, are the consumer surplus when the price for biofortified-yellow maize equals the price for plain-white maize, when its price is 20% higher than for plain-white maize, and when it is 20% lower.

4. Results

The change in consumer surplus resulting from the introduction of biofortified maize is substantial. It is highest in Western Kenya because consumers there like yellow maize. Figure 2 shows the distribution of the consumer surplus before and after the introduction of biofortified maize in the sample, under the assumption that the biofortified-yellow maize costs the same as the plain-white maize. In Western Kenya the

consumer surplus of over 85% of the participants increased. In Eastern Kenya the consumer surplus of over 40% of the participant increased.
On average consumer surplus increase would be 364 KShs (equivalent to 15.5 kg plain-white maize) per year in Siaya and slightly less in Vihiga (Table 1). The average consumption of 2 kg maize per week per person puts this in perspective. In Eastern Kenya, where consumers do not like yellow maize, the change in consumer surplus would be

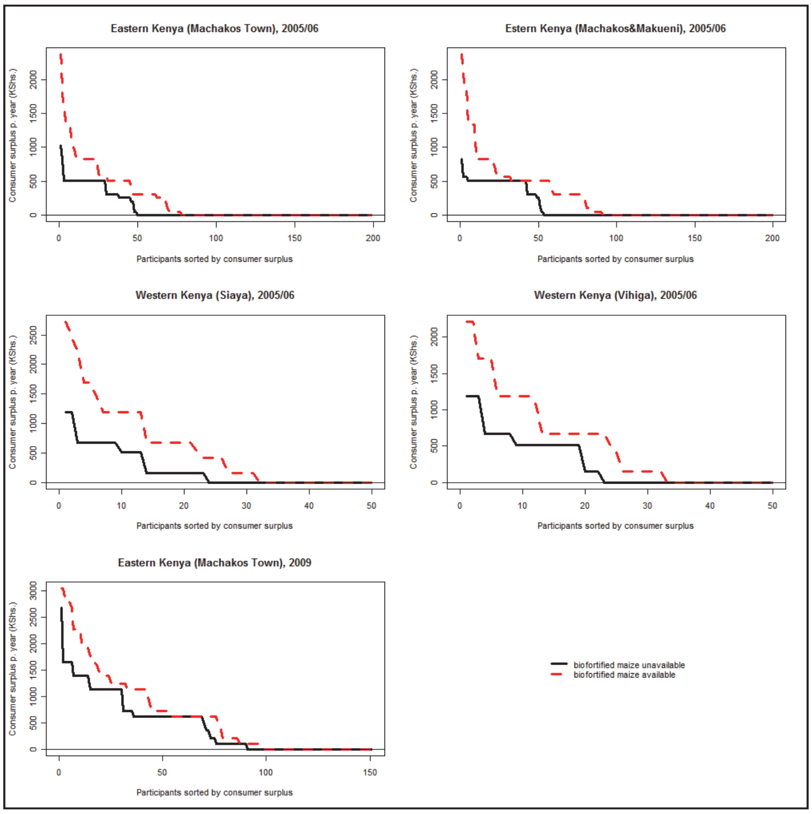

Fig.2: Consumer surplus with prices of biofortified-yellow maize equal to plain-white maize.
Source: Own calculations

substantially less (equivalent to 4.3 kg of plain-white maize for Machakos Town in 2005/06 and 2009). If the price of biofortified-yellow maize meal was 20% higher than the price for plain-white maize meal, the change in consumer surplus would be between 153 KShs (equivalent to 6.5 kg plain-white maize) in the Western Kenya and 38 Kshs (equivalent to 1.4 kg plain-white maize) in Eastern Kenya. If the price of biofortified maize meal was 20% lower than the price for plain-white maize, the change in consumer surplus would be between 670 KShs (equivalent to 28.5 kg plain-white maize) in Siaya in Western Kenya and 331 (equivalent to 12.2 kg plain-white maize) in Machakos Town in Eastern Kenya in 2005/06.

Tab.1: Consumer surplus under three scenarios

Assumed price of biofortified-yellow relative to plain-white maize:	**equal**		**+20%**		**-20%**	
Measured in:	KShs	Maize (kg)	KShs	Maize (kg)	KShs	Maize (kg)
Western Kenya:						
Siaya (2005/06)	364	15.5	153	6.5	670	28.5
Vihiga (2005/06)	281	12.0	107	4.5	568	24.2
Eastern Kenya:						
Machakos & Makueni (2005/06)	135	5.0	45	1.7	369	13.7
Machakos Town (2005/06)	117	4.3	38	1.4	331	12.2
Machakos Town (2009)	188	4.4	59	1.4	560	13.0

Source: Own calculations

These results depend on critical assumptions which can best be addressed before the data have been collected. Since the derivation of the consumer surplus was not planned at the time our experiments were run, these have only been partially addressed.

First, the WTP for vitamin A was taken as a well defined value of the participants in the survey. A thorough discussion with the participants might very well have altered their evaluation of vitamin A and color. Such a discussion is part of "valuation workshops" proposed to make the process of preference formation an integral part of the WTP measurement (HANLEY and SHOGREN, 2005). Second, if the price of alternative vitamin A sources changes, this changes the consumer surplus of biofortified-yellow maize. Estimating the marginal rate of substitution for the most important substitutes and doing a sensitivity analysis to price changes might be a feasible remedy. Third, a representative sample is needed for a generalization to a wider population. Our data cover a wide range of persons at different times of day. Due to random sampling, it is representative for shoppers in Machakos Town and for farmer in the rural areas. However, seasons are not represented as all data were collected within a couple of weeks. This limits the generality for the WTP over the whole year. Fourth, vitamin A has diminishing marginal benefits for the body (MEENAKSHI et al., 2010) which could lead to a diminishing marginal WTP for (bio)fortified maize. This could, in theory, be tested. Practically, though, marginal WTP for additional products is hard to measure as the marginal WTP is influenced by the endowment of the participants (CORRIGAN and ROUSU, 2006). More work on an appropriate procedure is necessary.

5. Conclusions

A procedure to calculate the average change in consumer surplus resulting from the introduction of biofortified maize is discussed. In a scenario where the price of biofortified maize equals the price of the plain-white maize, an increase in consumer surplus of at least equal to over 10% of the annual maize meal consumption was found, for the two regions where consumers usually do eat yellow maize. For the regions where consumers usually do not eat yellow maize the consumer surplus was found to be more than 4% of the maize meal consumption. The value of the findings is likely to be improved if valuation workshops, changes in price relations, the variation of prices over the season and the diminishing marginal utility of vitamin A are explicitly addressed. The method to determine the benefit of biofortified maize from experimental auction data provides a bottom-up process, which – so far – has not been applied to this question. If the calculated consumer surplus is combined with cost estimates already available (MEENAKSHI et al., 2010), the existing cost-effectiveness analysis could be supplemented by cost-benefit analysis.

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