Journal of Innovation & Knowledge 2 (2017) 87–89

Journal of Innovation & Knowledge

www.elsevier.es/jik

Empirical paper

Genetic engineering represents a safe approach for innovations improving nutritional contents of major food crops

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ARTICLE INFO

Article history:
Received 20 February 2017
Accepted 21 February 2017
Available online 28 March 2017

JEL classification:
L65

Keywords:
Genetic engineering
Hunger
Biotechnology
Genetically modified (GM)

ABSTRACT

About 70 years ago early microbial genetic research revealed that inherited phenotypic traits become determined by DNA filaments composed of 4 different nucleotides that are linearly arranged. In the meantime we know that genes, the determinants of specific life functions, are genomic segments of an average size of about 1000 nucleotides, i.e. a very small part of a genome. Fundamental insights into the structures and functions of selected genes can be reached by sorting out the relevant short DNA segment, splicing this fragment into a natural gene vector such as a viral genome or a fertility plasmid. This allows the researchers to transfer the genetic hybrid into an appropriate host cell in order to produce many copies that can then serve for functional and structural analysis. This research approach became efficient in the 1970s. On the request of involved researchers, safety guidelines became proposed 1975 at the Asilomar Conference on Recombinant DNA (Berg, Baltimore, Brenner, Roblin, & Singer, 1975), then generally introduced and still largely followed nowadays. Carefully carried out genetic engineering by horizontally transferring a selected and functionally well known DNA segment into the genome of another organism has in many published biosafety investigations never shown any unexpected harmful effect. We will present below selected examples of research contributions enabling innovations for the benefit of human life conditions.

La ingeniería genética representa un enfoque seguro para las innovaciones mejorando el contenido nutricional de las grandes culturas alimentarias

Códigos JEL:
L65

Palabras clave:
Ingeniería genética

RESUMEN

Hace unos 70 años, la investigación genética microbiana inicial reveló que los rasgos fenotípicos heredados se determinan mediante filamentos de ADN compuestos por 4 nucleótidos diferentes que están dispuestos linealmente. Mientras tanto, sabemos que los genes, determinantes de las funciones específicas de la vida, son segmentos genómicos de un

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http://dx.doi.org/10.1016/j.jik.2017.02.002
2444-569X/

Hambre
Biotecnología
Modificado genéticamente (MG)

tamaño promedio de aproximadamente 1.000 nucleótidos, es decir, una parte muy pequeña de un genoma. Pueden alcanzarse ideas fundamentales sobre las estructuras y funciones de genes seleccionados, ordenando el segmento corto de ADN relevante, empalmando este fragmento en un vector génico natural tal como un genoma viral o un plásmido de fertilidad. Esto permite a los investigadores transferir el hıbrido genético a una célula huésped apropiada con el fin de producir muchas copias que luego pueden servir para el análisis funcional y estructural. Este enfoque de investigación se hizo eficiente en la década de 1970. A petición de los investigadores implicados, las directrices de seguridad fueron propuestas en 1975 en la Conferencia de Asilomar sobre ADN Recombinante (Berg, Baltimore, Brenner, Roblin, & Singer, 1975), entonces se generalizó su introducción que se mantienen en gran medida hoy en día. Llevada a cabo cuidadosamente, la ingeniería genética cmediante la transferencia horizontal de un segmento de ADN seleccionado y funcionalmente bien conocido en el genoma de otro organismo, ha demostrado en muchas investigaciones de bioseguridad publicadas, que nunca se han observado efectos perjudiciales inesperados. A continuación, presentaremos ejemplos seleccionados de contribuciones de investigación que permiten innovaciones en beneficio de las condiciones de vida humana.

Prevention of hidden hunger by genetic engineering of major food crops

It is thanks to nutritional research carried out in the last two centuries that we acquired better knowledge on the quality of our daily diets and on possibilities to improve them. It is relatively recently that solid insights were reached on the importance of the steady availability of micronutrients in our body. These are small elements and molecules such as several essential chemical elements and vitamins. When important sources of energy are lacking in our bodies we feel hungry. But in the absence of an essential micronutrient no hunger is felt, although some important life functions may not be carried out properly. This is called “hidden hunger”. A good example is abnormal neurological developments in the embryo and early childhood in the absence of vitamin A. It is not possible to correct aberrant structures by feeding vitamin A to the suffering child, who has a high risk to become blind and to die in his childhood. This tragic situation is widespread among poor populations in parts of Indonesia and of Africa, where farmers produce rice to secure their own major daily food. It has become known that rice seeds contain no vitamin A so that their strong consumers must suffer from hidden hunger with its dramatic effects on the consumers health. Genetic engineering succeeded already 20 years ago to provide to the rice crop the capacity to incorporate into its seeds a precursor of vitamin A (Potrykus & Ammann, 2010). This becomes visible by a yellow color. These genetically modified (GM) plants are therefore called Golden Rice. Their expected prevention of the here described negative health effects by hidden hunger have so far not been confirmed by allowing suffering populations to eat Golden Rice seeds daily.

Possible roots of the widespread public opposition to consume GM food crops

As we have already mentioned, the possibility of existing biosafety risks of GM organisms had been discussed in 1975 at the Asilomar Conference on Recombinant DNA. Press representatives were invited to follow the scientific debates leading to request the introduction of binding guidelines. Press reports on the Conference and its proposals became widely spread and must have contributed to a still widespread opposition to consume GM crops and their products in order to prevent any largely unknown “danger”. Wide parts of the public and of political leaders have so far not noted, that intensive worldwide biosafety research could not confirm any negative effect of GM crops.

Comparison of procedures and biosafety of classical and of modern biotechnology

We can define biotechnology as taking advantage of identified biological functions. In the long-range past, classical biotechnology used living organisms as they had been found in nature. Think on the domestication of plants and of animals when agriculture became introduced about 10,000 years ago. In recent centuries both plant and animal breading strategies succeeded to improve biological properties and sometimes the yield of used products. Still more recently, scientific research revealed that irradiation of breeding partners increases the chance of finding in breeding experiments welcome improved and also novel properties. In the recent decades, irradiated breeding partners yielded many of nowadays generally used improved food crops. However, no biosafety study has systematically investigated the nucleotide sequence of the entire genome of the selected organism for the presence of novel mutations to be attributed to the irradiation.

In contrast, the horizontal transfer of a particular, functionally well known gene by genetic engineering is by all likelihood not causing any unpredicted risk of the resulting hybrid after a quality investigation before its use for nutritional purposes. This comparison leads to the conclusion that carefully produced GM crops can be expected to have no biosafety risk. This contrasts with generally ignored DNA sequence alterations that must exist in any variant obtained by breeding experiments using irradiation of the breeding partners.

Biodiversity can serve as a source to domesticate genes of use for mankind

The present-day very rich biodiversity on our planet Earth as a result of long-lasting biological evolution is likely to contain numerous genes that produce products that could find a welcome use by the human population. Most organisms carrying such genes cannot become domesticated in order to produce high quantities of the gene product of interest. However it is principally possible to isolate the relevant gene and to insert it by genetic engineering into another organism, often a microorganism or a eukaryotic cell, that can be expected to multiply the transferred gene and to allow it to express its product. An interesting example besides GM crops is the domestication of the genetic information carried in the genome of some spiders and serving to generate high quality fibers for constructing their web. It has recently been possible to transfer the relevant genetic information into a bacterium, which can now efficiently produce highly valuable spider silk filaments (Rech & Arber, 2013; Teulé et al., 2009).

Conclusions

Carefully undertaken genetic engineering represents a very safe method to enrich particular important food crops for essential nutritional contents. This can in principle serve to enrich any frequently consumed food crop by taking into account traditional habits of human populations. It remains an important task to inform wide parts of consumers and in particular politicians of the advantage and biosafety of eating functionally improved foods. As it was recently shown, genetic engineering can also domesticate any other gene of interest for mankind.

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