Benefits of Edible Plant Vaccines[1,2]

- Edible means of administration

  Because the vaccines' delivery is painless (there is no needle!), people may be more willing to receive the vaccine, especially children.

- Reduced need for medical personnel and sterile injection conditions

  Because needles are not used, there is no risk of an accidental needlestick (and possible transmission of disease) to the people giving the vaccines. Additionally, an edible vaccine will not necessarily require trained medical personnel to deliver. This fact is an important consideration in developing countries where doctors are not always available.

- Reduced costs to mass-produce and transport

  Plants can be grown cheaply and in large quantities, and they can be shipped easily.

- Heat stability

  Vaccines made from plants are more stable and are less affected by high temperatures, reducing the need for refrigeration during transport and onsite storage. This fact is important in rural areas where electricity is not readily available to refrigerate samples.

- Subunit vaccine

  Vaccines produced from plants contain only a part (or a subunit) of the disease-causing organism. For this reason, there is no chance of actually getting the disease. That finding is not necessarily true of vaccines that are made from the whole organism (referred to as live or attenuated vaccines).

Endnotes:

1. Diane E. Webster, Merlin C. Thomas, Richard A. Strugnell, Ian B. Dry, and Steve L. Wesselingh, "Appetising Solution: An Edible Vaccine for Measles," *Medical Journal of Australia* 176, no. 9 (2002): 434–37.
2. Hugh S. Mason, Heribert Warzecha, Tsafrir Mor, and Charles J. Arntzen, "Edible Plant Vaccines: Applications for Prophylactic and Therapeutic Molecular Medicine," *Trends in Molecular Medicine* 8, no. 7 (2002): 324–29.

Risks of Edible Plant Vaccines[1,2]

- Oral tolerance

  Repeated exposure to oral (taken by mouth) antigens may result in oral tolerance. Oral tolerance is when your body no longer responds to antigens that are ingested repeatedly. In the case of oral vaccines, this repetition would lead to people's becoming immune to the vaccine and, therefore, being susceptible to the disease.

- Accumulation of enough antigens

  The plant must be able to produce antigens (vaccine) in sufficient quantity. Ideally, you would want a normal serving size of the food to contain the correct dosage. For example, it would be unrealistic to expect a person to eat 30 bananas in one sitting to obtain the correct dosage of a vaccine.

- Public perception of genetically modified organisms

  People may not consider an edible vaccine made from a **transgenic** plant a viable option if they are opposed to consuming genetically engineered organisms.

- Transfers of genes to nontarget organisms

  There are concerns that plants genetically engineered for use as a vaccine may interbreed with crops that are not intended for vaccine usage. Furthermore, herbivores (animals that eat plants, such as cows) and other organisms that eat the plant material (sucking insects, soil microbes) may then be exposed to the antigen.

- Dosage

  The amount of antigen in each plant could vary, making it difficult to determine the correct dosage for each patient.

Endnotes:

1. Diane E. Webster, Merlin C. Thomas, Richard A. Strugnell, Ian B. Dry, and Steve L. Wesselingh, "Appetising Solution: An Edible Vaccine for Measles," *Medical Journal of Australia* 176, no. 9 (2002): 434–37.
2. Hugh S. Mason, Heribert Warzecha, Tsafrir Mor, and Charles J. Arntzen, "Edible Plant Vaccines: Applications for Prophylactic and Therapeutic Molecular Medicine," *Trends in Molecular Medicine* 8, no. 7 (2002): 324–29.

Creation of an Edible Plant Vaccine

(Questions and considerations to address when making your oral presentation and using your poster as a visual aid)

- What is the name of your transgenic plant?

- Describe the transgenic organism, and describe where the vaccine proteins are produced (stem, fruit, leaves). Explain why you chose this particular type of plant. You can refer to the list of plants and some of their advantages and disadvantages in Table 1 when choosing the type of plant to use for your vaccine.

- What is the purpose of your edible plant vaccine (or transgenic plant)? What type of disease does it protect against?

- What are the benefits of this transgenic organism?

- What are the risks of this transgenic organism?

- In what country do you plan to market this plant-based vaccine? Why?

Creation of an Edible Plant Vaccine (continued)

Table 1. Examples of Plants That Can Be Used to Produce Edible Vaccines, plus Advantages and Disadvantages for Each Species[1] (Remember that vaccines produced from plants are proteins.)

Plant	Advantages	Disadvantages
Tobacco	Transformation process (insertion of new genes into plant) is efficient. Plant produces large quantities of proteins.	Plant is toxic when eaten. Potential exists for outcrossing (breeding with other non-genetically modified plants) in field.
Potato	Plant can be eaten raw. Plant can be grown as a clone (no fertilization with other plants, which decreases risk of mixing with other plants).	Plant has a relatively low quantity of proteins (vaccine). Raw potatoes taste bad, and cooking could destroy proteins.
Tomato	Transformation process (insertion of novel genes into plant) is efficient. Fruit is edible raw. Greenhouse production is well established.	Plant has relatively low fruit protein (vaccine) content. Acidic fruit may damage certain vaccines and may be unhealthy for some people (such as babies).
Banana	Plant is grown widely in developing countries where vaccines are badly needed. Plant can be eaten raw by infants and adults.	Transformation process (insertion of novel genes into plant) is inefficient. Lots of space is required for growth. Plant is expensive to grow in greenhouse.
Legumes or cereals	Production technology is widely established. High protein (vaccine) content exists in seeds. Protein (vaccine) remains stable in seeds during storage.	Transformation process (insertion of novel genes into plant) is inefficient. Heating or cooking would destroy vaccine protein. Potential exists for outcrossing (mixing with plants not intended to contain vaccine) in field for some species.
Alfalfa	Transformation process (insertion of novel genes into plant) is efficient. High protein content exists in seeds. Leaves are edible uncooked.	Potential exists for outcrossing in field. Plant produces deep roots that are hard to get rid of after plant is harvested.

Endnotes:

1. Hugh S. Mason, Heribert Warzecha, Tsafrir Mor, and Charles J. Arntzen, "Edible Plant Vaccines: Applications for Prophylactic and Therapeutic Molecular Medicine," *Trends in Molecular Medicine* 8, no. 7 (2002): 324–29.

Rubric for Assessing Students' Poster and Oral Presentation

Criteria for Evaluations	Score
• Transgenic plant is represented with graphics or pictures. • Reasons for choice of plant are clearly addressed both orally and visually on poster. • Graphics or pictures are labeled clearly and accurately. • Students consistently refer to and use poster as an effective visual aid during presentation. • Both risks and benefits of their transgenic plant are clearly addressed, both on poster and during oral delivery (presentation is not biased).	4
• Transgenic plant is represented with graphics or pictures. • Reasons for choice of plant are clearly addressed, either orally or visually on poster. • Graphics or pictures are labeled but may not be clear and accurate. • Students refer to and use poster as a visual aid during poster presentation, but could use it more effectively. • Risks and benefits of their transgenic plant are addressed, either on poster or during oral delivery (presentation is not biased).	3
• Transgenic plant is represented with graphics or pictures. • Reasons for choice of plant are addressed, either orally or visually on poster. • Students occasionally refer to and use poster as a visual aid during presentation. • Presentation is biased, addressing only risks or only benefits of transgenic plant in poster or oral delivery or both.	2
• Transgenic plant is not clearly represented with graphics or pictures. • Reasons for choice of plant are not clearly addressed, either orally or visually on poster. • Graphics or pictures are not labeled accurately. • Students fail to refer to and use poster as a visual aid during presentation. • Presentation of risks and benefits of their transgenic plant is biased, or risks and benefits are not addressed at all.	1