Motherhood is a core of the life-maintaining system. Delivering babies is the key function in the continuity. Therefore, each generation usually supports its offspring by all means available. Bird eggs provide perfect confinement for developing chicks. These “unit packages” give the protection needed for the developing embryo. Their inner structure contains everything that is needed for growth and survival during the first weeks of life [Figure 1].

From the human point of view, the many uses of chicken in human nutrition, in addition to being a component of cosmetic or pharmaceutical products, have been illustrated [1]. In the medicinal or diagnostic realm, avidin proteins of the egg white and the chicken egg yolk antibody (IgY) have been widely used. This extended maternal protection of little chicken could thus be extended for the benefit of humans [Figure 2].

The egg white, for example, surrounds the embryo and the egg yolk. It contains avidin protein, which specially binds biotin. The tetrametric avidin molecule is specifically binding the biotin (vitamin B7). This vitamin is essential for microbial growth. The binding of the vitamin to the homotetrameric subunits of the avidin molecules could prevent the microbial protrusion into bird eggs and oviducts. Since the avidin-biotin complex is one of the strongest non-covalent bonds, it is effectively depriving biotin out of the reach of microbes [2]. Due to this effective binding, this complex is applied for molecular diagnostics [3]. Avidin occurs in the birds only, not in mammals. Passive immunization is the mechanism by which the essential elements of immunity—the antibodies—are obtained for the new-born babies as their first-line immunity from outside their body system. Human fetuses receive these antibodies from their mother through the placenta, which also keeps up the circulation of the growing fetus. The antibody molecules are transferred from the mother by blood. This kind of sanguineous support of the developing mammalian fetus is lacking from the bird embryo, which needs to include all the substances for

**Chicken IgY Antibodies Provide Mucosal Barrier against SARS-CoV-2 Virus and Other Pathogens**

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**ABSTRACT**

This mini review includes two case descriptions. It introduces the use of chicken egg yolk antibody (IgY) solutions in the prevention and cure of viral and bacterial infections. Application for the protection against severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), rotavirus, and influenza viruses, as well as for the eradication of *Pseudomonas aeruginosa*, carries, various enteric bacteria and other pathogens, and toxins have been developed. This approach is a fast, reliable, safe, and tested method for producing molecular shield and protection against emerging pathogens and epidemics. In the current pandemic situation caused by coronavirus disease-2019 (COVID-19), this method of passive immunization could be applied for rapid protection against modifiable agents. The specific IgY antibodies start to accumulate into egg yolks about 3 weeks after the immunization of the chicken. The product can be collected safely, as the antigen is not found in the eggs. This method for microbial safety uses natural means and commonly used food substances, which have been tested and could be produced for both blocking epidemics and applying personalized medicine.

**KEY WORDS:** coronavirus disease-2019 (COVID-19), egg yolk antibodies, epidemics, passive immunization, personalized medicine

The passive immunization by chicken egg yolk antibodies is a proven and safe method that could be developed to complement vaccination provided it is not ruled out by excessive regulation.
early growth from within the egg. In addition, the protective antibodies have to be present. Thus, the chicken and other birds have a special kind of passive immunization for the protection of the new generation. The corresponding molecular type of antibodies is designated as IgY, which are included in the egg yolk.

CHARACTERISTICS AND USE OF THE IGY IMMUNOGLOBULINS
The IgY antibodies resemble the human IgA immunoglobulins and they form a protective layer on the human epithelia, thus offering a potential use in immunoprotection. This method was used against viruses almost 30 years ago [4]. The affinity of the IgY molecules toward specific spike protein antigen epitopes could bind the SARS-CoV-2 virus like a magnet, thus preventing it from entering the human cells. Accordingly, the IgY molecules can be used for the shielding of respiratory, oro-pharyngeal, or digestive surfaces, for instance. Immunoglobulin A (IgA) is a complete natural immunoglobulin, which is a normal food component in the egg yolk. In contrast to the bivalent IgG molecules in the blood, it is monovalent, which prevents immunoagglutination. Other than these characteristics, IgY does not penetrate into the system. All of these attributes make IgY one of the safest possible therapeutic agents. About 25 years ago researchers proposed it as a means of blocking respiratory virus infections by one daily dosage [5]. The portion could be delivered by sprays, liquids, or in sweets. It proved to spread all over the upper oro-pharyngeal epithelia [6]. One egg-laying hen produces about 280 eggs annually. In Finland, we have approximately 3.9 million hens. One egg contains 1–10 therapeutic portions.

PASSIVE IMMUNIZATION AND PROTECTION AGAINST PANDEMICS
The situation with the coronavirus disease-2019 (COVID-19) pandemic has caused an urgency of action and the need for protective measures. The major strength of passive immunization is the fast production of antibodies against newly emerging pathogens and the variants.

The following examples of passive immunization include:
• In previous experiments, such as in Sweden and Finland, passive immunization has offered some sick individuals instant help for survival in devastating bacterial infections, which were impossible to cure with antibiotics.
• In Hanoi, Vietnam, there is a clinic which has 200 chickens producing antibodies for their patients.
• In China, IgY was used for producing antibodies against SARS CoV-1 virus in 2006 [7].
• In USA year 2020 Tulane National Private Research Center, Covington, LA; New York State Department of Health, Albany; Walter Reed Institute, MD; Mapp Biopharmaceutical Inc., CA; and University of Texas (Dallas) showed that they were able to protect Rhesus macaques with passive immunization using monoclonal antibodies against acute respiratory distress syndrome caused by ricin toxin [8]. However, the monoclonals usually contain only parts of the immunoglobulins.
• In Japan, protection of rats against dental caries (1991) and humans against caries-related bacterial dental plaque formation was achieved by passive immunization using IgY [9,10].
• WHO and two Australian universities (Sydney and New South Wales) published a review in 2016 about passive immunization against influenza [11].
• In the late 1990s in Finland, the authors demonstrated the wide distribution of IgY antibodies against Francisella tularensis, a hazardous respiratory pathogen, in the human mouth and pharyngeal tract when added in candies [6].

Researchers at Finnoflag Oy, a research and development company, as well as at the Universities of Helsinki and Eastern Finland and other Finnish universities, have a long history of investigations on the microbial antigenic epitopes [12–14]. Several hen houses could be mobilized for the production of the anti-COVID-19 IgY-antibodies. Researchers could use weakened viral antigens for the immunization. In Finland, some companies have facilities for the hygienic industrial separation of egg yolk material. The project for obtaining IgY for oral antidote could start as an experimental project in which regulatory affairs are solved quickly.

The IgY molecules provide effective molecular protection on the human epithelial membranes. This effect has been tested both in the digestive and respiratory tracts, as well as in the mouth and pharyngeal mucosal membranes. In June 2019 Prof. Philippe Sansonetti from the Pasteur Institute, Paris, stated that the latter upper airways and mouth define the microbiome constitution in the lower tracts. The effects of immunological reactions certainly contribute to this development.
The author discussed with Prof. Emer. Jukka Finne of the Helsinki University, a biochemist and immunologist, this initiative. He was interested in the possibility of contributing to the research in human protection against COVID-19 in this fast and effective way. He also suggested that the IgY antibodies could be used for the neutralization of viruses in the patient stools and other secretions.

Prof. Finne’s advice could provide a triple barrier against the spread of disease. Some of the main ideas include:

• Prevention of the spread of viruses into air, surfaces, and wastewater from diseased individuals
• Become a barrier of the mucosal epithelial membranes by IgY (e.g., in Finland there are more than 400,000 healthcare and social services personnel who need this protection)
• Inactivation of the contamination of further tissues, cells, and organs by the SARS-CoV-2 or other respiratory or alimentary pathogen.

One important use could be the prevention of the virus contamination at homes where the less severe cases are treated. The chicken eggs in Finland and Sweden are the cleanest in the world. They are almost free of salmonellae, and contamination can easily be prevented. The IgY purification process removes the potent allergen, the albumin protein, which causes reactions in 1% of the population.

Phases of the industrial process:
1. Antigen isolation and production (weakened or synthetic viral antigen)
2. Immunization of the chicken
3. Antibody collection and purification
4. Production of the passive immunization antibodies and protocol for their applications
5. Distribution of the product

Once the mass production of IgY antibodies has been established, it could provide protection against future pandemics of the possibly modified SARS-CoV-2 viruses and other pathogens and epidemics.

Two Patients Treated with IgY
Bacillus species bacteria are the ultimate survivors in the Negev desert. They are almost the only remaining microbial strains if the soil ecosystem is distorted. A similar type of dysbiotic condition may remain in the digestive tract.

Some of the Bacillus species, including Bacillus cereus, produce various toxins [15]. They could sometimes take over space in the human intestines. This condition happened to a middle-aged Finnish woman. In 1983 she had travelled in Israel. The group members contracted food poisoning from spoiled grilled meat. She did not recover from this episode, but developed allergies to many food substances, including milk and gluten. In 2016 her condition worsened and she sent stool samples to our laboratory. The only finding was the aggressive growth of B. cereus [Figure 3]. A Texas laboratory had also found the total lack of lactic acid bacteria in her intestines. She endured fatigue and various neurological symptoms. Since her condition was life-threatening, and standard treatments against Crohn’s disease did not cause any improvement, we produced an antigeneic solution of her B. cereus using the mild hydrochloric acid extraction [16]. A chicken was immunized with this extract using Freund's Complete Adjuvant (FCA) (50:50). After the treatments with the IgY was obtained, her gut microflora reverted into a more versatile one, and the B. cereus was outcompeted.

Another middle-aged woman and a mother of adult children had undergone surgery for colonic cancer in 2014. In 3 years the primary disease had remitted, but she still presented with devastating circumstances, including chronic fatigue, diarrhea four to six times daily, and many neurological symptoms. In the microbiological tests at the Finnoflag Oy’s laboratory in Finland, it was determined that her coliform microflora was lacking the dualistic balance between the mixed-acid fermenting and neutral substances producing metabolic groups [17]. This balance is important in preventing excessive growth of harmful bacteria [18]; therefore, it seemed possible that the highly abundant staphylococci in the stools implied high levels of toxin formation in the intestines. This condition could lead to the kind of symptoms that the patient was presenting. By using carefully selected immunization protocol for chicken, we were able to obtain prophylactic IgY antibodies against her staphylococcal isolates, which returned the alimentary balance of the patient, as well removed her symptoms due to the imbalance. In the microbiological analysis, the numbers of Escherichia coli (a mixed-acid fermenting species) and Klebsiella species were in balance. Also, the staphylococci had disappeared from the stool samples.

Figure 3. Dysbiotic Bacillus cereus growth on the ChromAgar™ (Becton Dickinson Inc., USA) plates, from fecal samples of a patient in a life-threatening situation.
DISCUSSION

The idea of passive immunization is old, and it has been used against contagious diseases for a long time [19,20]. In the current health situation, where COVID-19 has become a pandemic, passive immunization with chicken egg yolk antibodies should be rapidly accepted as a preventive method and for treatment for blocking the infection. World Health Organization (WHO) anticipates that even worse pandemics with the more severe disease-causing properties, such as Ebola, could arise from human contacts with bats, domestic animals, and other zoonotic sources [21]. Therefore, with vaccines, chicken egg yolk IgY antibodies could provide means for the eradication of emerging epidemics. They could be used against respiratory illnesses and other microbial illnesses [22,23]. This method is also suitable for the eradication of intestinal pathogens [24,25,26,27].

These antibodies could also be included in solutions, sprays, liniments, and other forms of vector for preventive and protective treatments. The IgY could be used as purified antibodies for the individuals with albumin allergy, but it could be applied also as raw egg yolk for most people. Eggs are an ancient food source. Nevertheless, hygienic surveillance must be accomplished.

We proposed the use of IgY antibodies for preventing respiratory infections already in the 1990s [5]. One potential form of distributing the IgY molecules is their integration into sweets [6]. These portions within the sweets could be distributed in schools and other places where people gather, such as hospitals, airports, buses, shops, and public places.

In the future, these specific therapeutic antibodies could be added into various foods used as treatments for confining contagious diseases on the population level, as well as individually in the personalized medicine applications [28]. Larsson and Carlander [29] reported the treatment of one individual patient with IgY-antibodies continuously for 8 years. The harmless nature of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated of IgY has been demonstrated in cases like this Swedish cystic fibrosis patient and the fellow patients. One patient was treated

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