Recent Advances in Egg Products Research and Development

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INTRODUCTION

Total egg consumption has basically become level with perhaps a slight increase in the last 3 or 4 years. Although shell egg consumption has declined, the growth of value added egg products has been very encouraging. In 1982, 12% of the total egg consumption was in the form of further processed or value added egg products. Today, approximately 30% of our egg consumption is in the form of value egg products.

Several new technologies, such as improved egg breaking machines, better dryers, new approaches to pasteurization, etc., have led to a variety of new egg products. Many of the egg products (liquid, frozen, dried) are used as ingredients in various formulated food products, such as cake mixes, salad dressings, noodles, confectionary products, surimi, etc. Speciality products, including hard cooked eggs, frozen scrambled eggs, omelets, egg patties and egg substitutes have also contributed to this growth. Perhaps, another important factor has been the use of eggs by the fast food industry. Breakfast menus in fast food restaurants, including such products as egg sausage sandwiches, have had a continuing positive influence on egg consumption. It is interesting that many of the egg entries have remained popular when other entries have come and gone.

These positive changes are certainly encouraging. Nevertheless, we must continue to look at other opportunities. Many of these new potential markets may come from egg products for food applications, but other growth may come from non-food uses. The egg has components that are unique which have new potential applications (food and non-food). A recent symposium in Banff Ontario Canada highlighted some excellent potential breakthroughs in uses of eggs and their constituents. Some of these will be covered in this presentation.

Egg Composition

The egg proximate composition is shown in Table 1. (Watkins, 1995) Protein and total lipid content are not affected by the diet of the hen. However, the types of lipids (fatty acid composition) can be enfluenced by the diet of the hen. Also, most of the vitamins, and some of the minerals, can be substantially changed by the diet of the hen. The influence of diet will be discussed further in this presentation since there are marketing opportunities with regard to composition manipulation of the egg.

Egg white is largely protein on a dry basis. There are many unique egg white proteins (Table 2) that have certain characteristics, which can be exploited from a

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marketing standpoint (Stadelman and Cotterill, 1995). Egg yolk also has one or two proteins with potential applications.

Antimicrobial Properties

Several of the egg white proteins have been found to have antibacterial properties (Table 3 and Table 4). Lysozyme and avidin are now being commercially separated using cation-exchange resins for several applications. Samuelson et al., 1985 found that a combination of lysozyme and EDTA was effective against *Salmonella typhimurium* on broiler legs (Table 5). Avidin (avidin-biotin system) is used widely as a medical diagnostic tool. There are likely many opportunities for using egg white proteins for antibacterial properties since we have the technologies to separate egg white proteins commercially.

Antioxidants from Eggs

The food industry continues to utilize more and more natural antioxidants. Negbenebor and Chen (1985) observed that adding egg white to ground poultry meat decreased oxidation during cooking. In another study, Froning et al. (1986) observed that conalbumin was an effective antioxidant when added to ground turkey meat (Table 6). Lu and Baker (1986) further noted that phosvitin (a yolk protein with metal binding capabilities) was an effective antioxidant. More work on the potential of conalbumin and phosvitin as natural antioxidants is needed.

Antibodies from Eggs

Antibodies from eggs may have application against microorganisms in humans and livestock or poulty (Gibbins, 1977). Serum antibodies of hyperimmunised hens are efficiently transferred and accumulated in the egg yolk (Fichtali et al., 1994). There are also efficient cation exchange chromatigraphic techniques for separating these antibodies from egg yolk. Coleman (1998) reported that antibodies from eggs can be effectively used to treat mastitis in dairy cows. Antibodies from eggs may also have potential in treating AIDS.

Edible Packaging Films from Egg White Proteins

Edible films, which can carry antioxidants, antimicrobial and spices, have created recent interest. Film formation from several proteins, polysaccharide and lipid substances have been studied. Germadios et al. (1996) prepared edible egg white films. Properties of egg albumen films were similar to other protein films. Egg albumen films were clearer and more transparent than wheat gluten, soy protein isolates and corn zein films. They indicated that albumen films could be used for water soluble packets (pouches) for ingredients in the food, chemical, and pharmaceutical industries.

Increasing Egg Proteins Through Genetic Engineering

Gibbons, 1997 indicates that there are potential approaches for increasing egg albumen proteins in the egg through genetic engineering. If this can be accomplished, there are exciting possibilities for greatly enhancing functional properties and increasing novel proteins. Proteins such as lysozyme, conalbumin, and avidin may be possibly increased for use in many applications.

Utilization of Egg Shell Membranes

Shell egg waste has long been a concern of the egg industry. Egg shells are sometimes centrifuged to remove albumen. In some cases, the egg shells including membranes are dried and used as a calcium source in laying rations. Froning and Bergquist (1990) reported on use of extrusion technology to utilize egg shells in laying rations. Other firms have spread the waste shells on land as a fertilizer source. Recently, MacNeil(l997) at Penn State University has developed a patent for separating egg shell membranes from the egg shell. They have found that the shell membranes is largely collagen. They reported that 5,066 tons of shell membranes are available in the U.S. They estimated that 10% of the shell membrane is collagen representing a yield 6 14,000 lbs. The current price of collagen is $1 ,000/gram or $454,000/pound. MacNeil is presently working on a procedure to extract collagen from shell membranes.

Sugaro (1998) reported that the egg shell membrane protein can be used to grow human skin fibroblasts for severe burn situations. Egg membrane protein is also being used in many cosmetics in Japan.

Egg Yolk Constituents

The egg yolk (vitelline) membranes may have utilization as an aid to tissue culture (Burley and Vadehra). Sim (1994) reported that lecithin and egg oil have increasing demand by the food, pharmaceutical and biotechnology industries. They have developed a patented method for extracting an egg oil and lecithin. Sugaro (1998) reported that egg lecithin combined with vitamin B_{12} may slow the progress and possibly prevent Alzheimer's Disease.

Increasing Omega-3 Polyunsaturated Fatty Acids Through the Hens' Diet

Eggs with modified fatty acid content are now being marketed in the United States. Dietary flax seed increases yolk omega 3 polyunsaturated acids in the egg yolk and may be useful in promoting cardiovascular health (Van Elswyk, 1997). Workers have further enhanced the nutritional and storage stability by supplementing the omega-3 hens diets with vitamin E (Scheidler and Froning, 1996). Polyunsaturated eggs are subject to lipid oxidation and vitamin E addition likely will improve flavor acceptability of these modified eggs. There appears to be good acceptance of omega-3 eggs and consumers are willing to pay up to $.50 to $1 .OO more per dozen eggs (Marshall et al.,

1994). However, there are limitations on making health claims related to Omega-3 enhanced eggs.

CONCLUSIONS

The egg is loaded with highly potential chemicals and components. There are tremendous possibilities with the egg. As an industry, we need to capitalize on these opportunities in the future.

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TABLE 1. Composition of the egg (Watkins, 1995)

	Whole	Egg White	Egg Yolk
		%	
Solids	24.5	12.1	51.8
Protein	12.0	10.2	16.1
Carbohydrate	1.0	1.0	1.0
Lipids	10.9	-----	34.1
Ash	1.0	0.68	1.69

TABLE 2. Egg white proteins (Li-Chan et al., 1995)

Protein	% of albumen proteins	Characteristics
Ovalbumin	54	Phosphoglycoprotein
Ovotranferrin (Conalbumin)	12	Binds metallic ions
Ovomucoid	11	Inhibits trypsin
Ovomucin	3.5	Sialoprotein, viscous
Lysozyme	3.4	Lyzes proteins
Globulins	8.0	
Ovoinhibitor	1.5	Inhibits serine proteases
Ovoglycoprotein	1.0	Sialoprotein
Ovoflavoprotein	0.8	Binds riboflavin
Ovomacroglobulin	0.5	Strongly antigenic
Cystatin	0.05	Inhibits thiol proteases
Avidin	0.05	Binds biotin

TABLE 3. Antimicrobial properties of egg white proteins

Protein	Antimicrobial Activity
Lysozyme	Lyzes gram positive bacteria
Conalbumin	Binds metal ions making them unavailable to bacteria
Avidin	Binds biotin making it unavailable to bacteria
Ovoflavoprotein	Binds ribaflavin making it unavailable to bacteria
Ovomucoid	Inhibits trypsin
Cystatin	Inhibits ficin and papain

TABLE 4. Lysozyme applications

- Eye drops
- Inhibits bacteria in cheese making
- Spray on vegetables to prevent bacterial growth
- Pharmaceutical uses
- Effective against *Listeria* (Johnson, 1994)

TABLE 5. Enumeration of *Salmonella typhimurium* on treated broiler legs

Treatment Time (min)	Treatment	Mean cfu/cm
3	Control	67.090
3	EDTA (5mg/ml)	78.559
3	Lysozyme (1 mg/ml)	51.385
3	Mix	52.625
180	Control	14.529
180	EDTA (5mg/ml)	96.77
180	Lysozyme (1 mg/ml)	77.80
180	Mix	46.33

TABLE 6. Effect of conalbumin on rancidity of ground turkey meat

	TBA values (Malonaldehvde mg/kg)			
% conalbumin	Storage Days			
	0	3	6	9
Control	0.85	2.15	1.95	1.95
1.5%	0.48	0.60	0.69	0.76
3.0%	0.50	0.52	0.62	0.62

Increase Omega 3 Fatty Acids

- through feeding of flax
- antioxidant (vitamin E) needed
- health benefits

Increasing Egg Proteins

- through genetic engineering
- increase functional properties
- increase novel proteins

Edible Packaging from Egg White

- clear and transparent
- food and pharmaceutical applications
- carrier for antioxidants, antimicrobials and spices

Antibodies from Eggs

- can be produced in the yolk through hyperimmunised hens
- easily separated with cation exchange chromatographic techniques
- used against microorganisms in humans (eg. AIDS) and animals (eg. mastitis in cows)

Shell Membrane Composition (MacNeil)

	%
Protein	69.2*
Fat	2.7
Moisture	1.5
Ash	27.2

*Source of type I, V, and X collagen fibers.

Antioxidants from Eggs

Phosvitin (yolk)

Conalbumin (albumen)