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Development of Ready to Eat Breakfast Cereal Incorporating Ovalbumin from Chicken Egg White

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***Abstract* – Ovalbumin incorporated breakfast cereal is a good source of protein with several functional properties. Formulation of breakfast cereal carried out several preliminary trials with different percentages of rice flour, chickpea, mung, cowpea, maize, skim milk powder, and ovalbumin. Breakfast cereal was achieved by mixing 20 % rice, 6.67 % maize, mung pea, cowpea and sugar, 12 % chickpea, 3.34 % skim milk powder and ovalbumin, 0.67 % salt and vanilla with 33.3 % water. Protein content of the formula 15.12±0.53 percentage and protein calories reported high value of 17.34 % from total energy. Moisture and ash contents were noted to be high and low in fat (4.32±0.65%) content. High value of Bulk Density of 0.67±0.03 g/mL reported with desirable packing abilities. Lower water absorption capacity 144.58±0.16 g/100g, of the product is desirable for nutrient uptake. High lightness and yellowness with low redness was reported (a*-3.96±0.36, b*-35.20±0.56 and L*-69.20±1.12), which results a desirable appearance. Total Plate Count was not exceeded the recommended level of ready to eat products up to forth week under room temperature. There were no *Salmonella* or *coliform* reported with same storage conditions. pH of the product did not vary with the period measured (p>0.05). Based on those facts ovalbumin incorporated breakfast cereal can be recommended as a good protein diet with low fat for adults and adolescent.**

***Keywords* – Breakfast, Cereal, Ovalbumin, Ready-to-eat, Chicken Egg, White.**

I. INTRODUCTION

Protein plays a vital role in health for synthesis of body protein and other nitrogen containing molecules [1]. Shrinking of the daily protein intake through breakfast associate with delay in cognitive functions and in long term it subordinates with obesity [2]. Breakfast is the first meal of the day, it is consider as the most important meal of the day. However, it is also a meal that often skipped by adults due to workaholic nature, low time management and feeling fullness in the morning [3].

According to Food and Agricultural Organization and Grain Research Institute [4], cereals play an important role in breakfast; rice and maize are the two most commonly consume cereal in the world. Egg and milk play a vital role as source of protein in breakfast diets [2]. Combination of cereals, egg and milk ensure the high protein diet through breakfast. Ready to eat Breakfast with those ingredients can have an option for high protein meal to avoid malnutrition of those elements.

Rice (*Oryza sativa*) stands for the half of the daily calories of the world population. Rice has found to be very easy to digest. It is low in fat, low in cholesterol, high in starch, and has a high nutritional content [5]. Chickpea (*Cicer arietinum*) is also an important food legume, consumption reported to have some physiologic benefits that may reduce the risk of chronic diseases and optimize health. In addition, chickpea reported cancer-preventing abilities referred to [6]. As [7] mentioned Maize (*Zea mays*) in human diet, consider as a good source of vitamin B1, B5, folate, dietary fiber, vitamin C, phosphorous and manganese. Cowpea (*Vigna unguiculata*) flour has high properties such as water absorption, fat absorption, and protein solubility [8]. According to [9] mung bean (*Vigna radiata*) is considered as a food which has balanced nutrients. Moreover it denotes in same orientation mung consist with antidiabetic, antihypertensive, and antitumor effects.

Skim Milk (SM) is the product that derives after separating cream from whole milk. With referring to WHO/FAO [10], adding only 2–5% of Skim milk powder to a blend gives a milky and creamy flavor; results in a considerable increase in protein intake.

Eggs are reasonable, nutrient-rich option for people of all ages. Egg white plays an extensive function as processed food ingredient. The egg white consists of 10.5% protein and 85% water [11]. Ovalbumin, approximately high protein consists in egg white (54%). Ovalbumin is a monomer, globular phospo glycoprotein with molecular weight of 44.5 kDa with isoelectric point of 4.5 [12]. Ovalbumin is the major egg white protein, has well-balanced amino acid composition, and thus can be used as an excellent protein source for many food items. Human blood albumin is reported as an excellent drug carrier, indicating that ovalbumin can also be a potential drug carrier [13]. Further ovalbumin was also reported to have tumor necrosis releasing factors, which can apply in tumor suppression [14]. Hydrolyzed ovalbumin showed a strong angiotensin I-converting enzyme (ACE) inhibitory activity [15]. Some of the peptides produced from ovalbumin not only showed strong ACE-inhibitory effects but also lowered blood lipid content [16]. Vasodilation effect was observed from the peptides derived from egg white as well as from ovalbumin. Therefore objective of this study was to develop a ready to eat breakfast cereal with high protein diet for adults and adolescent incorporating excellent nutrition blend of rice, maize, mung, chickpea, cowpea, skim milk powder and ovalbumin from chicken egg white.

II. MATERIALS AND METHODOLOGY

A. Product Preparation

Locally available Rice (Oryza sativa) and Chick pea (*Cicer arietinum*) flour, Mung (*Vigna radiata*), Cowpea (*Vigna unguiculata*) and Corn (*Zea mays*) flour were prepared with locally available grains. Ovalbumin was prepared by the method referred in [17] and locally available skim milk powder, and other ingredients (vanilla

and salt) were used for preparation. Initially preparations were arranged with several percentages of ingredients and sensory results were used to finalize the final recipe consists of 20% rice, 6.67% corn, 6.67% mung pea, 6.67% cow pea, 12% chickpea, skim 3.34% milk powder, 3.34% ovalbumin, 0.67% salt, 0.67% sugar, 0.67% flavor, 33.30% water. Two-flavor component salt and vanilla were used in the product, maintained less than 2% (dry basis) as it perceive on taste interaction [18]. During product preparation, aforementioned raw materials were adequately mixed adding water and dough was formed. Formed dough was steam cooked at 100 °C for 40 minutes and oven dried at 150 – 200 °C for 15 minutes. Finally oven dried product was ground to obtain the final breakfast cereal.

B. Proximate Analysis

Moisture of the product was analyzed using 2-5 g of homogenized sample at 100-105oC in a drying oven [19]. Crude fat analysis was conducted according to standard Soxhlet method with slight modifications [20] with moisture removed sample. Crude protein was carried out with Kjeldhal method with some modifications and Ash with muffle Furner [20]. Carbohydrate, total energy and protein caloric value of the product were calculated using the methods mention by [19].

C. Functional Properties

Bulk Density of the product was measured and expressed as gram of dry matter per one milliliter [21]. Further water absorption capacity was expressed as ratio of maximum gram of water absorb by 100 g of dry matter [22]. Color value of product was determined using color meter (CR 410, Konica Minolta Inc., Japan), which was calibrated against a white reference tile.

D. *Keeping Quality Analysis*

Microbiological and pH analysis were used to measure during storage period using the methods expressed in [23]. Total Plate Count Analysis was carried out with pour plate method using Plate count Agar. *Salmonella* analysis was conceded with Direct Enrichment method. Homogenate of sample at ratio of 1: 9 samples to distilled water, diluted through a series of tubes. Approximately 1mL of diluents of each tube with 9mL of *Salmonella* enrichment broth incubated at 37°C for 48 ±2 h. A loopful of each broth Sub cultured to Xylose-Lysine-Deoxycholate agar media. Plates were incubated at 37 °C for 20–24h. The plates were examined for typical colonies. *Coliform* analysis was carried out with pour plate method. Homogenate samples were poured into petri dishes and procedure was repeated with each dilution prepared. 15 mL of molten Violet Red Bile Agar was added to each plate, cooled to 44–47 °C and mixed carefully and allowed to set. Plates were incubated at 37 °C for 24±2h and observations were recorded. To determine the keeping quality of the ovalbumin incorporated breakfast cereals, pH of the homogenate samples were measured using calibrated digital pH meter (Delta, 320, Japan) with time duration of 5, 10, and 15 up to 30 days.

E. Sensory Analysis

Approximately equal portion of the product was served in odorless, disposable paper plates and sample was coded separately with a three-digit number and served for the sensory evaluation. Clean water was provided to clean the mouth between each sample. Thirty untrained panelists (Age group 21-26 years /male & female) assessed the appearance, texture, color, mouth feel and overall acceptability scores of the samples using a 5-point hedonic scale.

III. RESULTS AND DISCUSSION

A. Proximate Composition of the Product

Ovalbumin incorporated breakfast cereals consist with 15.12% of protein content which is comparatively higher than reported in [19] and [24]. In addition, evaluate with the [25] it has high protein value than sorghum incorporated breakfast cereals. Consistent with dietary recommendations in the report of joint World Health Organization/Food and Agriculture Organization [26] energy from protein is recorded as 10-15%. Furthermore, [27] reported that high protein diet habitually be supposed to consist 15-16 % from total energy. In addition, fat level of the breakfast cereals was reported as low value of 4.32±0.65%. Moisture and ash contents were noted to be high (Table 1).

Table 1: Proximate composition of the ovalbumin incorporated breakfast cereal

Parameter	Percentage
Protein	15.12±0.53
Fat	4.32±0.65
Ash	2.49±0.32
Fiber	1.60±0.10
Carbohydrate	60.58±1.08
Moisture	15.68±0.45
Total Energy (kcal/100g)	348.60
% Protein calories	17.34

** All values are given as percentage with their standard deviations.*

Results were well demonstrated that, proximate composition of the developed breakfast cereals satisfies the recommended levels of nutrition intakes. Furthermore fluctuations of the values in terms with the recommended values give more benefits to the consumers of the products as an added advantage compared to same type of products in the market with different origins.

B. Functional Properties

Bulk density (BD) of the product reported as average value of 0.67±0.03 g/mL. This value is higher than reported in [19] and [28]. Higher BD value for breakfast cereal (2.45+0.10 and 2.60+0.05) recorded by [29]. In relation to [29] higher the BD value less packaging space is required. Higher BD value recorded by the ovalbumin incorporated breakfast cereal important in lower packaging space and storage. It is important in terms of reducing the cost factor in storing and packing and transporting. Nevertheless product reported to has some lower water absorption capacity (WAC) of 144.58±0.16 g/100g. This value reported lower than [25] and [19]. In line with [28] WAC of the breakfast cereals may equally be associated with the nature of starch granules after

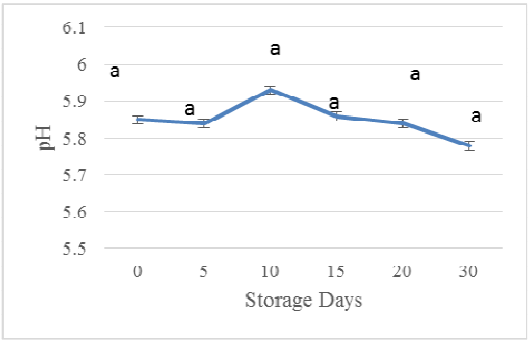
toasting. When water absorption is lower, it is desirable for making thinner gruels that will enhance more in-take of nutrients [30]. Lower WAC of the ovalbumin incorporated breakfast cereal may associate with more in-take of protein and other nutrients during digestion from the wide range of ingredients in the product.

Color values of the product were reported to change due to treatments that applied in production process [31]. Ovalbumin incorporated breakfast cereals have respectively a low redness and high yellowness and lightness (a*-3.96±0.36, b*-35.20±0.56 and L*-69.20±1.12). As it was denoted by [32] increasing the processing temperature reduces values of L*, a* and b*. This is due to Millard browning of sugar. Higher yellow value refers to low Millard reaction and it is favorable for product gelatinization. Developed ovalbumin incorporated breakfast cereal has recorded higher L* value due to lower Millard browning reaction during the processing. Lower reaction rate permits gelatinized starch to be rapidly digested after the ingestion.

C. Keeping Quality of the Product

The shelf life of most ready-to-eat dry breakfast cereals deems as 6 to 18 months at ambient temperature with package integrity [33]. pH of ovalbumin incorporated breakfast cereals was reported a mild acidic conditions (5.6 to 6), but relatively higher pH than most cereals (figure 01).

As it was reported by [28], blends of maize, African yam bean, defatted coconut cake and sorghum extract shows pH from 4.70 to 6.56. According to [34] maize–legume combinations and traditional processed cereal reported pH values of 4.72 to 4.88.



[a] *pH values are not significantly different*

Fig. 1. pH change of the ovalbumin incorporated breakfast cereal with the storage time

Therefore, the pH sustains in a healthy range over the storage period and it revealed the breakfast cereals can be consumed safely same as prevailing products similar to the developed product.

Total plate count of the ready to eat products should less than total colony count of 1×10^5 (log CFU) [23]. Moreover *Salmonella* and *Coliform* were not detected with the storage period and, it revealed the product is in the acceptable level under the ready to eat product category. However shelf life of the product can be increased with modified packaging material. Further, polypropylene bag with ultraviolet treatment or vacuumed packaging may help to increase a extended shelf life to the product.

IV. Conclusion

Ovalbumin incorporated breakfast cereals has met specific nutritional requirements such as a good protein diet with high protein calories and lower fat value. Furthermore functional properties and keeping quality parameters have clearly shown the developed breakfast cereal product is well fit with the standards and it can be successfully introduced to both adults and young ones. Further suggested hydrolyzed ovalbumin portion can be replaced and it may give additional functional properties to the ovalbumin incorporated breakfast cereals.

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AUTHORS' PROFILES

Dr. E.D.N.S. Abeyrathne, corresponding author and the supervisor of this study is an eminent academia and a researcher who has completed Bachelor of Science in Agriculture in University of Peradeniya, Master in Science in Dairy and Meat Product Technology in Post Graduate Institute of Agriculture, University of Peradeniya, Sri Lanka and subsequently his PhD in Biomodulation in Seoul National University, Seoul, South Korea (2010-2013). His major field of study includes isolation and separation of bio active compounds from poultry eggs and fresh water fish. Currently he has been serving as a Senior Lecturer attached to the Department of Animal Science, Uva Wellassa University of Sri Lanka, Badulla since 2007. Further he has contributed his valuable service as a Research Assistant, Protein chemistry Laboratory, Seoul National University, Seoul, Korea (09-2010to08-2013) and Research Assistant, Poultry Meat Laboratory, Iowa state University, Ames, IA, USA(11-2012 to 02-2013). Meantime he has published many scientific papers in various reputed journals and conferences both locally and internationally. Few important publications are as follows. Abeyrathne E.D.N.S., Lee, H.Y., Jo, C., Suh, J.W. and Ahn, D.U.. Enzymatic hydrolysis of ovomucin and the functional and structural characteristics of peptides in the hydrolysates. *Food Chemistry*. 2016, 192: 107-113.
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His current research interests basically focus on development of functional food to control type II diabetics and obesity, development of value added products from poultry eggs and fresh water fish, identifying natural antioxidants from livestock products, identifying hazard points in food processing and minimizing the hazards with cost effective methods.
Moreover, Dr. Abeyrathne is a life time member in Sri Lanka Association of Animal Production (SLAAP) and Sri Lanka Institute of Food Science and Technology (IFST-SL). Further he has been awarded with several titles including Young Scientist research award in WCU Biomodulation, 2013, Third place awarded in the poster retreat of WCU Biomodulation Major 2011 under PhD category, 4th International Biomodulation Symposium, Seoul national University, Second place awarded in the poster retreat of WCU Biomodulation Major 2012 under PhD category in WCU Biomodulation Major, Department of Agricultural. Additionally, Dr. Abeyrathne's outstanding findings in the doctoral studies have been rewarded with patents and he has bagged two patents in Separation of ovotransferrin from chicken egg white using environmental friendly techniques (Patent number :10-2012-0143230) and sequential separation of lysozyme and ovalbumin from chicken egg white (Patent number : 10-2013-0003215).

Mr. J.M.P. Jayasinghe contributed in preparation, writing, formatting of this paper and further he has completed Bachelor of Animal Science (BASc) (2009-2013), Department of Animal Science, Uva Wellassa University of Sri Lanka, Badulla and subsequently completed Diploma in Quality Management at Sri Lanka standards Institution, Colombo 08 in 2014. His major area of study is animal science with special emphasis on animal products and nutrition.
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Few recently published scientific findings are as follows.
Ishani A.H.M.E. Herath, Jayasinghe J.M. Priyanath, Dong U Ahn, E.D. Nalaka S. Abeyrathne.. Use of lysozyme from chicken egg white as a nitrite replacer in an Italian-type chicken sausage. Functional Food in Health and Diseases. 2015, 5(9): 319-329.
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Sandalanka, H.G.A.D.K., Jayasinghe. J.M.P. and Abeyrathne E.D.N.S. (2016). Development of a simple food safety model for sustainable food security of university cafeteria. Journal of Agricultural Engineering and Food Technology, Krishi Sanskriti Publications. New Delhi. Vol 3 (1): 1-3. His current researches basically focus on animal nutrition, herbage quality evaluation. .
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