EVALUATION OF THE PHYSICAL PROPERTIES OF EGG POWDER MADE USING FOUR DRYING METHODS

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ABSTRACT
A three phase Study was carried out to evaluate the physical properties of whole egg powder produced via oven, sun, dehydrator and air-drying methods. Two grams of each sample of the egg powders in three replicates were collected and used for various physical measurements in the experiments using a complete randomize design. Data were collected on Angle of repose (°), bulk density, tap density, hausner ratio, compressibility, caking, colour and particle size. The result of the physical properties shows that the whole egg powders were significant different (P < 0.05) across all properties examined except for gelation, colour absorbance and particle size. The study concluded that the physical properties of whole egg powder were generally affected by drying methods. Although dehydrator and air-dried egg powder were higher in most of the individual attributes determined and whole egg powder made from air drying was selected considering it adaptability while oven drying happen to be the least among the methods. It is recommended that egg powder should be made via air drying method.
Keywords: Sun-dried, Air-dried, Containers, Bacterial load.

INTRODUCTION

Powdered eggs came to existence as a staple of camp cooking as early as 1912. Their ease of storage and nutritional quality were also practical advantages in supplying military troops, and were used in the United Kingdom during World War II for rationing and were known as "Ersatz eggs" during that time (Techer, *et al* 2014). A lot of findings showed that powdered eggs dates back to the Middle Ages when Chinese used to air dry eggs that had been whipped and left in the sun to dry and then ground. In the United States, egg drying preceded the freezing of eggs on a commercial basis. Records indicate that in 1878, a St. Louis, Mo., firm was "transferring egg yolk and albumen, by a drying process, into a light brown, meal-like substance. From 1895 to 1905 a number of plants began operations and dried eggs were shipped to Alaska and even to China to be used by the United States Army stationed there. Egg powder has been defined as an eggs that has been dehydrated by using several methods which includes; sun drying, ovum drying, freeze drying, spray drying etc and turned into powdered form (Juliano *et al.,* 2010).

The benefits of dehydrated egg products go beyond extending its shelf life. Moisture removal in egg yolk products are important for egg product stability and to reduce costs. Recently, dehydrated egg yolk products have also been used by egg consumers instead of shell egg as raw material because of its longer shelf life, lower transport and storage cost, and specific functional properties (Koç *et al.,* 2011). Dehydrated egg yolk powders serve as raw materials for other products. Recently, there has been an increase in the use of dried egg powders that represents a growing importance of the ready-for-use packages industry (Franke *et al.,* 2002). By reducing the moisture content of egg products, microbial stability is achieved. Moisture is removed by a combination of heat and mass transfer; the system used to obtain dried egg products determines its quality (Koç *et al.,* 2011). The fact that powdered eggs are a non-perishable food when stored in an airtight container is their greatest advantage. There are several other advantages.

You never have to worry about dropping and breaking a dehydrated egg - and dehydrated eggs store in a much smaller space. A dozen fresh eggs take up about 122 cubic inches in their carton. When the eggs are powdered, this is reduced to less than 22 cubic inches per dozen powdered eggs. Not only will this free up room in your refrigerator, a can of powdered eggs requires no refrigeration and stores for months in your pantry. At the industrial level, eggs are preserved by processing them through spray drying into egg powder (Dixit *et al.,* 2010; Kumaravel *et al.,* 2012; Rannou *et al.,* 2013). In Nigeria there is a cyclical egg glut, egg wastage and egg loses in many areas of the country, which might be on the increase as more individuals embark on poultry production in order to alleviate poverty and unemployment. The loses and wastage or egg glut spans for a minimum of 4-5 months per year with several factors such as inadequate storage power facilities and techniques for processing eggs which thus contribute to egg loses and wastage Sonaiya *et al* (2022). However this study is geared toward evaluating the different drying methods for egg powder manufacture and comparing the physical properties of the egg powder manufactured.

Study Area
The survey was carried out in Sokoto metropolitan area while the Laboratory analysis were conducted at the Central Laboratory and Agric physical laboratory of the Faculty of Agriculture, Usmanu, Danfodiyo University Sokoto. Sokoto state is located in North-West, Nigeria, between longitude 4° and 7° E and latitude 10° and 14° N (Adeniji *et al.,* 2020). The state shares borders with Zamfara state, Kebbi state and Niger Republic. It has an altitude of about 350m above sea level and annual rainfall of about 645mm. The relative humidity ranges from 21-47% during the dry season and 51-79% during the rainy season with average minimum and maximum temperatures of 15^{o}C and 40^{o}C respectively (Aliyu *et al.,* 2022).

Sample preparation
Six hundred (600) pieces freshly laid eggs of commercial isah layers were obtained from Sarkin Gobir (SD) Adiya Farm in Sokoto. They were neatly unshelled and whisked thoroughly with the aid of a blender (Sonik Japan Model, SB-1515) to ensure Albumen-Yolk homogenization, then the mixture was placed into a 20 litter sterilized bucket whole egg powder were made using different batches of 500g of the egg liquid egg content was then homogenized using **Rotor stator homogenizer** (Auguste Gaulin 1900s) for 2minutes at 5000rpm for every egg fleck's that was produce from the four drying methods at intervals.

Preparation of sun-dried egg powder sample
A portion of the 500g liquid egg was taken from the pool of the homogenized liquid eggs and spread on a sterilized stainless tray 30cm x 50cm, covered with cotton foil and placed on an elevated position under the sun where it was allowed unhindered insulation and free air circulation, the eggs were stirred randomly after every one hour to ensure uniform drying and to prevent molding together under the sun until they had a crispy feel. This was repeated and After drying, the egg crispiest which appeared in a dried-crumbled form were ground with a grinder for 10minute each at the speed of 10,000rpm to get the sun-dried whole egg powder. The sun dried whole egg powder were packed into a Ziploc bags labelled and stored.

Preparation of oven dried egg powder sample
Another 500g portion of liquid egg was spread on a stainless-steel tray and placed in an oven for 5hours at 45 ^{0}C the egg liquid were stirred randomly after every 30minutes to ensure uniform drying and to prevent molding together until it had a crispy texture.

Preparation of dehydrator dried egg powder sample
Same 500g of liquid egg was spread using a dehydrator for 48 to 72 hours at temperature of 42^{0}C, the egg was stirred randomly after every five hours to ensure uniform drying and to prevent molding together until it had a crispy texture. This was repeated and After drying, the egg crispiest which appeared in a dried-crumbled form were ground with a grinder for 10minute each at the speed of 10,000rpm to get the sun dried whole egg powder. The dehydrator dried whole egg powder was packed into a Ziploc bags labeled and stored.

Preparation of air dried egg powder sample
The last sample 500g of liquid egg was air dried for 12 hours the eggs were stirred randomly after every 3hours to ensure uniform drying and to prevent molding until it turns crispy in texture. After drying, the egg crispiest which appeared in a dried-crumbled form were grinded with a grinder for 10minute each at the speed of 10,000rpm to get the egg powder product. The whole egg was packed into a Ziploc bags labelled and stored.

Data collection
The egg powder made from the four methods was utilized for all the evaluations. Two grams of the whole egg powder samples in three replicates were reconstituted in a ratio of 1:3 grams for experiments that required reconstitution as outlined by Vargas-del-Río *et al* (2022).

Particle size: determined using the X-ray diffraction machine (Rigaku miniflex XRD) in accordance to Herdan (1960).

Colour: was taken as the absorbance of reconstituted samples of egg powder at a wavelength of 750nm using a spectrophotometer (Shimadzu UV-1650PC UV/VIS) method outlined by Narayana and Narasinga (1984).

Caking: 2g of egg powder was exposed to high humidity (>90%) for 30min kept overnight. The samples were weighed then vibrated and osculated at a speed of 250rpm for 1 hour using an orbit shaker. The powder was then sieved through a 1mm screen. Caking was computed as the proportion of the retentate to weight of egg powder after drying. It is expressed as $\frac{w2}{w1}$ x 100 where w_1 is the initial weight before exposure and w_2 weight after exposure of the sample.

Bulk density and Heusner ratio: two gram of the whole egg powder (m) was taken in a graduated test tube and the volume (v_1) was recorded the test tube was then vibrated at speed of 250rpm for 30min, then a new volume (v_2) was recorded. Thus the loose bulk density was computed as $\frac{m}{v1}$ and the Tap bulk density was computed as; $\frac{m}{v2}$

Hausner ratio: was determined as ratio of loose bulk density to tap bulk density.
Compressibility: was taken as the percentage reduction in volume of 2garms sample of egg powder when vibrated at the speed of 1000rpm in a graduated cylinder.
Angle of repose: was determined using a samples of egg powder were funnelled unto a flat surface. The angle suspended by the incline of the cone formed on a flat surface was computed using the mathematical relationship $\tan^{-1} h/r$. Where h is the height of the cone formed and r is the radius of the vertical surface covered by the cone.

Data Analysis

The data obtained were analyzed using the General Linear Model procedure of SPSS version (2016), the means where separated using Tukey.

RESULT AND DISCUSSION

Physical Properties of whole egg powder.

There were significant differences across all the physical variables measured except for colour absorbance and particle size. Drying method had much effect on the physical properties of whole egg powder. See Table 1.

Table 1: Physical properties of whole egg powder prepared using four drying methods.

Physical property	Oven dried	Sun dried	Dehydrator dried	Air dried	SE
Angle of repose (°)	62.597^{ab}	59.287^{b}	65.507^{a}	60.220^{ab}	2.01
Tap Bulk Density (g/ml)	0.559^{b}	0.565^{ab}	0.570^{ab}	0.612^{a}	0.016
Loose Bulk Density (g/ml)	0.390^{c}	0.455^{a}	0.429^{b}	0.452^{a}	0.004
Compressibility (%)	30.278^{a}	19.049^{b}	24.762^{ab}	26.134^{ab}	2.746
Hausner ratio	0.697^{b}	0.810^{a}	0.752^{ab}	0.739^{ab}	0.027
Caking (%)	62.351^{b}	61.015^{b}	73.667^{a}	75.986^{a}	1.670
Colour absorbance (nm)	491.55	439.658	437.629	412.833	93.795
Particle Size (A°)	4.279	4.168	4.066	4.203	0.124

abc = Means bearing different super scripts along the same column differ ($P < 0.05$)

That the whole egg powder made from dehydrator had higher ($P < 0.05$) Angle of repose compared to sun drying methods. This may be due to the higher moisture content in dehydrator dried egg powder see (Table 1) which might have played a role in the Angle of repose of the powder because the more the moisture content the more likely the particles stick together and form a bridges which increases friction between the particle and as a result of this, the angle of repose increases. This is in agreement with Kalman (2021) that increase in moisture content leads to increase the angle of repose as result of the increase in size of the particle. Also it agrees and disagrees with findings of Zhang *et al.* (2022) who found that angle of repose decreased with increase in moisture content until a certain point then angle of repose begin to increase with increase in moisture content.
Bulk density (Loose bulk density, tap bulk density) and caking were higher ($P < 0.05$) in the whole egg powder made from air drying than egg powder made from oven drying. This may be because in air drying typically it involve passing of air through the egg mixture which remove water from the mixture through evaporation. This process makes the powder more porous and tends to have higher density unlike the oven where heating is involved making the egg powder denser, less porous and low bulk density.
Compressibility was higher ($P < 0.05$) in whole egg powder made from oven drying than powders made from sun drying. This may be because compressibility is highly influence by temperature and rate of drying which oven drying utilized more temperature and faster rate of drying than any other method. Also the extraction moisture from the egg particles leads to compaction and lower the bulk density with reduction in particle moisture content thus increases compressibility. This is in agreement with Basma (1994) who stated that compressibility increased in drying temperature
Huasner ratio was higher ($P < 0.05$) in whole egg powder made from sun drying than powders made from oven drying. It is expected to have higher huasner ratio in sun dried egg powder because the lower the bulk density the higher the huasner ratio. This is in agreement with the findings of Nansereko (2022) who reported that oven dried powder had lower bulk density, lower rehydration ratio and higher hausner ratio.
Caking was higher ($P < 0.05$) in whole egg powder made from dehydrator and air drying than powders made from oven and sun drying. This may be due to the higher moisture content contained of dehydrator and air dried powders. The higher the moisture content of powders the most likely the increase in the cohesion and binding of particles together resulting in higher caking. According to Zafar *et al.* (2017) who stated that higher moisture content

increases cohesiveness or cake strength of the food powders. Also Fitzpatrick (2007) reported higher caking are obtained with increased adhesion to liquid bridging because of the higher water content.

Conclusion and recommendation

Most of the physical properties of egg powder were affected by drying methods and egg powder made from air drying had optimized physical properties while oven is the least effective method of drying. Therefore Air drying is recommended for adoption considering that whole egg powder had the optimized properties.

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