Air Classification: Eco-Friendly Separation Technique in Food Technology- An Article

Youssef, M.M.[1] & Abo-Dief, M.F.[2]

(1) Food Science and Technology Dept., Fac. of Agric. University of Alexandria, El-Shatby, 21545, Alexandria, Egypt.

(2) Arabian Milling & Food Industries Co., Borg Al-Arab, Alexandria, Egypt.

Received: 9 June, 2022 *Revised: 19 June, 2022* *Accepted: 23 June, 2022*

ABSTRACT

Air classification is one of the oldest green (eco-friendly) technologies known to man. According to the centrifugal force gravity and other internal forces different components can be separated in air depending on their sizes in air. Recently, interest has been renewed in many applications of air classification due to the development of commercial air classifiers.

The present article shed a light on air classification in terms of its theory along with its main applications in the sector of food industry. The most predominant applications of air classification in food industry include: preparation of protein concentrates, enrichment fractions of antioxidants. Moreover, air classification can be applied to produce functional foods and to improve the nutritive value of food and functionality of emulsions.

Keywords: Air classification, protein concentrate, β-glucan, antioxidants functional spaghetti, nutritive value, O/W emulsion, wheat filter flour (WFF).

INTRODUCTION

Air classification is one of the oldest green technologies (eco-friendly) known to man. However, in recent years interest was renewed in application of this technique. Such an interest is attributed to the development of various commercial air classifiers. This technique is capable of fractionating of heterogenous particles into sub-groups of fairly uniform size based on particle density and mass of products sharply graded in the range from 2 to 60 micron (Vose, 2006).

Air classification of flour is economically and technologically practicable in cases of producing special products, such as mixes, that require accurate protein content and narrow distribution of particle sizes.

The present article aimed to shed a light on air classification in terms of its theory, principle and applications in food industry.

Theory and principle

According to the centrifugal forces, gravity, internal force and some other forced of flour particles of different sizes. It is worth to mention that there are two kinds of protein in flour, the first is the wedge (interstitial) protein being the matrix in which the starch particles are embedded. The second type of protein is adherent protein which coats the starch granules. After air classification microscopic examination reveals high protein fractions containing a large amount of wedge protein, whilst, the low-protein fractions contain very little amount of wedge protein.

Figure (1) shows the mechanism of air classification. The small particles (less than 17 μm in size) consist of wedge protein. On the other hand, the large particles (larger than 35 μm in diameter) are mainly agglomerates or chunks of indosperm cells containing both starch and protein in about the same proportion as the parent flour with some large starch cells. Consequently, by air classification of flour, two main fractions cab be obtained; namely, high protein fraction "Coarse Fraction" and high starch fraction "Fine Fraction" (Posner and Hibbs, 2005).

Applications in Food Industries

There are numerous applications of air classification as a method of separation in the sector of food industries. In the present article, attention is focused on the most common applications.

Protein enrichment fractions

Air classification is applied as pre and post treatment to prepare protein concentrates from

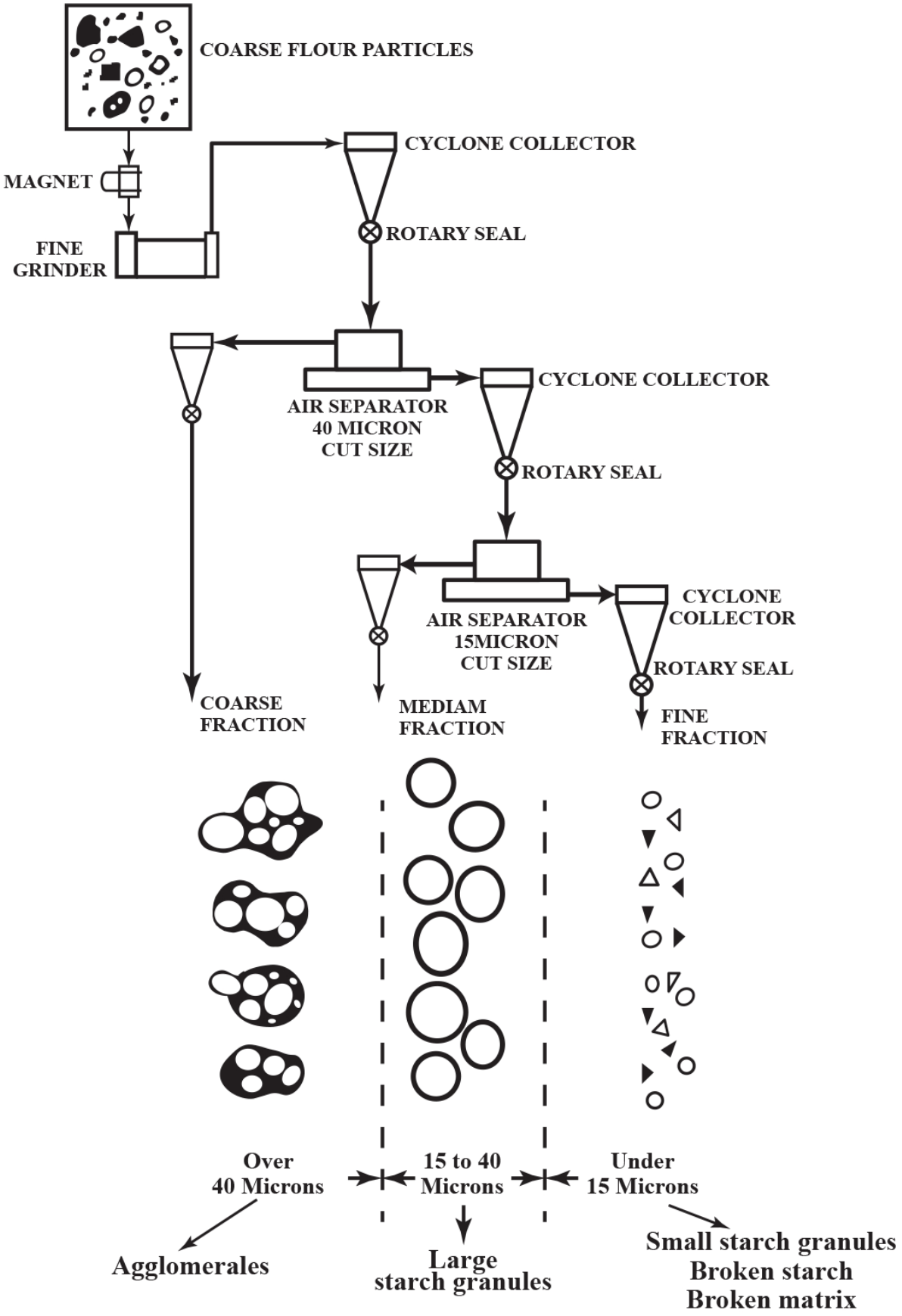

Figure 1: Schematic flow of an air-classification system
Source: Posner & Hibbs (2005)

legumes. Xing *et al.* (2020) applied a two-step dry fractionation process on flour of pea, lentil and chickpea. Milling, air classification and subsequent triboelectrostatic separation were conducted on the aforementioned legume flours to prepare protein concentrates.

Compared to conventional wet extraction, air classification is much less energy consuming and much maintaining the native functionality of legume flours (Xing *et al.*, 2020). It was obvious that adding electrostatic separation to air classification, a higher pea protein purity (up to 63.4–67.6 g /100g) could be obtained and being higher than its counterparts obtained by air classification only (57.1 g/100g).

β-Glucan enrichment fractions

Wu & Doehlert (2022) applied air classification to maximize β-glucan in oat bran. The highest content was obtained in fractions larger than 30μm from 3× 14000 rpm in a pin mill. This fraction accounted for 393 g/kg of defatted oat bran and it contained 188g/ kg of β-glucan and 302g/kg protein.

It is worth to mention that oat bran fractions of particle size greater than 90μm contained 200g/kg of β-glucan and less than 100 g/kg of starch. Consequently, the enriched β-glucan fraction could be obtained in a good yield and it has commercial potential as a food ingredient (Wu & Doehlert, 2022).

Antioxidants enrichment fractions

Air classification was used to produce phenolics enriched ingredients of barley flour for pasta and bakery industry (Verado *et al.*, 2011a). The obtained enriched fractions exhibited an increase of free flavan–3 ols of 157–173% compared to whole flour. Meanwhile, these fractions were found to contain higher concentration of bound phenolic compounds (160-236%) with respect to whole flour. Data revealed that air classification is a good technique to enrich the flours in order to utilize the barley co-products.

Martin-Garcia *et al.* (2021a) investigated the distribution of free and bound phenolic compounds and alkylresorcinols in wheat aleurone enriched fractions. Data indicated that air classification could be used to produce enriched aleurane fractions as a source of phenolic and alkylresorcinol compounds. Such fractions could be of great interest for the formulation of enriched foods.

Air classification was used by Martin-Garcia *et al.* (2021b) to obtain phenolics–enriched buckwheat flour fraction. The total content of phenolic compounds (by HPLC-MS) in coarse fractions (starch rich fractions) increased by 1.7–2.1 times compared to fine fractions (protein rich fractions). Furthermore, the antioxidant activity in the coarse fraction increased by 1.2-1.3 times higher than fine fraction. It was obvious that air classification is an effective technique in order to obtain coarse flour fractions rich in phenolic compounds.

Manufacture of functional spaghetti

Different barley functional spaghetti comparable to different commercial whole semolina samples were manufactured (Verado *et al.*, 2011b). It was proved that barley spaghetti reached the FDA requirements and thereby these pastas deserve the health claims as good source of dietary fiber and (may reduce the risk of heart disease).

Improvement of nutritive value

Effects of air classification and fermentation by lactic acid bacteria (LAB) on faba-bean flour nutritional properties were investigated (Coda *et al.*, 2015). The anti-nutritional compounds namely Vicine and Convicine, trypsin-inhibitor activity, condensed tannins and phytic acid) were separated mostly from the fine protein-rich fraction.

According to Spaggiari *et al.* (2020), they used for the first time air classification to separate functional lipid compounds of rice bran (RB). These compounds such as monoacylglycerols were found to concentrate in fine RB fraction. These findings could be of relevance to the food industry because the molecules could provide a textural improvement in food products (as gluten-free food stuffs. Notwithstanding, RB has a good fatty acid profile with higher content of mono unsaturated fatty acids (MUF) and polyunsatureated fatty acids (PUFA) than saturated fatty acids (SFA).

Improving the functional of emulsions

The dry fractionation of lentils by air classification was investigated in terms of composition interfacial properties and behavior in concentrated Oil/Water (O/W) emulsions (Funke *et al.,* 2022). It was clear that air classification is a promising method to obtain less refined protein ingredients from legumes with novel techno-functionalities compared to solvent extracted protein isolates.

Wheat filter flours (WFF)

Wheat filter flours (WFF) are by-products resultant from air classification of wheat flour. The WFF contains higher crude protein, lipid and damaged starch as compared with its counterpart in standard (straight) flour belonging to the same batch (Wang *et al.*, 2013).

The WFF was found to possess higher water absorption, longer stability time, shorter peak time and lower peak viscosity than their corresponding for straight flour. Consequently, there is a potentiality of utilizing WFF in food industries (Wang *et al.,* 2013).

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التقسيم بالهواء: تكنيك فصل صديق للبيئة في تكنولوجيا الأغذية

محمد محمود يوسف[١]، محمد فتحي أبو ضيف[٢]

١- كلية الزراعة، جامعة الإسكندرية، الشاطبي، الإسكندرية، ٢١٥٤٥، مصر.

٢- الشركة العربية للمطاحن والصناعات الغذائية، برج العرب، الإسكندرية، مصر.

الفصل (التقسيم) بالهواء هو أحد أقدم تقنيات الفصل الصديقة للبيئة التي عرفها الإنسان، وتتم عملية الفصل للمكونات المختلفة في أحجامها والتي يتم نشرها في مجال من الهواء، وذلك تحت تأثير قوى الطرد المركزي، الجاذبية الأرضية، فضلًا عن القوى الداخلية للجزيئات. ولقد عاد حديثًا الاهتمام بهذه التقنية في الفصل على ضوء تطوير عدد كبير من أجهزة التقسيم الهوائي.

يلقي هذا المقال الضوء على تقنية الفصل (التقسيم) بالهواء من منظور الأساس العلمي وأهم التطبيقات في مجال التصنيع الغذائي، ومنها الحصول على المركزات التي تحتوي على البروتين، مضادات الأكسدة، البيتا جلوكان بالإضافة إلى تحسين النتيجة التقديرية والصفات الوظيفية للمستحلبات.