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SHAPE DESCRIPTORS OF EGGSHELL PIECES AFTER EGG MEMBRANE EXTRACTION

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INTRODUCTION

Eggshells are highly valuable byproduct in food industry which can be reused in many ways [1]. In general, it comes from industry in form of halves after egg braking and separation egg white and egg yolk from shell. Aim of this research is to determine size distribution and shape of eggshell particles after 60 minutes hydrodynamical extraction of egg inner membrane in three different weight to weight ratio, water to eggshell: 1:5, 1:10 and 1:15 (ESW_1_5, ESW_1_10 and ESW_1_15) with constant mixing speed and same mixing body (four blade metal impeller), in order to find optimal filter dimension for separation of eggshells and membranes from water solution. Size and shape descriptors are determined by image analysis from digital images obtained after photographing 25 % of randomized eggshells particles from whole sample. Image analysis was performed by open-source Fiji software [2] and measured parameters (descriptors) are number of eggshell particles, area [mm^2], perimeter [mm], circularity, Ferret diameter [mm], minimal Ferret diameter [mm], aspect ratio, roundness and solidity (Figure 1).

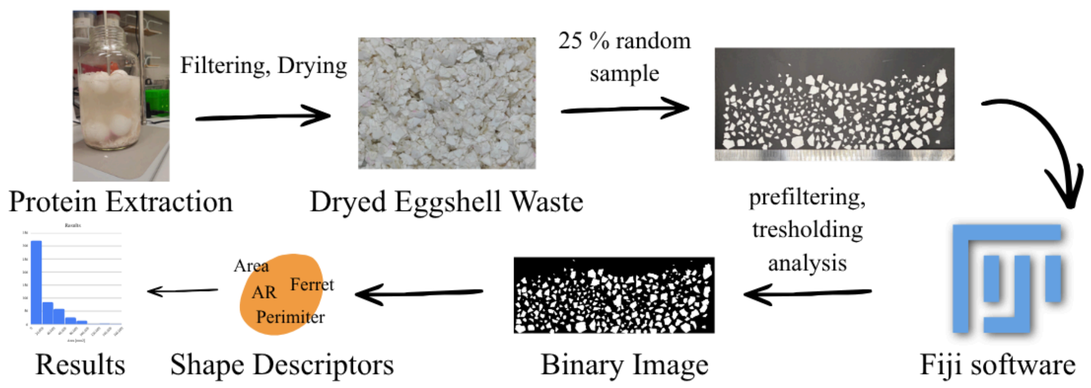

Figure 1 Research graphical abstract

Table 1 Eggshell particles shape descriptors

	ESW_1_5				ESW_1_10				ESW_1_15			
	Min	Median	Max	IQR	Min	Median	Max	IQR	Min	Median	Max	IQR
Area	0,002	12,752	97,945	27,244	0,003	8,896	123,720	16,637	0,003	7,914	120,907	18,412
Perimiter	0,132	15,896	58,733	16,508	0,166	12,949	72,724	11,222	0,166	12,278	65,257	12,958
Circularity	0,152	0,676	1,000	0,102	0,054	0,709	1,000	0,107	0,232	0,703	1,000	0,119
Ferret's	0,066	5,696	20,759	5,763	0,083	4,662	21,482	3,892	0,083	4,453	20,171	4,599
min Ferret's	0,047	3,559	12,832	3,568	0,059	2,914	10,420	2,565	0,059	2,772	11,563	2,862
AR	1,000	1,495	7,121	0,548	1,000	1,478	48,504	0,480	1,000	1,469	4,285	0,508
Roundness	0,140	0,669	1,000	0,237	0,021	0,677	1,000	0,209	0,233	0,681	1,000	0,227
Solidity	0,512	0,925	1,000	0,043	0,534	0,929	1,000	0,037	0,562	0,931	1,000	0,038

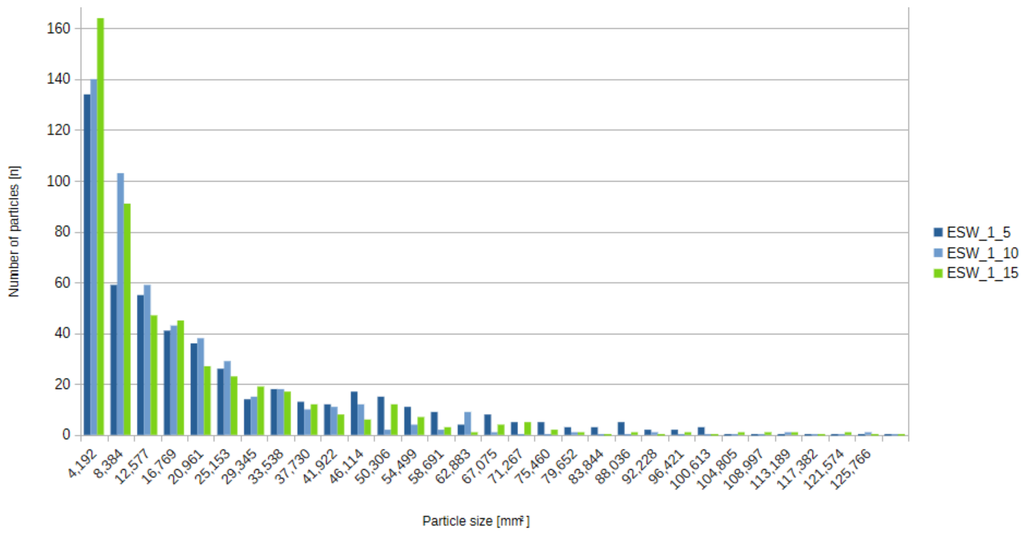

Figure 2 Histogram of particle surface area distribution

RESULTS

For each sample (ESW_1_5, ESW_1_10 and ESW_1_15), 500 particles were randomly chosen with respective measured descriptors. For all parameters , non normal distribution was observed as frequency analysis showed skewness in parameters distribution (Figure 2). Non-parametric statistics was used median and inter quartile range (IQR) for data description shown in Table 1 (instead mean and standard deviation), Kruskal-Wallis rank sum test was done to find difference between samples. Test showed that area, circularity, Ferret's and minimal Ferret's diameter show statistical significant difference with $p<0,05$ (Table 2) but aspect ratio, roundness and solidity were not significant different $p>0,05$. Dunn's test was performed to find which samples are statistically different. Result showed that ESW_1_5 is different from both ESW_1_10 and ESW_1_15 but there is no statistically significant difference between ESW_1_10 and ESW_1_15.

Table 1 Results of Kruskal-Wallis test, df=2

	chi-squrred	p-value
Area	20,535	0,00*
Perimiter	25,642	0,00*
Circularity	46,078	0,00*
Ferret's	25,199	0,00*
min Ferret's	22,175	0,00*
AR	0,866	0,65
Roundness	0,869	0,65
Solidity	4,442	0,109

*Values are non-zero < 10^{-5} thus rounded to 0,00

REFERENCES
[1] B. Ngayakamo, A. Onwualu, Recent advances in green processing technologies for valorisation of eggshell waste for sustainable construction materials. Heliyon 8, (2022).
[2] J. Schindelin, I. Arganda-Carreras, E. Frise et al., Fiji: an open-source platform for biological-image analysis. Nat Methods 9, 676–682 (2012).

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