Acta Agrophysica, 2012, 19(4), 857-863

FUNCTIONAL PROPERTIES OF INFANT MILK POWDER*

Karolina Szulc[1], *Ewa Ostrowska-Ligęza*[2], *Andrzej Lenart*[1]

[1]Department of Food Engineering and Process Management, Faculty of Food Science,
Warsaw University of Life Sciences
[2] Department of Chemistry, Faculty of Food Science, Warsaw University of Life Sciences
Faculty of Food Science, Warsaw University of Life Sciences
ul. Nowoursynowska 159C, 02-776 Warszawa
e-mail: karolina_szulc@sggw.pl

Abstract. The aim of the study was investigation of the influence of raw material composition and agglomeration on functional properties of infant milk powder. Technological methods included three processes: mixing, agglomeration and drying. 15% aqueous solution of lactose and 20% aqueous solution of maltodextrin were used as wetting liquids for the agglomeration. Analysis of functional properties included: particle size, bulk density, Hausner ratio, Carr index, flowability as the pouring time, angle of repose, wettability and solubility. Wet agglomeration of powdered mixtures caused an increase of particle size and it made possible to obtain agglomerates with good flowability and wettability, and reduced bulk density. Wet agglomeration with 15% aqueous solution of lactose, compared with the agglomeration by using 20% aqueous solution of maltodextrin as the wetting liquid, improved the wettability of the obtained agglomerates. The agglomeration of modified milk powder, without milk fat (whole milk powder), resulted in obtaining agglomerates with instant properties.

Keywords: infant milk powder, flowability, agglomeration, essential polyunsaturated fatty acids

INTRODUCTION

Agglomeration of food powders is successfully applied to improve the instant properties of spray dried products. The process is called “instantisation” and it is applied in the production of milk products (hot chocolate, milk powder for the production of ice cream), beverages (tea, coffee), or starch-based products (soups,

---

*The research was supported by project No. N N312 366637, National Science Centre.

sauces, meal concentrates, powdered infant foods) (Vissotto *et al*. 2010). However, that process is also applied for the improvement of transport properties of materials (flowability), or of the attractiveness of a product in terms of visual and sensory values, and also to lower the density of products and prevent their lumping in storage. Physical properties of agglomerated products, such as particle size, porosity, solubility, wettability, shape and density, are dependent on the type of agglomeration and on the process parameters applied. Agglomeration in fluidised bed is proper for the obtainment of products in the form of agglomerates with high porosity and mechanical strength properties, important in subsequent processes related with the turnover of the products (Dacanal and Menegalli 2009, Szulc and Lenart, 2010, Vissotto *et al*. 2010). The objective of the study was determination of the effect of raw material composition and agglomeration on the functional properties of modified infant milk powder.

MATERIAL AND METHOD

The experimental material consisted of the following food powders: skimmed milk powder (SMP), whole milk powder (WMP), whey protein concentrate (WPC), lactose (L), essential unsaturated fatty acids (EPUFA) omega-3 and omega-6, calcium citrate (CC) and vitamins (VIT) B and C. Simulation of the raw material composition of the powdered mixtures corresponded to the composition of the modified infant milk powder (Tab. 1).

Table 1. Raw material composition of infant milk powder

Mixture	SMP (%)	WMP (%)	WPC (%)	L (%)	EPUFA (%)		CC (%)	VIT (%)	
					Ω-3	Ω-6		B	C
1	43.5	43.5	0	0	4.5	8.5	0	0	0
2	37	0	10	39	4.5	8.5	0.6	0.1	0.3
3	49.5	49.5	0	0	0	0	0.6	0.1	0.3
4	88.5	0	0	0	5.8	5.7	0	0	0

The technological methods applied comprised three processes: mixing, agglomeration and drying. The mixing of the experimental material was conducted in a laboratory mixer for the granulation of loose materials, Lödige type L5 (Lödige Plughshare Mixer), during 5 min, at stirrer speed of 200 revs min^{-1}. Agglomeration and drying were conducted in a laboratory fluid bed dryer, STREA 1 (Niro-Aeromatic AG). In the process of agglomeration 15% water solution of lactose and 20% water solution of maltodextrin were used as wetting fluids, in amounts of 20 ml per 300 g of mixture, at feed rate of 4 ml min^{-1}, at temperature of 50°C. After agglomeration, the material tested was dried at temperature of 50°C, during 15 min.

For the mixtures and the agglomerates obtained from them the following assays were made: particle diameter (median), loose and tapped bulk density, Hausner ratio and Carr index (Turchiuli *et al*. 2005, Jinapong *et al.* 2008), flowability, as the pouring time, angle of repose (Domian and Bialik 2006), wettability at temperature of 40°C, and solubility index (Shittu and Lawal 2007).

The results obtained were presented as mean values ± standard deviation, and subjected to statistical analysis with the use of the statistical software package Statgraphics 5.0 using one-factor analysis of variance. The significance of differences was estimated at significance level of $p < 0.05$

RESULTS AND DISCUSSION

The initial material in the form of mixture of various components was characterised by notable variation in terms of raw material composition (Tab. 1). The raw material composition had a significant effect on the particle size (particle diameter) of the modified infant milk powder (Fig. 1). After agglomeration, the particle diameter increased with increase in the share of milk powder in the mixture. Irrespective of the kind of wetting liquid, agglomeration had a significant effect on the increase of particle diameter of the material tested; this is supported also by studies conducted by Jinapong *et al*. (2008), Szulc and Lenart (2010). The kind of wetting liquid (15% lactose solution and 20% maltodextrin solution) and the raw material composition had a significant effect on the particle size of the agglomerates produced. The largest increase in particle size was observed for mixtures 1 and 2, agglomerated with 20% maltodextrin solution and 15% lactose solution, respectively.

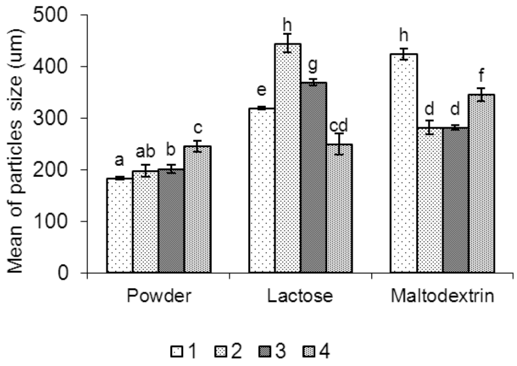

Fig. 1. Particle size of infant milk powder before and after agglomeration; 15% lactose solution and 20% maltodextrin solution were used as wetting liquids. The results are expressed as mean values with standard deviation. Values followed by a different letter are significantly different at p < 0.05.

The raw material composition of the modified infant milk powder had a statistically significant effect on the loose and tapped bulk density of the mixtures (Fig. 2a and 2b). A statistically significant decrease of the bulk density of the agglomerates produced was observed, related primarily to the wetting liquid and, to a lesser degree, to the raw material composition. The lowest bulk density after agglomeration was obtained for modified milk powder 2, in which the share of one of the main components – skimmed milk powder, was that lowest at 37%.

a) b)

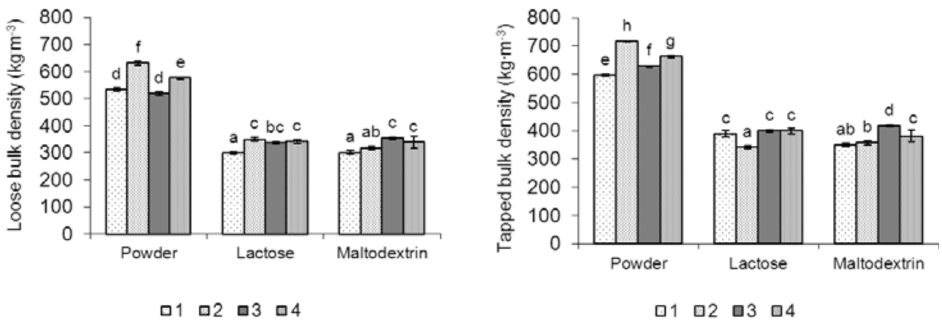

Fig. 2. Loose (a) and tapped (b) bulk density of infant milk powder before and after agglomeration; 15% lactose solution and 20% maltodextrin solution were used as wetting liquids. The results are expressed as mean values with standard deviation. Values followed by a different letter are significantly different at $p < 0.05$.

The Hauser ratio and the Carr index define the flowability of powdered materials. The powdered mixtures and their agglomerates can be classified as materials with good flowability due to the obtained values of the Hausner ratio below 1.2 and of the Carr index below 18% (Fig. 3a and 3b). The exception was mixture 3, with its considerable content of whole milk powder with an absence of unsaturated fatty acids. Statistical analysis of the values of the Haunser ratio and the Carr index confirmed comparable flowability, according to those indices, for the particular mixtures in the form of powders and agglomerates. On the basis of the statistical analysis, a significant effect of the raw material composition of the modified infant milk powder on the values of the Hausner ratio and the Carr index was observed (Fig. 3a and 3b).

The values of flowability, defined as the time of pouring from a cylindrical measurement vessel rotating at a constant speed, were significantly affected by the kind of mixture (Fig. 3c). The pouring time of the agglomerates tested was related to their raw material composition and to the kind of wetting liquid. In the case of modified milk powder 3, agglomeration caused further improvement of flowability in relation to the mixture prior to the process of agglomeration. The agglomerates produced were characterised by very good flowability, as they poured through the slot of the cylindrical vessel within less than 20 s (Domian 2005).

The angle of repose is another indicator of flowability of powders (Fig. 3d). The value of the angle of repose depended on the raw material composition of the modified infant milk powders. Mixtures whose raw material composition included whole milk powder (1, 3) were characterised by poor flowability. Irrespective of the raw material composition of the modified infant milk powders, the process of agglomeration caused a further improvement of the flowability of the materials tested.

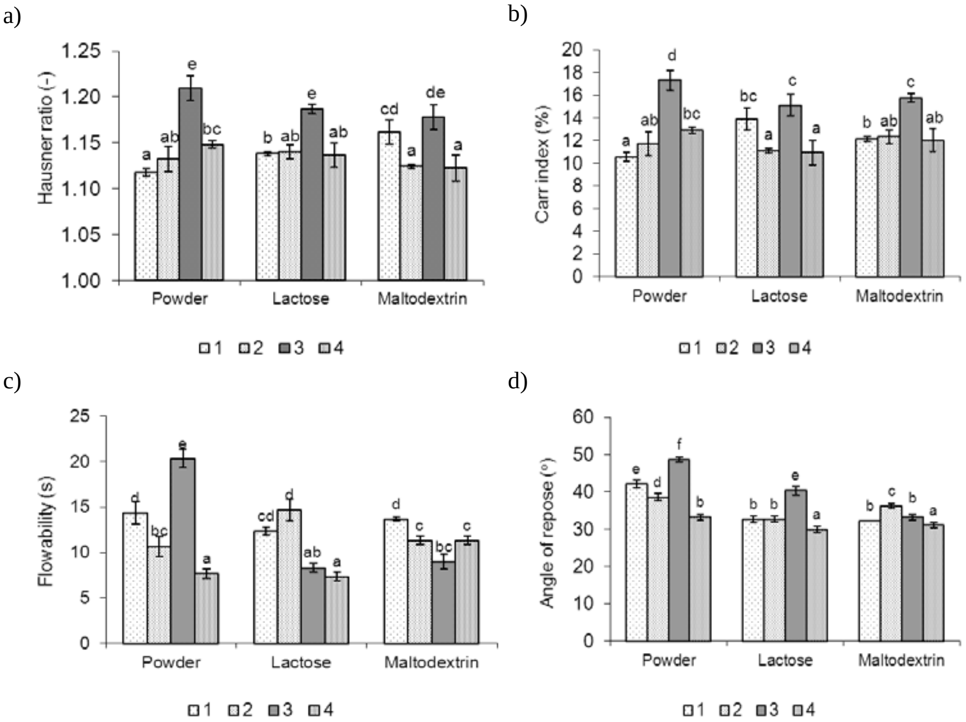

Fig. 3. Flowability factors of infant milk powder before and after agglomeration; 15% lactose solution and 20% maltodextrin solution were used as wetting liquids: a) Hausner ratio, b) Carr index, c) flowability, as pouring time, d) angle of repose. The results are expressed as mean values with standard deviation. Values followed by a different letter are significantly different at $p < 0.05$.

The reproducibility of powders in liquids is related with such processes as wettability and solubility (Fig. 4a and 4b) (Turchiuli *et al.* 2005). Wettability is expressed is seconds, as the time required for a certain amount of powder to sink beneath free surface of a liquid. With an addition of whole milk powder in the mixtures, the wettability of the modified infant milk powder deteriorated. Agglomeration of the modified infant milk powder, irrespective of the wetting liquid applied, caused a notable reduction of the wetting time. Agglomerates of modified infant milk powders 2 and 4 were characterised by wetting times below 15 s (characteristic of instant products). The mixtures tested, irrespective of their raw material composition and method of agglomeration, were characterised by very good solubility (sediment amount below 1 ml).

a) b)

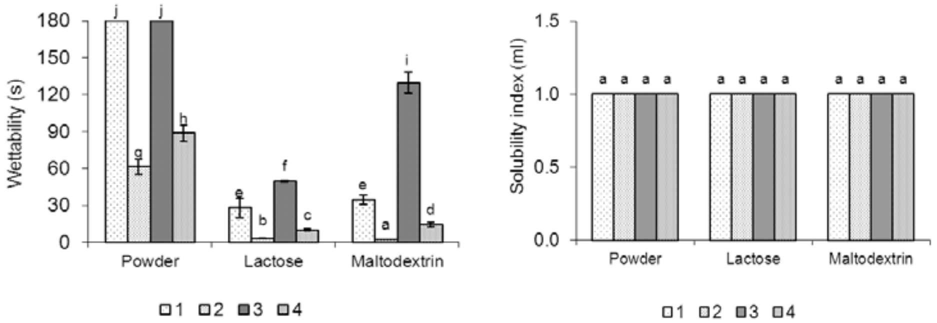

Fig. 4. Wettability (a) and solubility index (b) of infant milk powder before and after agglomeration; 15% lactose solution and 20% maltodextrin solution were used as wetting liquids
The results are expressed as mean values with standard deviation. Values followed by a different letter are significantly different at $p < 0.05$.

CONCLUSIONS

1. The modified infant milk powders under analysis were characterised by varied functional properties, including, in particular, particle diameter, bulk density, flowability and wettability. The raw material composition of the mixtures analysed had a significant effect on the physical properties assayed.

2. Irrespective of the kind of wetting fluid and raw material composition of the modified infant milk powders, fluidised bed agglomeration caused an increase of particle size, reduction of bulk density, and an improvement of flowability and wettability in relation to the non-agglomerated mixtures.

3. Wet agglomeration with 15% water solution of lactose, as compared to agglomeration with the use of 20% water solution of maltodextrin as the wetting fluid, caused an improvement of wettability. Agglomeration of modified infant milk powder with no content of whole milk powder caused that the agglomerates produced achieved the properties of instant products, irrespective of the kind of wetting fluid, resulting in a notable improvement of their wettability.

REFERENCES

Dacanal G.C., Menegalli F.C., 2009. Selection of operational parameters for the production of instant soy protein isolate by pulsed fluid bed agglomeration. Powder Technology, 203, 565-573.

Domian E., 2005. Flowability of agglomerated model food powders (in Polish). Acta Agrophysica, 6, 605-615.

Domian E., Bialik E., 2006. Selected physical properties of apple juice powder (in Polish). Acta Agrophysica, 8, 803-814.

Jinapong N., Suphantharika M., Jamnong P., 2008. Production of instant soymilk powders by ultrafiltration, spray drying and fluidized bed agglomeration. Journal of Food Engineering, 84, 194-205.

Shittu T.A., Lawal M.O., 2007. Factors affecting instant properties of powdered cocoa beverages. Food Chemistry, 100, 91-98.

Szulc K., Lenart A., 2007. Effect of agglomeration on functional properties of model infant milk powders (in Polish). Żywność. Nauka. Technologia. Jakość, 5(54), 310-318.

Szulc K., Lenart A., 2010. Effect of agglomeration on flowability of baby food powders. Journal of Food Science, 5(75), E276-E274.

Turchiuli C., Eloualia Z., El Mansouri N., Dumoulin E., 2005. Fluidised bed agglomeration: Agglomerates shape and end-use properties. Powder Technology, 157, 168-175.

Vissotto F.Z., Jorge L.C., Makita G.T., Rodrigues M.I., Menegalli F.C., 2010. Influence of the process parameters and sugar granulometry on cocoa beverage powder steam agglomeration. Journal of Food Engineering, 97, 283-291.

WŁAŚCIWOŚCI UŻYTKOWE MODYFIKOWANEGO MLEKA W PROSZKU

Karolina Szulc[1], Ewa Ostrowska-Ligęza[2], Andrzej Lenart[1]

[1]Katedra Inżynierii Żywności i Organizacji Produkcji,
[2]Katedra Chemii,
Wydział Nauk o Żywności, Szkoła Główna Gospodarstwa Wiejskiego
ul. Nowoursynowska 159 C, 02-776 Warszawa
e-mail: karolina_szulc@sggw.pl

S t r e s z c z e n i e . W pracy przedstawiono wpływ składu surowcowego i aglomeracji na właściwości funkcjonalne otrzymywanych aglomeratów na przykładzie modyfikowanego mleka w proszku. Metody technologiczne obejmowały trzy procesy: mieszanie, aglomerację i suszenie. W procesie aglomeracji zastosowano 15% wodny roztwór laktozy i 20% wodny roztwór maltodekstryny jako ciecze zwilżające. Analiza właściwości użytkowych modelowych mieszanin i utworzonych na ich podstawie aglomeratów obejmowała: rozmiar cząstek, gęstość nasypową, współczynnik Hausnera i Carra, sypkość jako czas wysypu, kąt nasypu, zwilżalność i indeks rozpuszczalności. Aglomeracja nawilżeniowa badanych mieszanin wpłynęła na wzrost rozmiaru cząstek oraz otrzymanie aglomeratów o dobrej sypkości i zwilżalności, jak też o obniżonej gęstości nasypowej. Aglomeracja nawilżeniowa 15% wodnym roztworem laktozy, w porównaniu z aglomeracją przy zastosowaniu 20% wodnego roztworu maltodekstryny jako cieczy nawilżającej, wpłynęła na poprawę zwilżalności otrzymanych aglomeratów. Aglomeracja modyfikowanego mleka w proszku, w którym nie występowało mleko tłuste, spowodowała uzyskanie właściwości instant przez utworzone aglomeraty.

S ł o w a k l u c z o w e : mleko modyfikowane, sypkość, aglomeracja, niezbędne nienasycone kwasy tłuszczowe