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ВНИИ Молочной Промышленности

LACTOSE CRYSTALLIZATION FROM SATURATED SOLUTIONS

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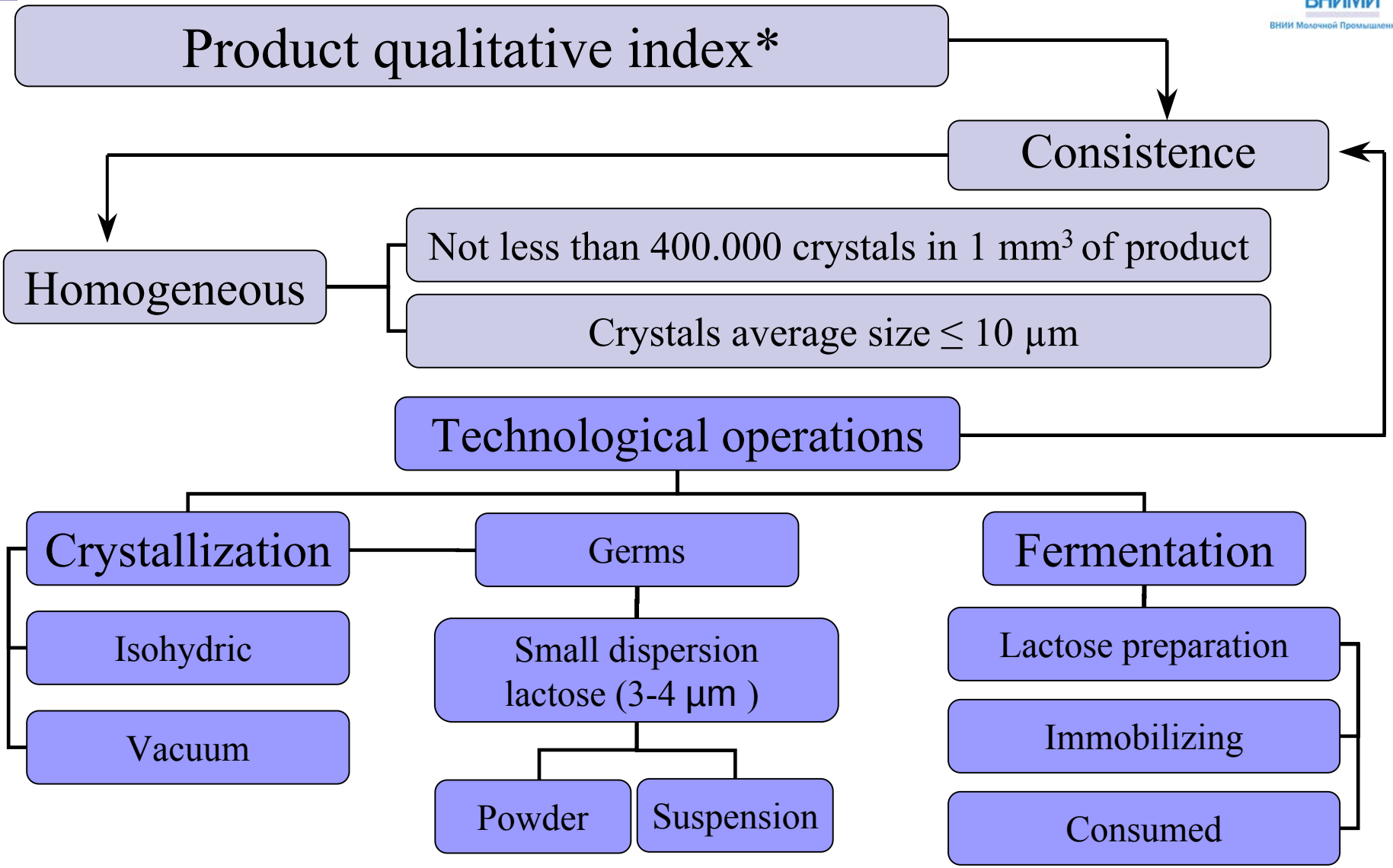

* Радаева И.А., Гордезиани В.С., Шулькина С.П. Технология молочных консервов и ЗЦМ: Справочник– М.:Агропромиздат, 1986.
Чекулаева Л.В., Чекулаев Н.М Сгущенные молочные консервы. – М.: Легкая и пищевая пром-ть, 1982.
Чекулаева Л.В., Полянский К.К., Голубева Л.В. Технология продуктов консервирования молока и молочного сырья.– Воронеж: Изд. ВГУ, 1996.

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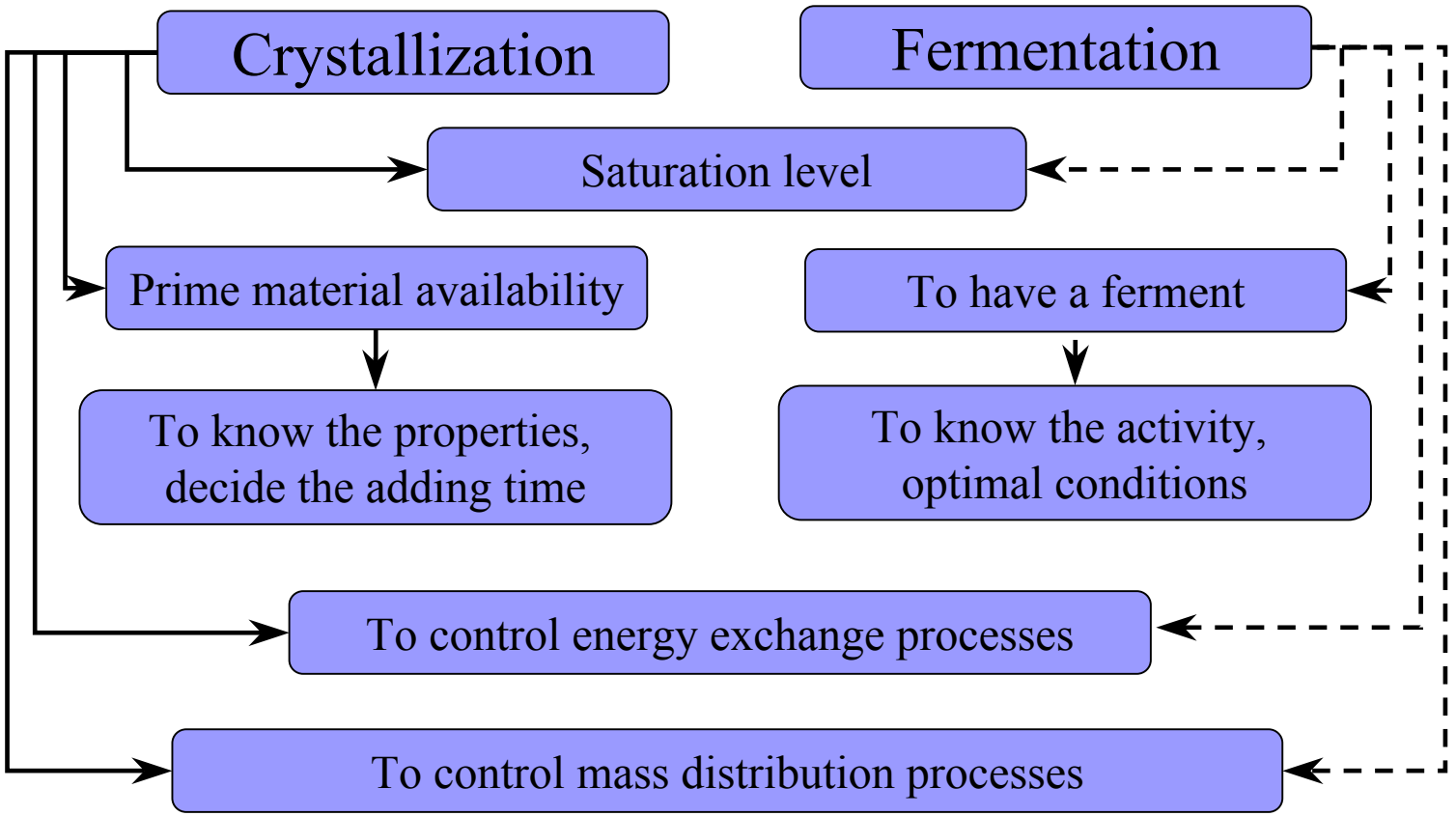
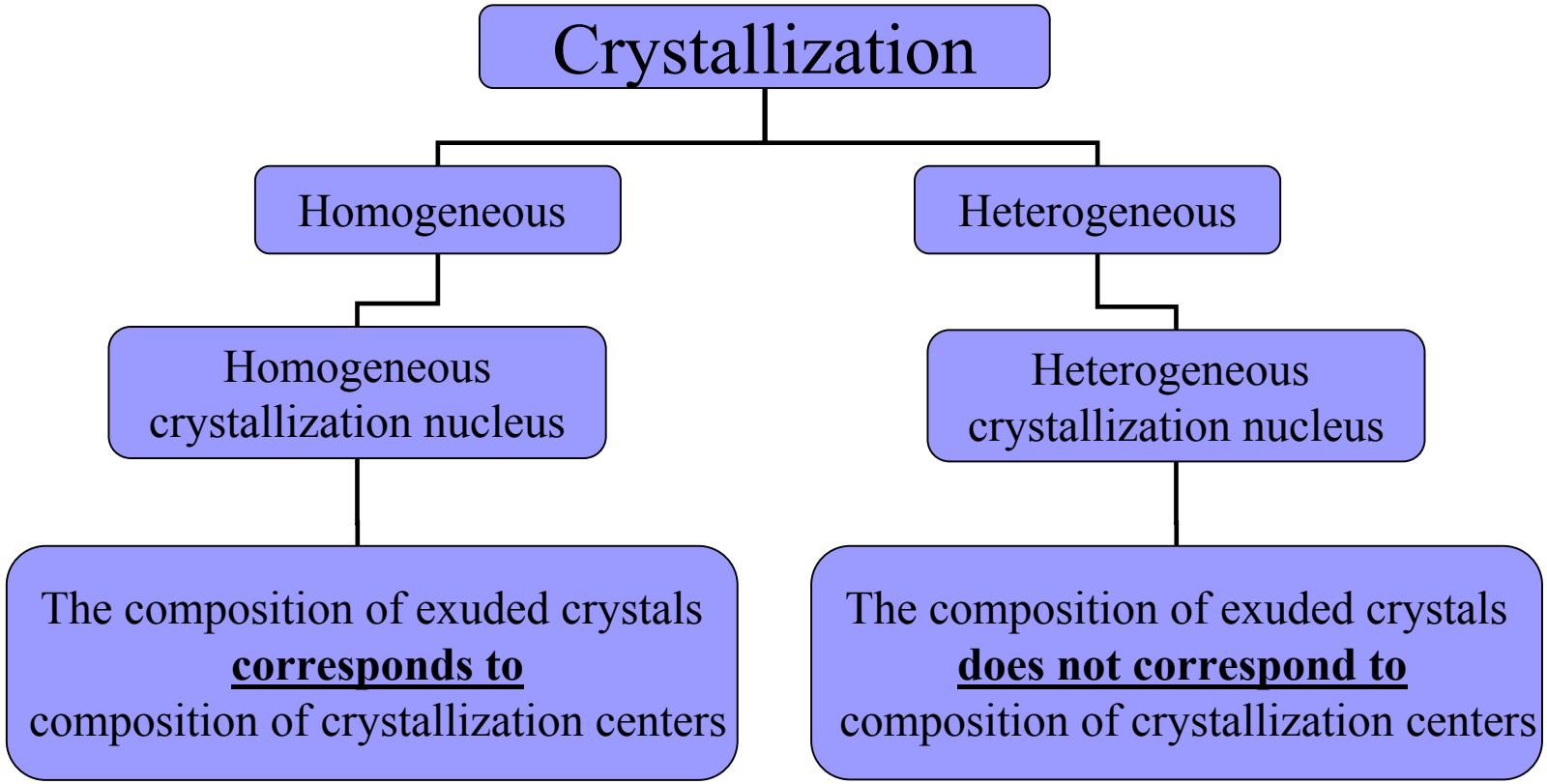
Technological requirements

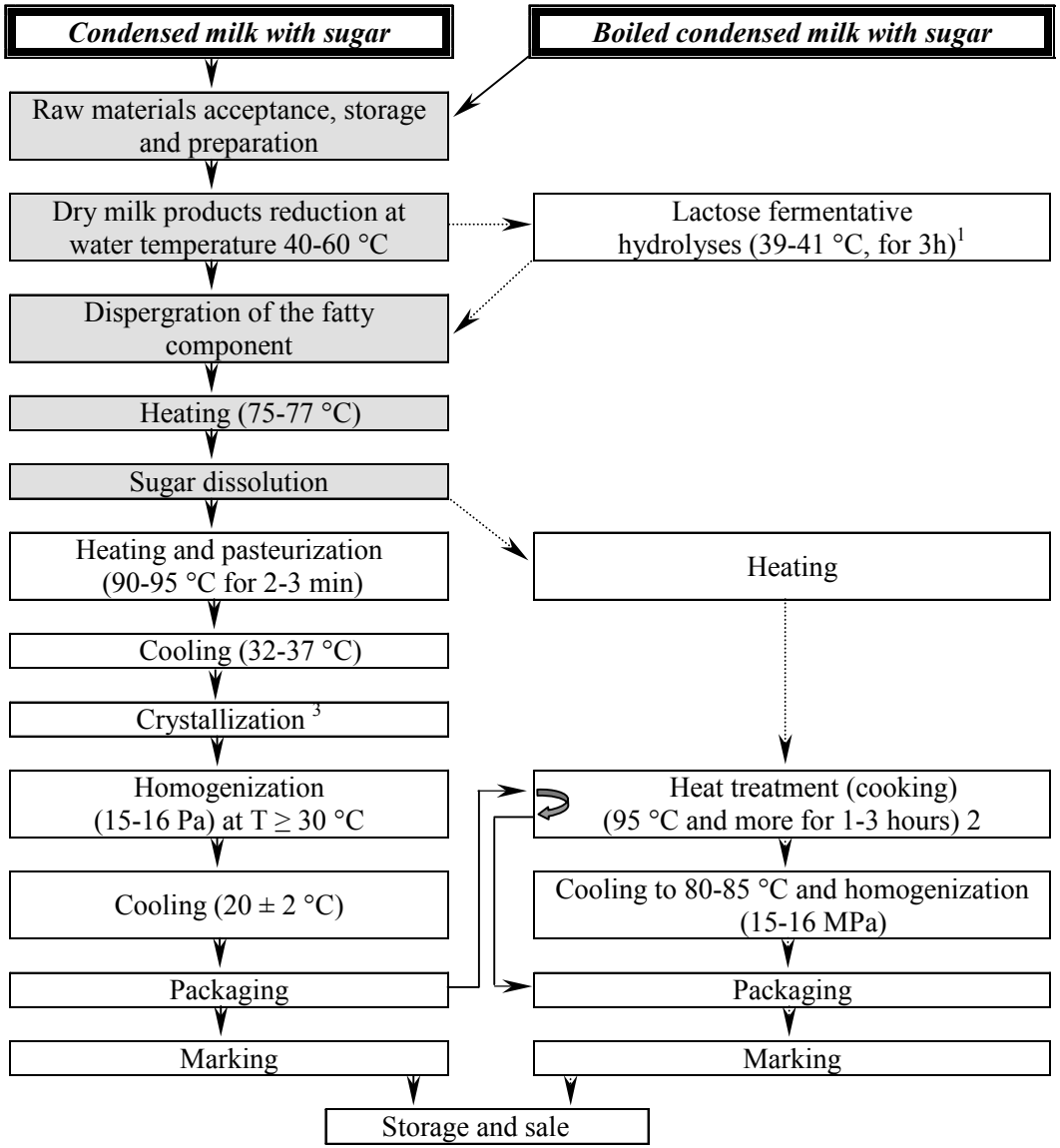




1) Shabalin V.N., Shatoxina S.N. Morphology of biological fluids. – M.:Chrizostom, 2001
2) Rosenberger F. Fundamentals of Crystal Growth.— Berlin, 1979
3) Ohtaki H. Crystalization Processes. – Wiley, 2001
4) Hartel R.W. Crystallization In Foods.- Kluwer Academic Publishers, 2001
5) Веригин А. Н., Щупляк И. А., Михалев М. Ф. Кристаллизация в дисперсных системах: Инж. мет. расчета.- Л.: Химия, 1986
6) Портнов В.Н., Чупрунов Е.В. Возникновение и рост кристаллов.-М.:Изд. Физ.-мат.лит., 2006

http://www.wikipedia.org http://www.xumuk.ru http://www.paceka.ru http://www.cheresources.com http://www.geo.web.ru и др.

Principle technological schemes of manufacture of sugar containing condensed milk products



[1] Employed with a purpose of prevention the uncontrolled crystallization & speeding-up cooking time

[2] Duration depends on the temperature & fermentation process

[3] The adding of priming material in vacuum meant. In manufacture of sugar-containing condensed milk "cooking" is not employed.

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Model product's normalized indices

Index appellation	**Standards**
Mass proportion of moisture, %	≤ 26,5
Mass proportion of saccharose, %	≥ 43,5
Total mass proportion of milk dry materials, % *also fat, %*	≥ 28,5 ≥8,5
Acidity, ^{0}T	≤ 45
Viscosity, Pa*c *valid within 2 months* *valid within 2 to 12 months*	 ≤ 3-6 15
Allowed size of lactose crystals, μm ,	≤ 15

Recipes of sugar-containing condensed milk products and established conventional coding

Components	Recipes	Coding
Dry skimmed milk (dry materials proportion 95%, fat proportion 1,5%)	213,0	X_1
Milk fat (fat proportion 99,8%)	82,0	X_2
Granulated sugar (dry materials proportion 99,8%)	450,0	X_3
Water	255,0	X_4
Total product	1000,0	X_5

Appellation of the operation	Coding	Appellation of the operation	Coding
Dissolution	Y_1	*Vacuuming*	Y_8
Germs bringing in	Y_2	*Crystallization*	Y_9
Dispergration	Y_3	*Cooking*	Y_{10}
Heating	Y_4	*Packing*	Y_{11}
Homogenization	Y_5	*Mixing*	Y_{12}
Pasteurization	Y_6	*Marking*	Y_{13}
Cooling	Y_7	*Storing*	Y_{14}

$$X_5 = X_4 + X_1 + X_2 + X_3$$

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Operative models: condensed milk with sugar (A,B,C) and condensed milk with sugar "cooked" (C/)

Operations sequence	*Possible modification of germs adding time*			
	A	**B**	**C**	**C/**
TO1	$Y_4X_4 \leftarrow Z$	Y_4X_4	Y_4X_4	Y_4X_4
TO2	Y_1X_1	Y_1X_1	Y_1X_1	Y_1X_1
TO3	Y_4X_{41}	Y_4X_{41}	Y_4X_{41}	Y_4X_{41}
TO4	Y_3X_2	Y_3X_2	Y_3X_2	Y_3X_2
TO5	Y_5X_{412}	Y_5X_{412}	Y_5X_{412}	Y_5X_{412}
TO6	Y_4X_{412}	$Y_4X_{412} \leftarrow Z$	Y_4X_{412}	Y_4X_{412}
TO7	Y_1X_3	Y_1X_3	Y_1X_3	Y_1X_3
TO8	Y_6X_{4123}	Y_6X_{4123}	Y_6X_{4123}	Y_6X_{4123}
TO9	Y_8X_{4123}	Y_8X_{4123}	$Y_8X_{4123} \leftarrow Z$	$Y_8X_{4123} \leftarrow Z$
TO10	Y_7X_{4123}	Y_7X_{4123}	Y_7X_{4123}	Y_7X_{4123}
TO11	Y_9X_{4123}	Y_9X_{4123}	Y_9X_{4123}	$Y_{11}X_5$
TO12	$Y_{11}X_5$	$Y_{11}X_5$	$Y_{11}X_5$	$Y_{10}X_5$
TO13	$Y_{13}X_5$	$Y_{13}X_5$	$Y_{13}X_5$	Y_7X_5
TO14	$Y_{14}X_5$	$Y_{14}X_5$	$Y_{14}X_5$	$Y_{13}X_5$
TO15	-	-	-	$Y_{15}X_5$

TO – technological operation; Z – time point of bringing in of germs

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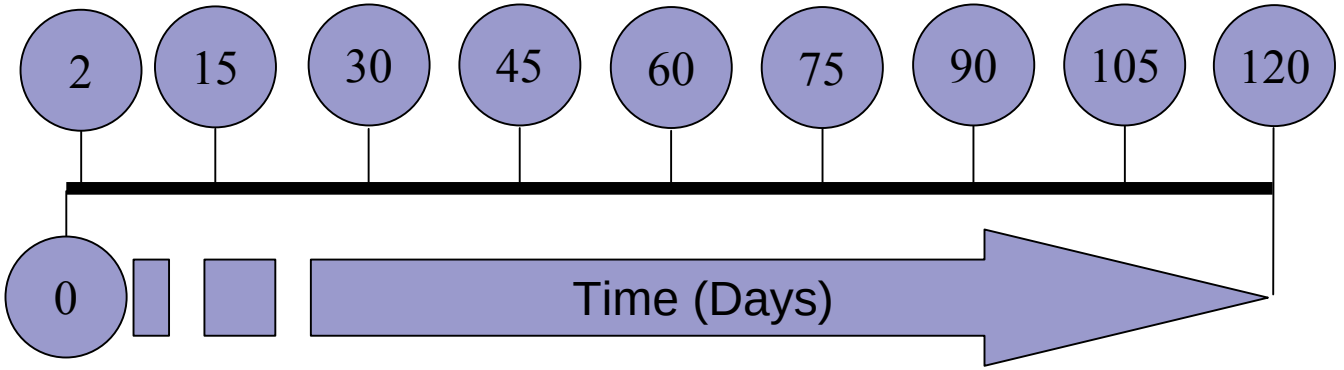
Time point of sampling for microscoping

Storage temperature 6-10^{0}C



0 – end of technological process and beginning of analysis
120 – end of analysis

Materials and Methods

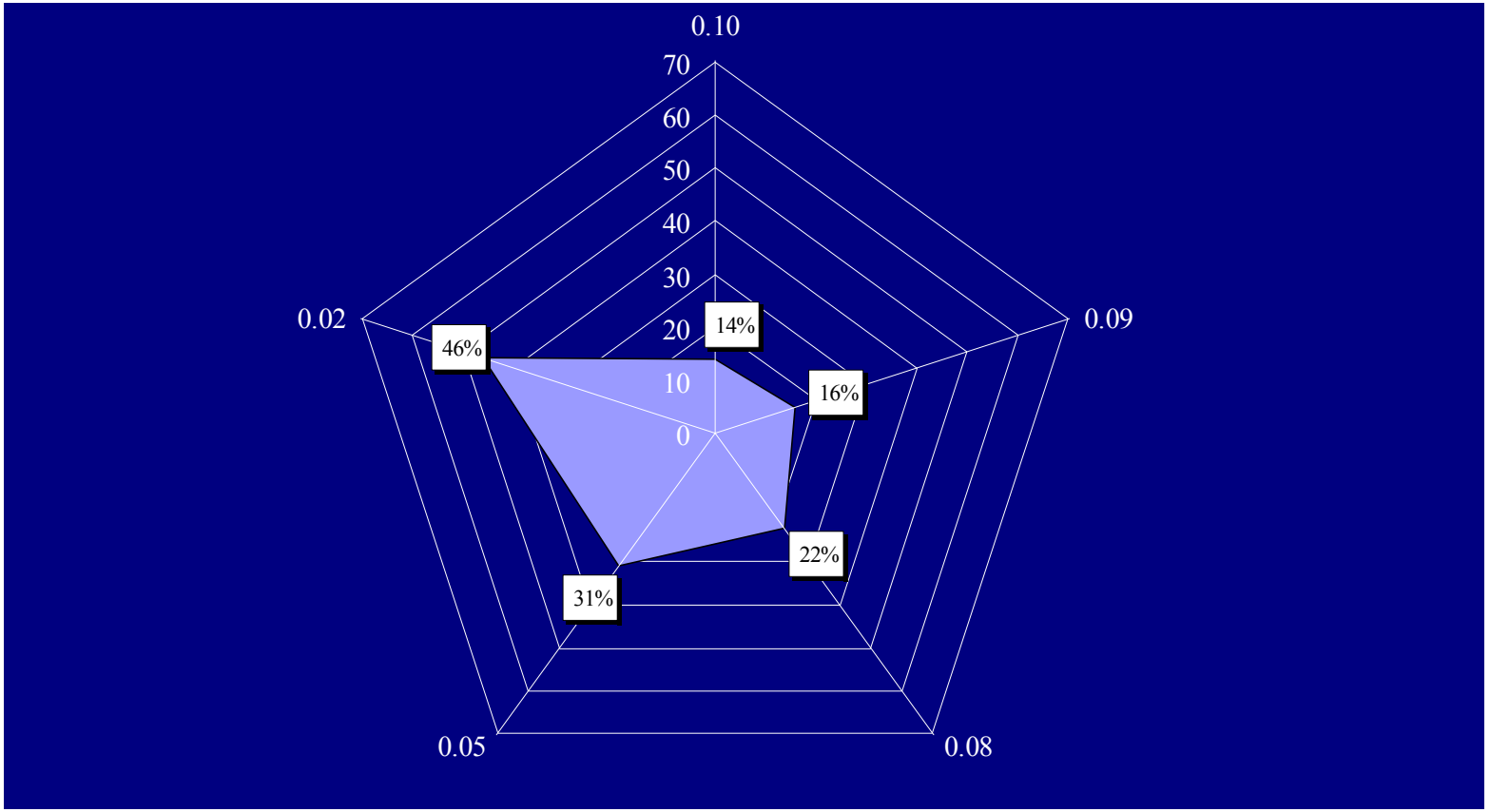
№	Products	Molecular formula	Properties, %	Solubility in water at pH≤7,0, mg/l
1	Silicon dioxide	SiO_2	≥ 98	Not present
2	Titanium dioxide	TiO_2		not present
3	Calcium carbonate	$CaCO_3$		14-15

Crystals average size was calculated by formula: $D = \sum na / \sum n$	Coefficient of crystals homogeneity was calculated by the means of N. Figurovskii's formula $U = \Delta a\sqrt{\sum n/(2\sum nv^2)}$
D – mean value of crystals size, μm ; n – crystals frequency; a – crystals linear size, μm	U – homogeneity coefficient; Δa – crystal size limit, μm; n – crystals frequency; v – *given and mean sizes divergence,* μm

Crystals average size, μm	Lactose crystals likely amount in 1mm^3 of product, M	Crystals average size, μm	Lactose crystals likely amount in 1mm^3 of product, M
6	770 000	12	98 000
7	500 000	15	50 000
8	270 000	20	21 000
9	220 000	30	7 000
10	175 000	40	2 600

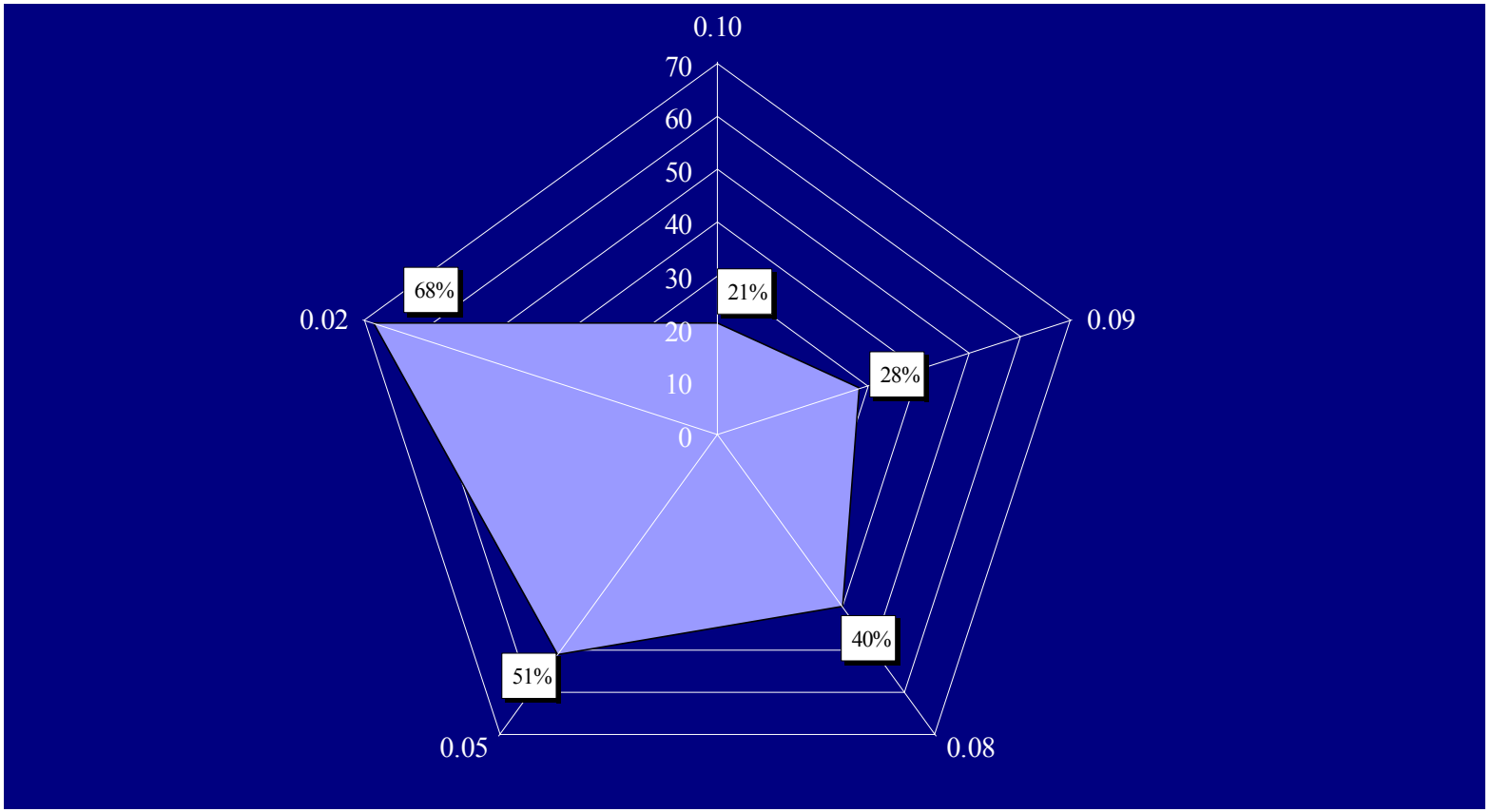
Distribution of samples with no crystallization effect when germ size is 3 μm and its corresponding dosage 0,02…0,10% of product mass

Model C
Y_4X_4
Y_1X_1
Y_4X_{41}
Y_3X_2
Y_5X_{412}
Y_4X_{412}
Y_1X_3
Y_6X_{4123}
$\boldsymbol{Y_8X_{4123} \leftarrow Z}$
Y_7X_{4123}
Y_9X_{4123}
$Y_{11}X_5$
$Y_{13}X_5$
$Y_{14}X_5$



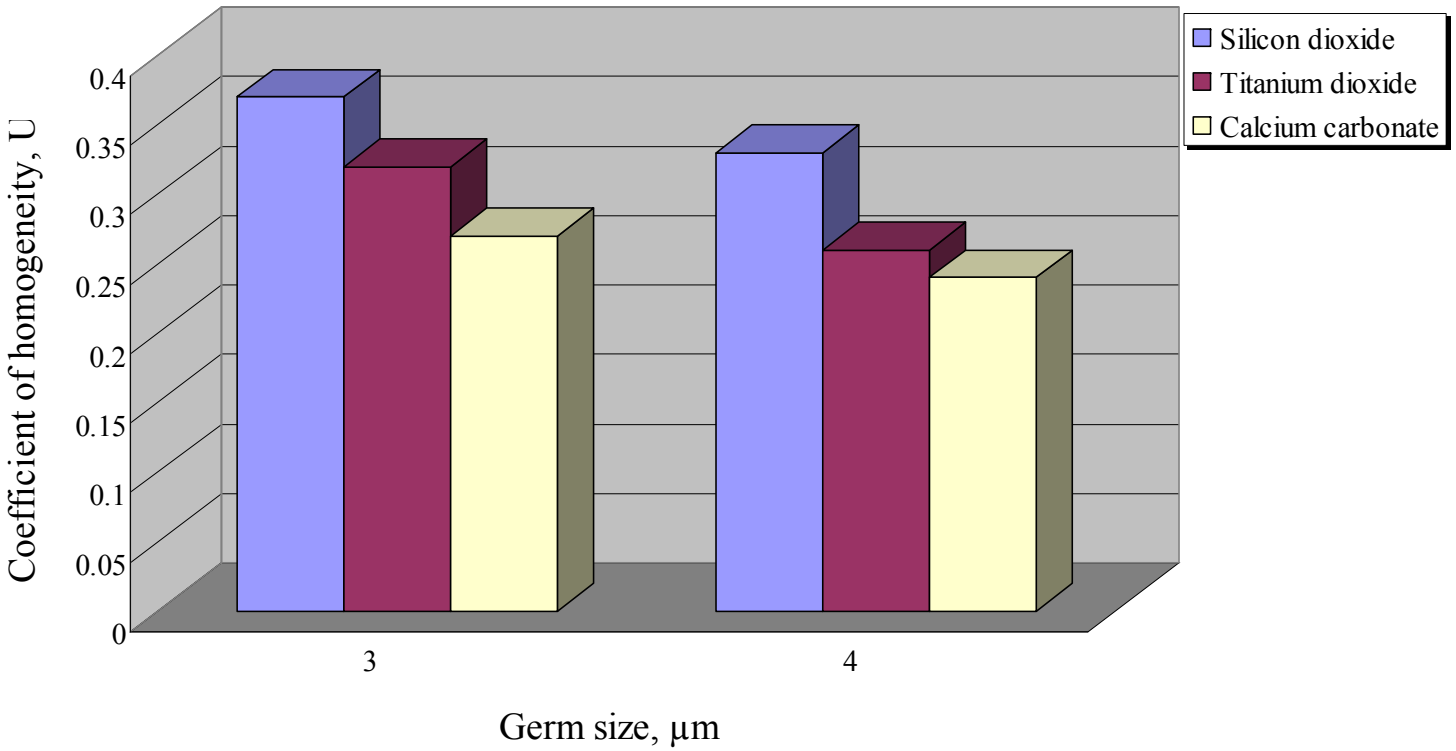
Distribution of samples with no crystallization effect when germ size is 4 μm and its corresponding dosage 0,02…0,10% of product mass

Model C
Y_4X_4
Y_1X_1
Y_4X_{41}
Y_3X_2
Y_5X_{412}
Y_4X_{412}
Y_1X_3
Y_6X_{4123}
$Y_8X_{4123} \leftarrow Z$
Y_7X_{4123}
Y_9X_{4123}
$Y_{11}X_5$
$Y_{13}X_5$
$Y_{14}X_5$



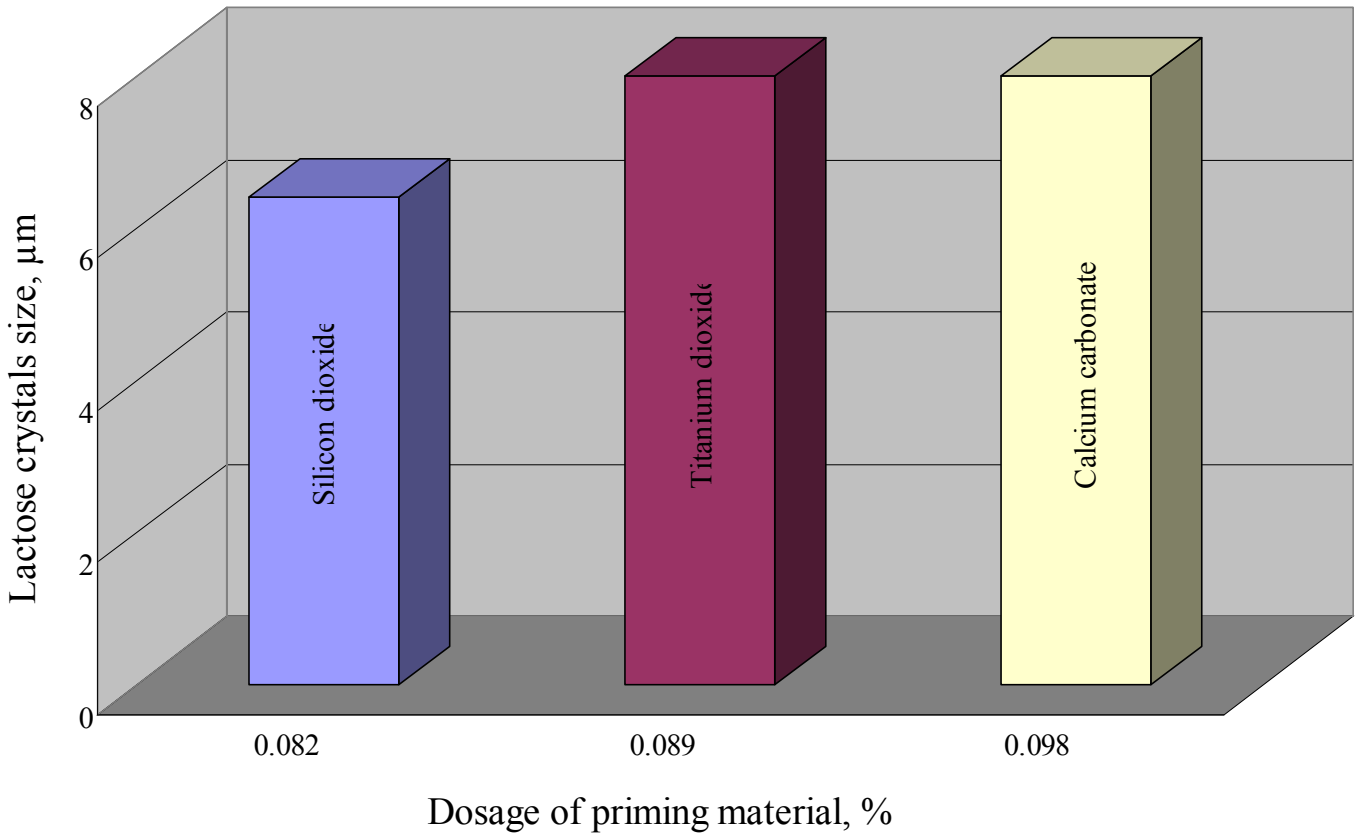
Lactose crystals homogeneity coefficient when priming material size is 3-4 μm

Model C
Y_4X_4
Y_1X_1
Y_4X_{41}
Y_3X_2
Y_5X_{412}
Y_4X_{412}
Y_1X_3
Y_6X_{4123}
$Y_8X_{4123} \leftarrow \boldsymbol{Z}$
Y_7X_{4123}
Y_9X_{4123}
$Y_{11}X_5$
$Y_{13}X_5$
$Y_{14}X_5$



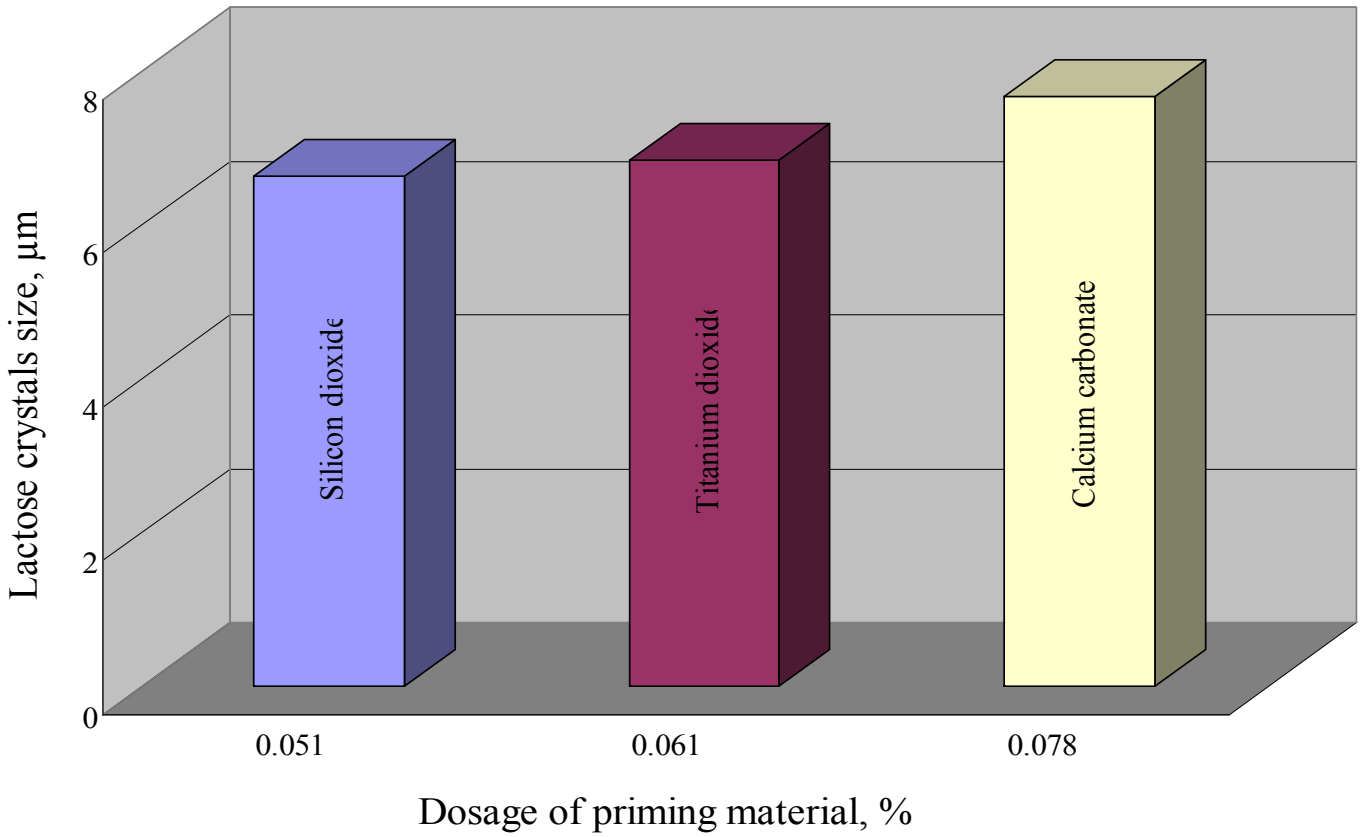
Rational dosage of priming material for lactose crystallization by model A

Model A
$Y_4X_4 \leftarrow Z$
Y_1X_1
Y_4X_{41}
Y_3X_2
Y_5X_{412}
Y_4X_{412}
Y_1X_3
Y_6X_{4123}
Y_8X_{4123}
Y_7X_{4123}
Y_9X_{4123}
$Y_{11}X_5$
$Y_{13}X_5$
$Y_{14}X_5$



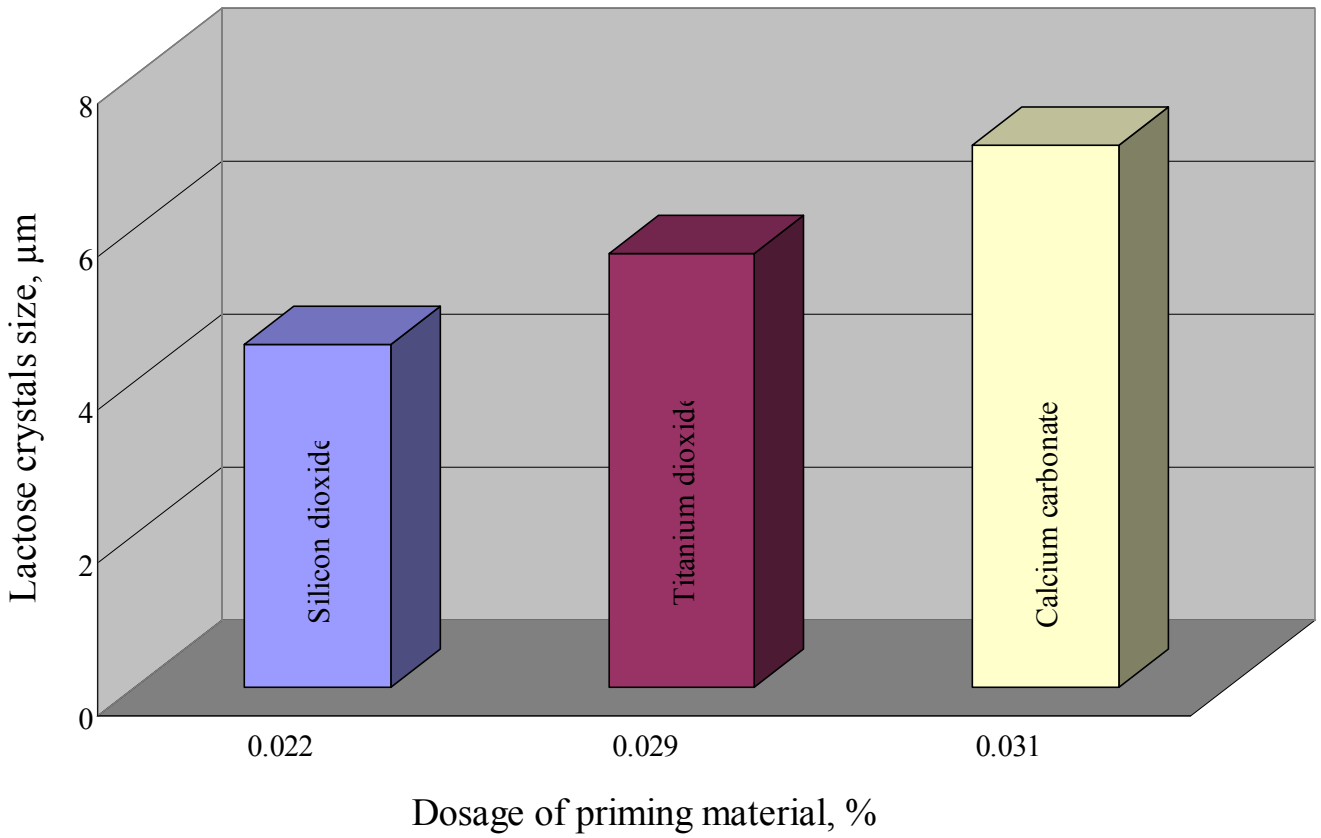
Rational dosage of priming material for lactose crystallization by model B

Model B
Y_4X_4
Y_1X_1
Y_4X_{41}
Y_3X_2
Y_5X_{412}
$Y_4X_{412} \leftarrow \boldsymbol{Z}$
Y_1X_3
Y_6X_{4123}
Y_8X_{4123}
Y_7X_{4123}
Y_9X_{4123}
$Y_{11}X_5$
$Y_{13}X_5$
$Y_{14}X_5$



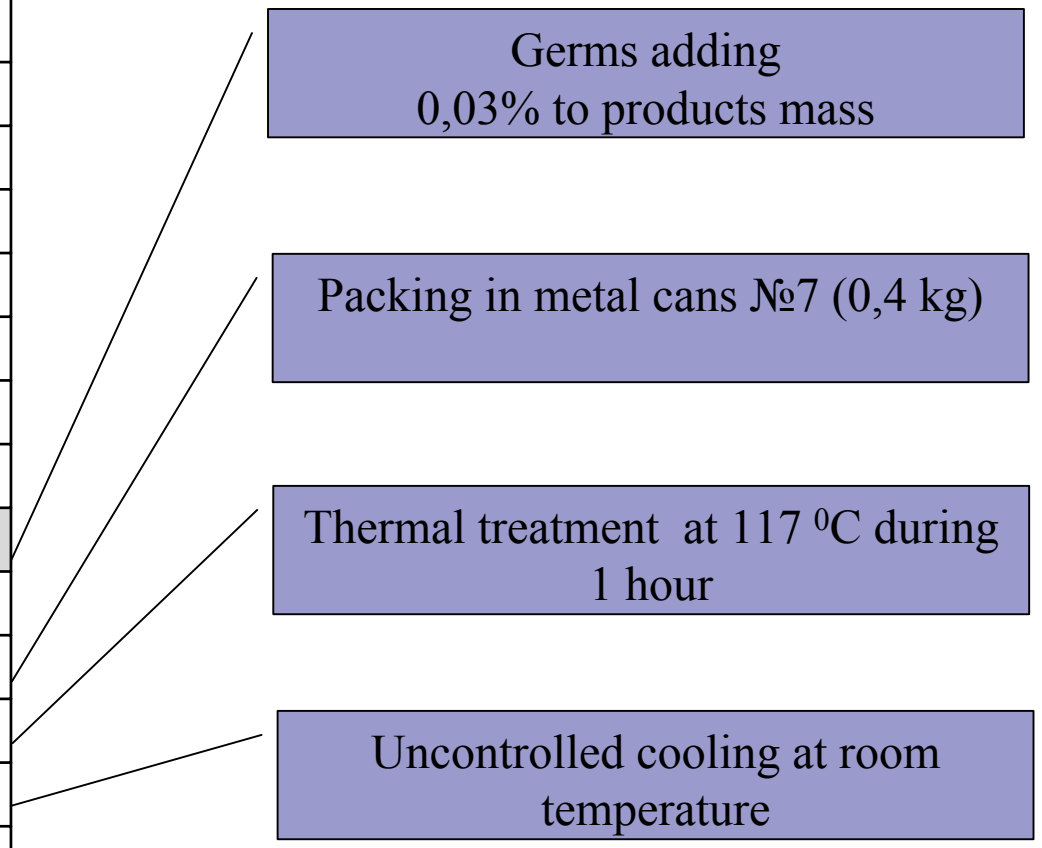
Rational dosage of priming material for lactose crystallization by model C

Model C
Y_4X_4
Y_1X_1
Y_4X_{41}
Y_3X_2
Y_5X_{412}
Y_4X_{412}
Y_1X_3
Y_6X_{4123}
$Y_8X_{4123} \leftarrow \boldsymbol{Z}$
Y_7X_{4123}
Y_9X_{4123}
$Y_{11}X_5$
$Y_{13}X_5$
$Y_{14}X_5$



Operative model of packaged product lactose crystallization after its thermal treatment

Model C/
Y_4X_4
Y_1X_1
Y_4X_{41}
Y_3X_2
Y_5X_{412}
Y_4X_{412}
Y_1X_3
Y_6X_{4123}
$Y_8X_{4123} \leftarrow \boldsymbol{Z}$
Y_7X_{4123}
$Y_{11}X_5$
$Y_{10}X_5$
Y_7X_5
$Y_{13}X_5$
$Y_{15}X_5$



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Results of packaged product lactose crystallization after its thermal treatment

Model	Crystals group	Crystals size, ***a***, μm	Crystals frequency, ***n***	Product ***na***	Discrepancy, ***v***	v^2	nv^2
C/	I	4	26	104	2.98	8.88	230.9
Y_4X_4		6	14	84	0.98	0.96	13.5
Y_1X_1		8	51	408	1.02	1.04	53.1
Y_4X_{41}		10	4	40	3.02	9.12	36.5
Y_3X_2	II	12	4	48	5.02	25.20	100.8
Y_5X_{412}		14	1	14	7.02	49.28	49.3
Y_4X_{412}	III	16	0	-	-	-	-
Y_1X_3		18	0	-	-	-	-
Y_6X_{4123}		20	0	-	-	-	-
$Y_8X_{4123} \leftarrow$ ***Z***		22	0	-	-	-	-
Y_7X_{4123}		24	0	-	-	-	-
$Y_{11}X_5$	IV	≥ 25	0	-	-	-	-
$Y_{10}X_5$							
Y_7X_5		***Δa = 2***	***∑n=100***	***∑an=698***	-	-	***∑nv²=484.1***
$Y_{13}X_5$							
$Y_{15}X_5$		***M = ∑na / ∑n = 6.98***			***U = 0.64***		

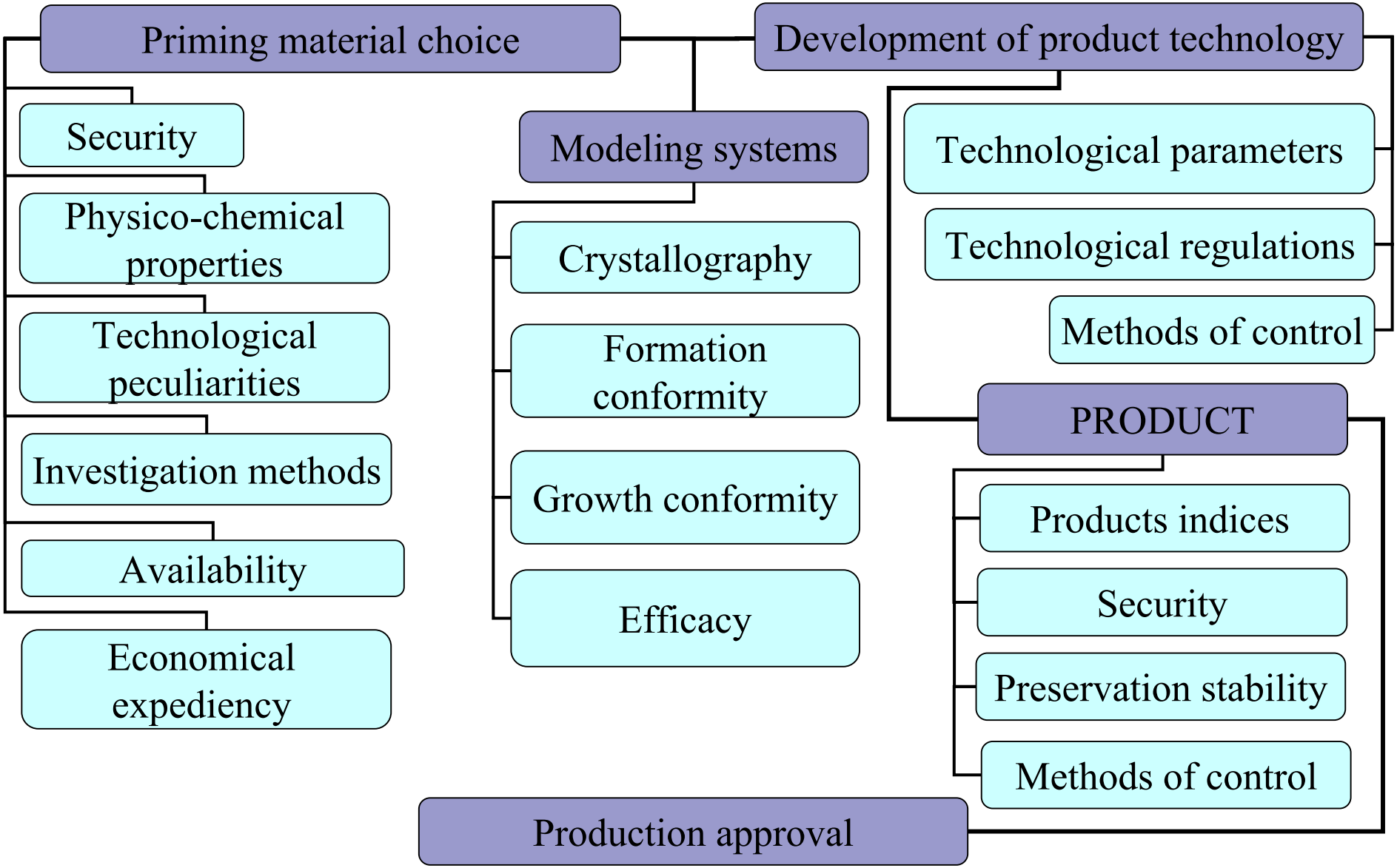
Efficacy gradation → $SiO_2 > TiO_2 > CaCO_3$

Results of lactose crystallization depending on the operating model and priming material type

Priming material type (1-2µm)	Variant of modification of germs adding time							
	A				B			
	K, %	D,µm	U	M, in 1mm³	K, %	D, µm	U	M, in 1mm³
SiO_2	*0,082*	*6,41*	*0,76*	***770.000***	*0,051*	*6,65*	*0,82*	***500.000***
TiO_2	*0,089*	*8,26*	*0,54*	***270.000***	*0,061*	*6,86*	*0,63*	***500.000***
$CaCO_3$	*0,098*	*9,13*	*0,41*	***220.000***	*0,078*	*7,68*	*0,59*	***270.000***

Priming material type (1-2µm)	Variant of modification of germs adding time							
	C				C/			
	K, %	D, µm	U	M, in 1mm³	K, %	D, µm	U	M, in 1mm³
SiO_2	*0,022*	*4,48*	*0,88*	***≥770.000***	*0,022*	*6.98*	*0.64*	***500.000***
TiO_2	*0,029*	*5,67*	*0,85*	***≥770.000***	-	-	-	-
$CaCO_3$	*0,031*	*7,09*	*0,82*	***500.000***	-	-	-	-

Farther investigations algorithm



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