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REGARDING THE BIOPOLYMERS HEAT STABILITY FORMATION

Abstract. Any biopolymer used as raw material for further treatment for food purposes besides the conformity with sanitary-hygienic regulation, physical-chemical and organoleptic regulation requirements should possess the specific technological properties that allow to manufacture high quality and safe finished products. All these pertain to raw milk. One of the basic technological characteristics is heat stability i.e. the ability of milk to sustain high temperature treatment while keeping at the same time the initial colloidal-disperse state of proteins that form its composition.

The article presents the methods of heat stability determination. It bases on both visual estimation and the usage of different instruments, created in the investigation process and fixation of physical characteristics or milk components.

The basic factors effecting the intravital formation of raw milk heat stability namely zootechnics, biochemical and physical have been also addressed in the article.

The authors describe several zootechnical factors, such as animal breeding and genetic traits, lactation periods, feed allowance and year season, housing conditions and level of health. It was proved that in order to obtain milk products manufactured under high temperature treatment, utilization of cow's milk of cows subjected to selective choice is preferable relating to accumulation in their A-alleles milk proteins; the maximum stability shows the milk produced within the 4th and the minimal within the 10th months lactation; full-value and the balance of the ration can be provided by pasture forage for cow or usage a twelve month confinement of soiling food, probiotic vitamins, mineral concentrates separately or as the complex additives; three times milking comparing to two times milking raises milk yield per lactation by 15-18% and effects positively the animals udder health state that is expressed by lower amount of somatic cells in milk.

The data covering the effect of milk composition, its components ratio density, titratable and active acidity on protein system stability are presented. The different correlation of milk heat stability depending on fat mass fraction, total protein and whey proteins, size and casein micelle fraction composition, salt composition and index of milk system physical state in the whole are considered.

Key words: biopolymers, raw milk, heat stability, methods of control, zootechnical, biochemical and physical factors.

The world milk production made up 844 million of tons in 2018 from which the part of the Eurasian Economic Union amounted to 5.4% (45.5 mln t). Russia ranks 6th place (30.3 mln t) among Top-10 best producers: USA (98.7 mln t), India (89.8 mln t), Brazil (33.8 mln t), Germany (33.0 mln t), China (30.8 mln t), France (25.5 mln t), New Zeuland (21.4 mln t), Turkey (20.0 mln t), Pakistan (16.7 mln t). In 2019 milk production in RF increased up to 31.3 mln t, that corresponds to 85.1% of self – sufficiency. For 2020 the task was to produce about 32.0 mln t and achieve the index of 86.5% which in the nearest years, according to the Doctrine of Food Safety of RF, should make up 90% [1]. When implementing the positive dynamics in raw milk production the primary attention should be payed to its quality conditioned by sanitary-hygienic, physical-chemical, organoleptic and technological properties among which heat stability is of great importance.

The scientific literature uses different synonyms of "heat stable" term: "thermostability", "heat stability", "heat tolerance". In dairy production practice this term implies the capacity of milk to withstand high temperature treatment (115-140°C) while preserving initial protein colloid-disperse properties, meaning that casein should remain in the colloid suspension and whey proteins – in the solution. Since the share of heat stable milk (available for high temperature impact) makes up from 60 to 80 % in different the RF regions during the summer-autumn period (even less for winter-spring period), the attention of Russian and foreign scientists is inter alia concentrated at investigation of mechanism of protein heat coagulation and the factors effecting the system stability as well as the problem of its het stability improvement under heating. Some scientists determined the relation between milk heat stability and its protein and mineral composition; the theory of salt balance was created and developed under which the basic factor of milk stability against heating is its mineral composition [2-4].

Due to the fact that the mechanism of milk proteins heat coagulation process up to the present time has not been fully determined and milk stability under heating is characterized by not only one index of its physical-chemical state but by the complex of a number of factors (active acidity, concentration of free ions of calcium, magnesium, phosphorous, citrates, mas protein fraction and separate protein components, protein hydration rate, etc.), the common method of heat stability determination which can consider all nuances of the system variability integrally is lacking. Thus the scientists offer different methods between which the total aptitude and correlation have not been revealed [2,5,6]. The following methods of heat stability determination are the best known and more often used:

- the alcohol test – the method is based on the detection of milk proteins coagulation under the action of ethyl alcohol within the definite period of time;
- the thermal test – this method sets up the duration of proteins coagulation in milk samples placed into oil or glycerin bath at 115-140°C;
- the flask test – determines the lack of coagulation in milk samples subjected to thermal action in ultrathermostat at 135°C within 5 min;
- the calcium-chloride test – the method is based on the investigation of milk protein fraction stability under the action of calcium chloride solution and high temperature within the specific period of time;
- phosphate test – monosaturated potassium phosphate is used as the coagulant which is added to milk with immersion of the sample for the definite time into the boiling water bath;
- RAMSDEL – the type of the phosphate test where different amounts of monosaturated potassium phosphate are added into the milk;
- the acid-boiling test – the combination of thermal effect and acid (hydrochloric and sulfuric) rangering them by the volume is used as influence on milk protein.

Among the mentioned above methods of heat stability determination only the alcohol test is the standardized method (GOST 25228-82 "Milk and cream. Method of determination of termostability on alcohol test") due to simplicity of performance that was widely used in the industry as the rapid method for detection of not thermostable milk.

It should be mentioned that the thermal test is the most reliable and objective method, possessing high sensitivity and accuracy of the results. It also allows to immediately determine milk proteins stability under high temperature action without considering the effect of the added denaturants. However, due to the complex instrumental execution and the duration of measurement taking, the mentioned method cannot be used in the industry but only as the arbitral method.

The described above methods are based on the visual evaluation of thermal stability. To except the subjectivity during investigation the different test methods have been developed including the express control methods based on , for example, determination of electric conductivity size; detection of protein coagulation case by the hydro-mechanical method ("Thermol-1"); determination of calcium ions amount determined by the potentiometric method using ion-selective electrode; determination of titratable and active acidity quantity ratio, etc. Nowadays the mentioned methods are not widely used.

A lot of studies determined the following basic factors effecting life long formation of raw milk thermal stability:

- zootechnics (breed and genetic the animals characteristics, lactation period, feed allowance and year season, housing conditions, state of health);
- biochemical and physical (milk composition, proportion of its ingredients, density, titratable acidity, pH value).

It is known that milk of different breeds of cows has different physical-chemical composition, incl. protein amount, casein and fractions and minerals ratio that in turn effect milk thermostability. Thus, the top-priority of the zootechnical science is the selection of cow's breeds of highly productive milk of dairy farming, possessing not only high yield and mass fraction of fat and protein in milk, but milk with the specific technological properties that allow to manufacture high quality products requiring high temperature treatment during production as well [7,8].

Thus, the first calving cows of red-multicolored breed (control group) compared with Leningrad type black-multicolored breed (experimental group) being at non tethering maintenance in cowshed-transformers food allowance of which composed feed mixtures, milking and the primary milk treatment was performed in the industrial milking parlor. It was determined that milk samples of the control group corresponded on average to the 3d group of thermal stability by alcohol test and the experimental – to the 2d group. Thus the milk of the last group was more stable against high temperature treatment its usage was preferable in the manufacture of long-term storage sterilized products [9].

The investigation of milk protein component heat stability of the cows of Bestuzhevskiy, Airshirsky, Holstein breeds and their hybrids of different genotype showed that the milk of Holstein breed possesses the best capacity to stand ultrahigh temperature (endure the heat test within 72,2 min), the lesser – Bestuzhevsky (39.9 min). At cross-breeding of Bestuzhevsky (B) cows with Airshirsky (A) and Holstein (H) breeds these properties were significantly improved comparing to maternal breed and achieved the best figures in three breeds hybrids B x A x H (62.8 min) [10]. The data covering milk thermostability increase were published depending on increase of blood portion of farther-holstein breed in the genotype of hybrids cows: the milk of Holmogorsky-Holstein breed in the second generation endured 50.4 min of heat treatment but in the fourth generation – 68.2 min [11].

The works relating to the improvement of productivity of the red-multi colored breed cows due to usage of bull-breeders of Holstein cows are presented. Evaluation of the physical-chemical and technological properties of milk from cows-daughters of the first and second lactation being maintained without tether in boxes, milking – in milking parlor DeLaval "Elochka" type showed that cows part producing heat stable milk was increased by 60-89% [12]. Moreover the selection works proved that usage of Holstein breed increases the productive qualities of the red-multicolored cows. The cows of new genotype with blood portion in Holstein breed gave 75% during lactation period higher milk yield (by 1.7 times), milk portion of the first group of thermostability was increased by 1.6 times, the second group – by 1.5 times [13]. It gives the ground for continuation of the selection works in this field.

It has been proved that milk stability against heat treatment is conditioned by heredity that is evidenced by breed, linear and genotypic differences under the defined milk property. Milk of black-multicolored and red-steppe breeds is characterized by higher thermostability due to small casein micelles content than milk of Simmental and Kostromsky breeds, containing more calcium, that results in faster rennet coagulation. It has been also determined that milk of Tatarstan breed cows possesses higher stability at sterilization temperature and keeps protein in the native state up to 74% and milk of Holstein cows – up to 70% due to high milk casein stability (up to 90% and 84% respectively) [14].

A lot of data was obtained in studies of thermostability and cheese aptitude of milk from cows with different genotypes by milk proteins such as alfa S1-casein (*CSNISI*), beta-casein (*CSN2*), kappa-casein (*CSN3*) and beta-lactoglobulin (*BLG*). On the basis of genotyping of the black-multicolored and Holstein cows according to *CSN3* gene by the PCR-RFLP method of analysis, it was shown that milk from cows with *BB* genotype *CSN3* possessed reduced thermostability (39,3±5,43 min), *AA* genotype – increased thermostability (57.2±1,61 min) and milk of the animals with *AB* genotype took the intermediate position (56.5±2.52 min) [15,16,17].

The presence of *B* allele beta-casein in cow's genome improves the milk technological characteristics and allows to use it cheese making and *A*-allele – effects positively the thermostability. The studies of the question of genetic *CSN2* gene polymorphism of Tatarstan Republic cattle showed that *A* allele variant of *CSN2*-gene prevails (gene frequency 0.90-0.95) [18].

The investigation of the technological milk properties of the black-multicolored cows with different genotypes of β-lactoglobulin showed that the highest themostability (58.9±4.67 min) possesses milk from cows having in their genome the allele variant of *A* gene and the lesser (52.7 ± 2.52 min) – *B* gene [19].

The presented data relating to relation of milk from different thermostability groups on genotype by kappa-casein of first calving black-multicolored, red-multicolored and red-steppe breeds. It was determined that the milk of the I and II groups gave 67% cows of the red-steppe breed, 60% – red-multicolored breed, 15% – black-multicolored breed besides the last animals gave only milk of the II group [20].

Thus, in order to receive the milk products manufactured with high temperature treatment, it is better to use milk from cows which passed the selection on the accumulation of *A*-allele in milk proteins in their genotype.

The composition and properties of milk depend as well on cow's lactation period. Usage of raw milk received from healthy cows after 7 days after the calving and 5 days before the calving is regulated by law for dairy products manufacture. It is determined that milk thermostability of tatarstan type cows and Holstein breed within the lactation period is subjected to significant changes, e.g. the better stability possessed the milk received within the 4^{th} and the lesser – within the 10^{th} month of lactation. The highest part of milk thermostability (87.5-100%) related to the I and II groups was observed in the period of the 7^{th} month. The stable negative correlation was observed between lactation variability of milk by thermostability and the amount in it the protein in the whole as well as its separate fractions. [14,21]. It was detected as well that milk independent on cows breed (Holstein, Cholmogor, Tatarstan) and their cross breed of different genotype 15 days prior to the start didn't stand heat treatment required for manufacture of sterilized products [11].

It is evident that the technological peculiarities of milk are influenced certainly the fodder type, their balance in cows' ration, regime of feeding, housing conditions as well as seasonal factors having the systematic character. The increased part of the concentrates at low level of carbohydrates, vitamins and minerals in cows' nutrition within long time results in reduction of milk thermostability. Pasture forage or usage of soiling food all the year round at stabling improve milk thermostability [2,22]. For example, it is determined that inclusion of granular birch bark into lactating cows diet in the dosage of 10 g per 10 kg of live weight even after 7 days increases thermostability from the III to the I group [22]. Other investigations showed the positive effect on the heat stability of milk from the cows with feeding ration with addition of probiotic oreparations, e.g. lactic acid bacteria that made it possible to increase milk part from the Ist group by thermostablity from 30% to 40% [23]. Administration into the fodder buffer mixtures, protein, vitamins, minerals concentrates separately or as complex additives improves milk thermostability as well [5,24].

Dairy plants receive collected milk which meets all established sanitary-hygienic, physical-chemical and organoleptic requirements. The individual peculiarities in the composition and properties of milk from separate cows do not significantly effect the raw milk quality. In the case of deviation from physically normal state of health the lactating animals milk secretion disorder, yield reduction, decrease of casein, lactose, fat, potassium, phosphorus, magnesium, calcium in milk take place and on the contrary a lot of whey proteins, sodium, chlorine appear. Due to these the technological characteristics of milk are deteriorated incl., heat stability is decreased which extent of variation depends on severity of illness [2].

Along with feeding the milking is significantly influenced by the method of maintenance and the order of cows' milking which acquire special meaning in high-productive herds. It has been determined that threefold milking comparing to twofold increases lactation by 15-18% and effects positively of the animals udder state of health that is expressed in lower number of somatic cells in milk; exceeding of the regulated figures of which (legislatively fixed level – at most $7.5x10^5$ of somatic cells in 1 cm^3) is the sign of udder mastitis and disturbance of mammary gland secretory function. At threefold milking the number of cows with somatic cells more than $1x10^6$ made up only 2.6% whereas at twofold milking – 6% [25,26]. The works relating to the creation of the methods of milk quality forecasting prior to its milking by determination of bioelectrical potential of surface localized biologically active centers are of great interest. The direct correlation relation between thermostability of milk proteins and the level of average potential which is influenced by the secretion intensity in mammary gland including conditioned by microflora provoking mastitis and reducing casein micelles stability against high temperature impact [27].

Raw milk thermostability besides its dependence on zootechnical factors is mainly conditioned by the biochemical composition and physical state of milk. The scientists detected different correlations of milk heat stability depending on mass fat fraction, total protein and whey proteins, the size and composition of casein micelle fraction, salt composition, titratable and active acidity, density, etc.

For example, in the evaluation of the collected milk composition classified according to the groups of therostability by alcohol test the higher amount of minerals 0.66% was fixed in nonthermostable milk (III-V groups) comparing to thermostable (I-II groups) – 0.47%, whey proteins -0.61% and 0.52% and the ratio of calcium to phosphorus –1,6 and 1,4 respectively. The non-thermostable milk had bigger casein micelles (by 2.4%), higher titratable acidity (by 10.6%), contained slightly more dry matters (by 1.3%) and dry skimmed milk residues (by 1.8%) and less casein amount (by 3.7%) at practically equal part of total protein 3.06%, lactose (by 0.9%), phosphorus (by 11.8%), citrates (by 10.7%). Herewith the fact of prevailing of the negative effect on titratable acidity thermostability was determined (coefficient of correlation 0.38) and the sharp reduction of heat stability at mass part of whey proteins more than 0.9% [4,14].

The analysis of the interconnection between total protein, whey proteins, β-lactoglobulin, α-lactalbumin and proteozo-peptone fraction showed that increasing of their level as a rule resulted in decreasing of milk capacity to keep its initial heat stability. The largest correlation dependence was determined on total protein content (-0.283) and milk whey proteins (-0.190). Thus at high level of total protein and whey proteins (3.439% and 0.799%), average (3.392% and 0.754%) and low (3.294% and 0.746%) milk sustained without visible coagulation 46.1:51.9:60.2 min and 45.3:53.7:54.0 min. The investigation by β-lactoglobulin and proteozo-peptone fraction showed 49.6:52.5:55.3 min and 47.5:53.6:57.6 min. The correlation coefficient made up in average: -0.139 and -0.159. Slightly different picture of heat stability was observed in α-lactalbumin 49.4:55.6:48.1 min. Thus the author confirmed the supposition that total protein level renders greater negative effect than whey proteins on milk thermostability [10].

The other scientists carried out the whole year analysis of milk thermostability depending on the ratio of its basic components. It was stated that increase of mass fraction of fat in milk effects positively its heat stability. The coefficient of correlation between fat content, ratio of fat to protein and thermostability made up 0.134-0.136. Moreover, the preferable ratio between fat and protein 1.21-1.50 for milk system was determined. Besides it was mentioned that if milk contains less than 2.5% of protein and density is less than 1,027 g/cm^3 or more than 1,032 g/cm^3 the part of non-thermostable milk is increases (up to 18.2-21.6% of the tested samples). Simultaneously more than 55% of milk samples with mass protein fraction 3.01-3.25% were related to I-II groups by thermostability. The increase of milk acidity to more than 20°T resulted in the increase of non-thermostable milk part (to 60%) [5,28]. The obtained data were confirmed by the studies [26] and namely: milk with 3.07-3.10% of protein showed the largest part of thermostability of I-II groups (with reduction of protein amount to 2.9% milk thermostability was reduced to III-IV groups); fixation of milk density in the range of 1.027-1.028 g/cm^3 showed thermostable milk (with density 1.025 g/cm^3 and the part of non-thermostable milk was increased sharply); milk coagulation began titratable acidity lower 15°T or higher 19°T.

Fresh milk has subacid medium (the average value of active acidity (pH) makes up to 6.75, fluctuation range of pH 6.65-6.85) and as a rule at such values it stands high temperature action without visualization of casein coagulation. There is no direct relation between milk active acidity and its thermostability. Meanwhile, it was stated that one of the reasons for the reduction of casein micelles negative charge and decreasing of hydrate coating size resulting in casein particles aggregation and their destabilization during heating is the change of milk active acidity. The increase of calcium ions concentration with decreasing of pH values results in coagulation [2,9,29].

Thus the directed intravital formation of raw milk thermostability allows to minimize usage of different additional technological methods of milk heat stability improvement and obtain qualitative raw milk for dairy products manufacture including the technologies which stipulate usage of high temperature treatment of milk.

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БИОПОЛИМЕРДІҢ ЖЫЛУГА ТӨЗІМДІЛІГІН ҚАЛЫПТАСТЫРУ

Аннотация. Тағамдық мақсат үшін одан әрі қайта өңдеу барысында шикізат ретінде пайдаланылатын кез келген биополимер санитарлық-гигиеналық, физика-химиялық және органолептикалық сипаттамаларға қойылатын талаптарды қанағаттандырумен қатар, сапалы және қауінсіз дайын өнімді шығаруға мүмкіндік беретін белгілі бір технологиялық қасиеттерге ие болуы керек. Мұның бәрі шикі сүтке қатысты. Оны әрі қарай өңдеу мүмкіндігінің негізгі технологиялық сипаттамаларының бірі, әсіресе, зарарсыздандырылған өнімдерді өндіруде жылуға төзімділігі болып саналады, яғни оның құраушы ақуыздарының алғашқы коллоидты-дисперсті күйін сақтау барысында сүттің жоғары температуралық өңдеуге төтеп беру мүмкіндігі.

Мақалада жылуға төзімділікті визуалды бағалауға (алкогольдік, жылулық, тигелдік, кальций хлориді, фосфатты, қышқылды-қайнатылған сынамалар), сонымен қатар зерттеу негізінде жасалған және сүттің физикалық сипаттамалары мен компоненттерін тіркеуге арналған түрлі құрылғыларды қолдану әдістері ұсынылған. Сонымен қатар, шикі сүттің жылуға төзімділігіне әсер ететін негізгі факторлары, атап айтқанда, зоотехникалық, биохимиялық және физикалық қарастырылған.

Зоотехникалық факторлардың ішінде, мысалы, жануарлар тұқымы мен генетикалық сипаттамалары, лактация кезеңі, азықтандыру рационы мен жыл маусымы, ұстау шарттары, денсаулығының жай-күйі сипатталған. Жоғары температурада өңдеу арқылы өндірілген сүт өнімдерін алу үшін сиыр сүтін қолданған жөн, ол үшін генотипінде А-аллел ақуыздарын жинақтау үшін селекциялық жұмыстар жүргізілген; лактацияның 4 және 10-айында алынған сүт анағұрлым төзімді; толық және теңдестірілген тамақтануды сиыр жаю немесе көкпен азықтандыру, пробиотикалық препараттар, түрлі буферлік қоспалар, ақуыз, дәрумендер және минералды концентраттарды жеке-жеке немесе жыл бойы қоректендіруге арналған кешенді қоспалар түрінде қамтамасыз етуге болады; қосарланған сауумен салыстырғанда, үш есе сауу, лактация кезінде сүттің өнімділігі 15-18% жоғарылайды және жануарлар желінінің денсаулығына жағымды әсер етеді, бұл сүттегі соматикалық жасушалардың төмен құрамы арқылы көрінеді.

Мақалада сүттің құрамына әсері, оның құрамдас бөліктерінің қатынасы, тығыздығы, титрлеу және белсенді қышқылдығы ақуыз жүйесінің тұрақтылығы келтірілген. Майдың, ақуыздың және сарысу ақуыздарының массалық үлесіне, казеин-мицелла фракцияларының мөлшері мен құрамына, тұздың құрамына және тұтастай алғанда сүт жүйесінің физикалық күйінің мәніне байланысты сүттің жылуға төзімділігінің түрлі арақатынасы көрсетілген.

Жылуға төзімді сүттің ғылыми-техникалық көзін талдау негізінде минералды тұздар, сарысу ақуыздары мен кальцийдің фосфорға қатынасы төмен болады. Сонымен қатар, жылуға төзімді емес сүттің құрамында казеин мицелласы ірі, титрлеу қышқылдығы жоғары, құрамында бірнеше қатты заттар бар және құрғақ майсыз сүт қалдықтары, ал аз мөлшерде казеин, лактоза, фосфор және цитрат бар. Жалпы ақуыз, сарысуы бар ақуыз, β-лактоглобулин, α-лактоальбумин және протеоза-пептон фракциясының арақатынасын талдау олардың деңгейінің жоғарылауы арқылы, әдетте, сүттің бастапқы жылуға төзімділігінің сақтау қабілетінің төмендейтінін көрсетті. Кейбір зерттеушілер сүттегі майдың массалық үлесін оның жылуға төзімділігіне арттырудың оң әсерін анықтады. Сонымен қатар, май мен ақуыздың арақатынасы анықталады.

Осылайша шикі сүттің жылуға төзімділігінің өмір бойына бағытталған қалыптасуы сүттің термиялық төзімділігін арттыру және сүт өнімдерін өндіру үшін жоғары сапалы сүт шикізатын алу үшін түрлі қосымша технологиялық әдістерді азайтуға мүмкіндік береді, технологиясы жоғары температуралы сүтті өңдеуді қолдануды көздейді.

Түйін сөздер: биополимерлер, шикі сүт, жылуға төзімділік, бақылау әдістері, зоотехникалық, биохимиялық және физикалық факторлар.

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К ВОПРОСУ ФОРМИРОВАНИЯ ТЕРМОУСТОЙЧИВОСТИ БИОПОЛИМЕРОВ

Аннотация. Любой биополимер, используемый как сырье для дальнейшей переработки на пищевые цели, кроме соответствия регламентируемым требованиям по санитарно-гигиеническим, физико-химическим и органолептическим показателям, должен обладать определенными технологическими свойствами, позволяющими осуществлять выпуск качественной и безопасной готовой продукции. Все это в полной мере относится к сырому молоку. Одной из основных технологических характеристик возможности его дальнейшей переработки, особенно в производстве стерилизованной продукции, является термоустойчивость, т.е. способность молока выдерживать высокотемпературную обработку при сохранении первоначального коллоидно-дисперсного состояния входящих в его состав белков.

В статье приведены методы определения термоустойчивости, основанные как на визуальной оценке (алкогольная, тепловая, тигловая, хлоркальциевая, фосфатная, кислотно-кипятильная пробы), так и с использованием различных приборов, созданных на базе исследования и фиксирования физических характеристик, либо составных частей молока.

Рассмотрены основные факторы, влияющие на прижизненное формирование термоустойчивости сырого молока, а именно зоотехнические, биохимические и физические.

Среди зоотехнических факторов выделены и описаны такие, как порода и генетические особенности животных, период лактации, кормовой рацион и сезон года, условия содержания, состояние здоровья. Показано, что для получения молочной продукции, вырабатываемой с использованием высокотемпературной обработки предпочтительнее применять молоко коров, в отношении которых проведены селекционные работы по накоплению в их генотипе А-аллелей белков молока; наибольшей устойчивостью обладает молоко, полученное в течение 4-го, а наименьшей – в течение 10-го месяца лактации; полноценность и сбалансированность рациона можно обеспечить за счет пастбищного содержания коров или использования при круглогодичном стойловом содержании зеленой подкормки, препаратов пробиотического действия, различных буферных смесей, белковых, витаминных, минеральных концентратов по отдельности или в виде комплексных добавок; трехкратное доение по сравнению с двукратным повышает удои за лактацию на 15-18% и положительно влияет на состояние здоровья вымени животного, которое выражается в более низком содержании соматических клеток в молоке.

Представлены данные по влиянию состава молока, соотношения его составных частей, плотности, титруемой и активной кислотности на стабильность белковой системы. Приведены различные корреляции тепловой стабильности молока в зависимости от массовой доли жира, общего белка и сывороточных белков, размера и состава фракций мицелл казеина, солевого состава и значений показателей физического состояния молочной системы в целом.

На основе анализа научно-технических источников в термоустойчивом молоке зафиксировано более низкое содержание минеральных солей, сывороточных белков, соотношение кальция к фосфору. Наряду с этим, нетермоустойчивое молоко имело более крупные мицеллы казеина, более высокую титруемую кислотность, содержало несколько больше сухих веществ и сухого обезжиренного молочного остатка и меньшее количество казеина, лактозы, фосфора, цитратов. Также анализ взаимосвязи содержания общего белка, сывороточных белков, β-лактоглобулина, α-лактоальбумина и протеозо-пептонной фракции показал, что при увеличении их уровня, как правило, снижается способность молока сохранять свое первоначальную тепловую стабильность. Некоторыми исследователями установлено положительное влияние увеличения массовой доли жира в молоке на его термостойкость. Кроме этого, определено предпочтительное соотношение между жиром и белком.

Таким образом, направленное прижизненное формирование термоустойчивости сырого молока позволит минимизировать использование разнообразных дополнительных технологических приемов повышения тепловой устойчивости молока и получать качественное молочное сырье для производства молочной продукции, в т.ч. технология которой предусматривает применение высокотемпературной обработки молока.

Ключевые слова: биополимеры, сырое молоко, термоустойчивость, методы контроля, зоотехнические, биохимические и физические факторы.

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