KRMIVA

HYGIENISATION AT FEED COMPOUNDING

HIGIJENIZACIJA KOD SASTAVLJANJA HRANE

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1. INTRODUCTION

The hygienic status is an important quality characteristic of compound feed with increasing sensibility. The feed millers have to meet the requirements by legislation and different demands coming from the market. The usual concept of processing only high quality raw materials does not give the desired safety. Therefore, preventive measures are necessary which include active hygienisating treatment and activities within the framework of the hygiene regime in the feed mill.

2. HYGIENE STATUS OF COMPOUND FEED

The cleanness and the micro-biological state of the compound feed are characterised by hygiene status i. e. mainly:

- existence of alien admixtures and pests
- presence and concentration of micro organisms (number of germs, cfu/g)
- contamination by salmonellae and toxic metabolic products of bacteria and fungus
- existence of carriers or secretors of pathogenic germs.

The legal and market requirements are directed to the hygienic and health harmlessness without quantitative limits of germ concentrations a. o. Therefore, sometimes the market requirement is expressed by the words salmonella-free animal feed without correct knowledge of what it means. Such requirement can be fulfilled by the feed mill if non-infected raw materials are obtained and no infection takes place during the production of the feed. Both cases are relatively unknown to the feed miller because of the time and money needed for salmonellae-control analysis, i.e. test results are available after delivering (and consuming) the final product. Therefore, preventive measures are recommended in order to meet the requirements for hygienic and health harmlessness.

In case of infection, the fulfilment of the demand salmonella-free compound feed means sterilisation of the feed, i.e. killing all micro organisms because selective killing is not possible. The result of the sterilisation is the micro-biologically dead feed which must never be the aim of the compound feed manufacture, because micro organisms, are necessary for digestion and development of the immunity of the animals. It is more serious to speak about decontamination, i.e. reduction of the concentration and multiplying ability of the germs in the compound feed.

Contaminations by salmonellae are of relative by high public interest. For a lot of food infections the animal feed is considered as the cause. Taking into account more than 2000 serotypes of salmonellae, an infection has a high probability. Especially feed stuff of animal origin such as fish-meal, meat meal, animal meal - can be contaminated, feed stuff of vegetable origin is lessfrequently contaminated. Mainly the following serotypes have been established:

- salmonella senftenberg

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- salmonella allachua
- salmonella agona
- salmonella infantis
- salmonella havanna
- salmonella altona
- salmonella manhattan.

Only two serotypes attack the health of the human:

- salmonella enteriditis
- salmonella typhimurium

which are found in compound feed with low frequency. As sources of salmonellae infection •the following have to be considered:

- infected raw materials
- harmful animals (beetles, mice, rats, mews, pigeons, sparrows)
- secretions of animals
- waste water, slurries and faecal matter
- dust
- cooling air, residues and deposits in the equipment of the technological plant
- internal and external personnel.

3. MEASURES OF THE DECONTAMINATION

The efficiency of each decontamination will be influenced by

- the level of infection
- the formulation and structure of the compound feed
- the intensity and time of treatment.

The decontamination itself follows logarithmic laws (reaction with logarithmic gradient). Therefore, the decontamination effect cannot be expressed as percentage of germ reduction: e.g. 90% reduction means decontamination by one decimal power (10^1) or from 1.000.000 cfu/g to 100.000 cfu/g . The decontamination rate of any treatment procedure has to be given in decimal power with the orientation that a considerable decontamination effect is realised if the rate has the minimum value of 3 decimal power or 10^3, e.g. the decontamination result is the reduction from 1.000.000 cfu/g to 1.000 cfu/g (from 10^6 cfu/g to 10^3 cfu/g or reduction by 10^3). Because of the behaviour of the salmonellae to form colonies, i.e. to settle in nests, the reliability has to be assured by homogeneous treatment which can be evaluated by the portion of positive findings taken from the treated material.

In the past, the decontamination ability of any procedure was expressed by the D- value which indicates the time needed for reduction by one decimal power (10^1). Lower D-values mean higher efficiency. The use of the D-value can lead to mistakes because not every prolongation of the treatment time results in improvement of the decontamination effect.

Several treatment procedures for preventive decontamination, in feed compounding are available which can be assigned to the following principles of action:

- high energy irradiation
- chemical treatment with organic acids
- hydrothermal treatment
- hydrothermal treatment combined with mechanical shear stress and heating by energy dissipation.

For evaluation of any decontamination procedure several aspects have to be taken into account, e.g.:

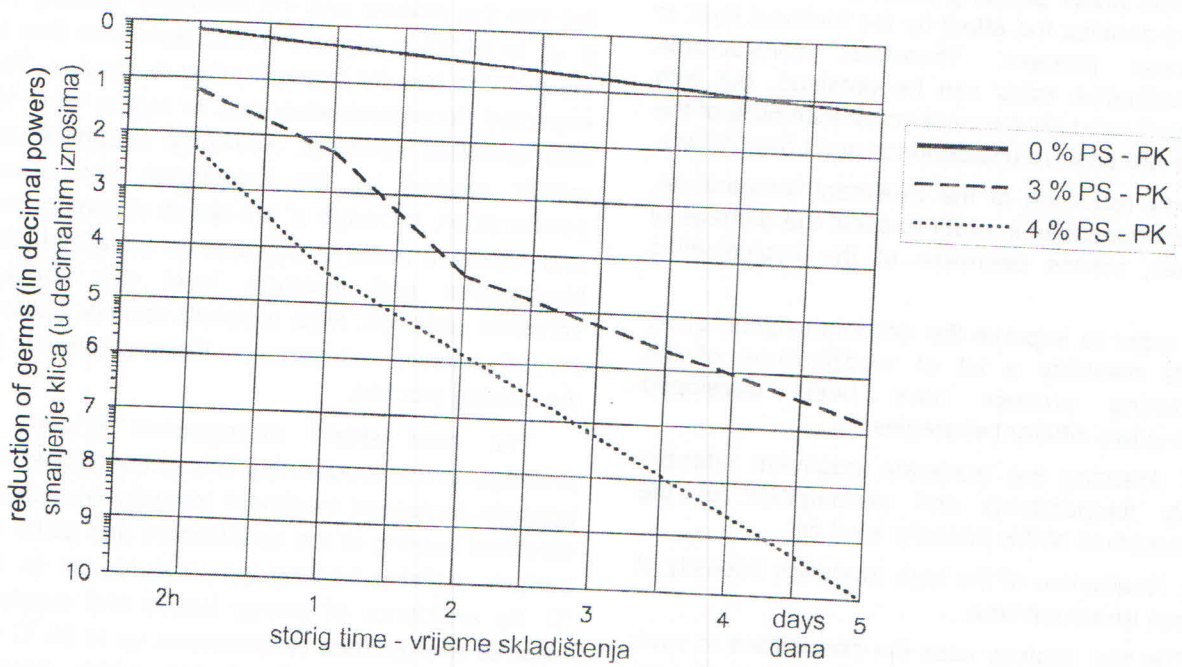
- real decontamination effect
- additional expense
- possible benefit in addition to the decontamination
- side effects.

The decontamination by high energy irradiation using ionising rays (e. g. γ-radiation) and it realises most effective decontamination in dependence on the intensity and time, but more better sterilisation than decontamination with the danger to obtain micro biological dead feed. No additional benefit can be expected, but additional costs because of the special equipment required. The formation of reactive groups and the damage of the proteins are under discussion.

4. CHEMICAL TREATMENT

The conservation of compound feed by organic acids (e. g. propionic acid, formic acid) with low concentration (in the order of 0.3 ... 0.5%) is well-known and out of discussion. For preventive decontamination of possible infected material relatively high concentrations and time for chemical treatment are necessary in order to obtain the demanded decontamination effect (Pietsch et al., 1981). Figure 1 shows a possible decontamination effect in dependence on the time and concentration: in order to obtain the decontamination rate of 10^3 more than 36 hours are necessary using 3% propionic acid or approximately 10 hours if 4% propionic acid is applied.

Figure 1. Reduction of germs by propionic acid (PS) treatman
Slika 1. Smanjenje klica tretiranjem propionskom kiselinom (PK)



Additional expense is caused by the costs of the organic acid, equipment for storage and dosing as well as for treatment time, of course. The influence of propionic acid on nutrition is positive, but the acceptance of compound feed containing high concentration of propionic acid by animals is decreasing. Considerable side effects are corrosion of the equipment, the danger for the employees, unpleasant smell, the losses of the effect by use of limestone and the bad image of chemical treatment in general. The undisputed advantage of the chemical decontamination by organic acids is the long-term action of this treatment.

5. HYDROTHERMAL TREATMENT

The hydrothermal treatment of compound feed is mainly realised as short-term conditioning process before the pellet press. Depending on the structure of the feed mixture and the amount of the saturated steam fed into the mixture, the treatment effect is determined by the level of temperature and moisture. Using the correlation of experience that 0.6% of feed saturated by steam increases temperature by 10 degree the treatment intensit of the short-term conditioning can be expressed by temperatures in the order of 70 °C and moisture at 14%. By the press process an additional

temperature increase takes place in dependence on the structure of the mixture and geometric configuration of the die which can result in maximum increase by 10 °C or the maximum total treatment temperatur at the level of 80 °C. The treatment time depends on the throughput, it takes few minuts only, but without the same treatment intensity at each step and without homogeneous treatment of all parts of the mixture. Therefore, the reliability of the preventive decontamination by usual pelleting is insufficient (Friedrich and Robohm, 1995).

Double press pelleting prolongs the treatment time and doubles the effect by the frictional heat at the press process. Therefore, considerable decontamination rates can be obtained, but with insufficient reliability because more than 50% of the findings are positive (Heidenreich and Löwe, 1994).

Every reduction of the treatment temperature, e. g. recommended in order to avoid the damage of enzymes, means decrease of the hygienisating effect.

In order to improve the decontamination effect and its reliability a lot of modifications of the conditioning process have been developed following two different strategies:

1. Assuring the moderate treatment intensity (mainly temperature) and prolongation of the treatment time at this intensity level or

2. Realisation of the high treatment intensity at reduced treatment time.

The first strategy uses the possibilities to work under ambient pressure conditions and it pre-supposes sufficient decontamination effect by treatment at 85 °C for 4 minutes, which has to be prooved by systematic investigations (Heidenreich, 1996). Examples for this strategy are

- long- term conditioning
- SIRT (sterilisation by increased retention and temperature) procedure (Ekperigin et al., 1990)
- heat shield with double conditioning
- APC (anaerobic pasteurising conditioning) procedure (Ekperigin et al., 1990 and Major, 1991)

The evaluation of the decontamination effect and reliability of the long-term conditioning (Figure 2) are difficult because of the energy losses during the treatment time (up to 20 minutes) in cases of non-isolated conditioner as usual and the resulting incomplete treatment. The additional expense caused by the other type of conditioner is relatively small. The experience shows only low increase of the starch decomposition and pellet quality in dependence on the intensity level which influences possible side effects (e. g. damage of sensitive additives).

The SIRT procedure (Figure 2) does not include the sterilisation, the description is unclear. Saturated steam and partly superheated steam are fed into the mixture and the treatment intensity (e. g. up to 95 °C) is assured by the residence time in the isolated box for approximately 4 minutes. The expected decontamination rate is higher than 10^3 with sufficient reliability. Additional expenses are mainly caused by the investment and steam consumption. Increase of the starch decomposition and improved pellet quality can be beneficial. The temperature and moisture level can damage sensitive additives. High moisture content reduces the pellet quality and increases the requirements for the cooling process.

The heat shield arrangement (Figure 3) prolongates the conditioning time (2 conditioners) at possible increased treatment intensity by external electrical heating of the conditioners and pellet mill surface realising heating temperatures up to 110 °C. By avoidance of energy losses and supply of external energy, feed temperatures up to 95 °C can be held over several minutes which enables decontamination rates higher than 10^3. The external electrical heating facilitates relative high temperatures at standstill, i. e. avoidance of the condensation and suitable conditions for multiplying of microorganisms. Additional expenses are to be expected by installation of the additional conditioner and external electrical heating as well as energy costs for the external heating. Depending on the heating level, decomposition of the starch and improvement of the pellet quality are possible benefits. The higher the temperature the greater the danger of the damage of sensitive additives. The life of the heating mats not known.

Figure 2. Modifications of the conditioning process
Slika 2. Modifikacija procesa kondicioniranja

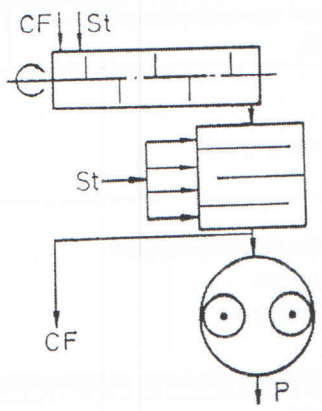
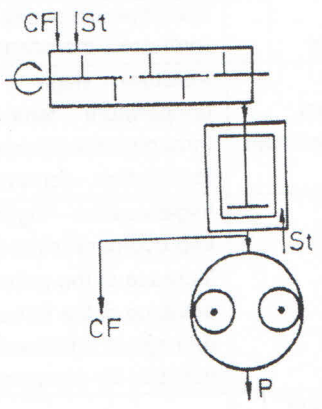
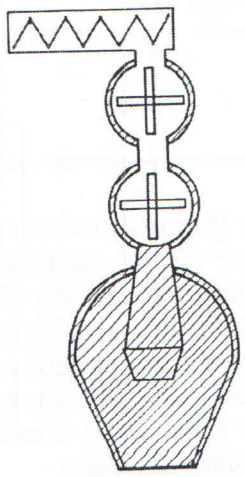
Process Proces	Long-term conditioner – Dugoročni kondicioner	SIRT (sterilisation by increased retention and temperature) – steriliziranje povećanom retencijom i temperaturom
Action Djelovanje	Hydrotermal stress – Hidrotermalni stres	Hydrotermal stres – Hidrotermalni stres
Main parameters Glavni parametri	moisture – vlaga temperature – temperatura throughput/residence time – postotak/ vrijeme prerade formulation – formulacija	moisture – vlaga temperature – temperatura throughput/residence time – postotak/ vrijeme prerade formulation – formulacija
Effects Učinci	starch decomposition – rastvaranje škroba improvement of the pressability – poboljšanje svojstva tlačenja increase of the pellet - povećanje kakvoće peleta hygienisation – higijenizacija	hygienisation – higijensko poboljšanje improvement of the pressability – poboljšanje svojstva tlačenja increase of the pellet - povećanje kakvoće peleta damage of additives? – oštećenje dodataka
Arrangament Uređaj		

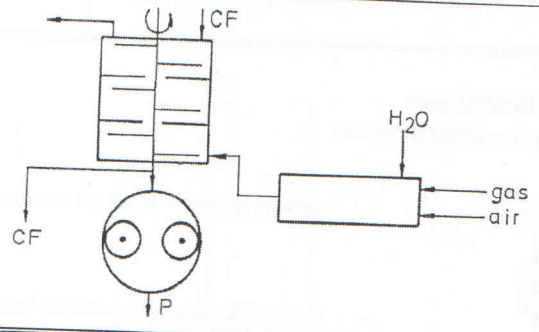
Figure 3. Pelleting with heat shield
Slika 3. Peletiranje s toplinskim štitnikom



- dosing screw – vijak za doziranje
- 2 conditioners with surface heating
- 2 kondicionera s površinskim grijanjem
- pellet mill with surface heating
- uređaj za peletiranje s površinskim grijačem

The APC-procedure uses the counter flow between the cool feed mixture and the mixture of directly generated steam and combustion gases (Figure 4). In order to have a sufficient average temperature for decontamination the inlet temperature of the steam (mixed with combustion gases) has to be higher. The components of the combustion gases CO and CO_2 support the decontamination which is higher than 10^3. The investment costs are relatively high, but the direct fired steam generator is included. In addition to the decontamination benefits are the same as mentioned for the treatment procedures considered so far. The application of the APC-procedure for treatment of compound feed which should not be pelleted is posisible if the cooling process for feed is mastered. The possible side effects regarding the damage of sensible additives depend on the temperature level at the inlet at the bottom of the apparatus and the pollution of the compound feed by combustion products takes place according to the purity of the used natural gas.

Figure 4. APC – procedure
Slika 4. APC – postupak

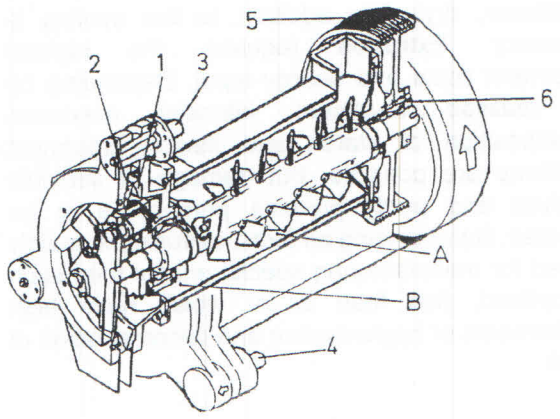
Process - Proces	APC (anaerobic pasteurising conditioning) – Kondicioniranje anaerobičnog pasteriziranja
Action Djelovanje	hydrothermal stress (counter flow); increased concentration of CO and CO_2 – hidrotermalni stres (protutok); povećana koncentracija CO i CO_2
Main parameters Glavni parametri	moisture – vlaga temperature – temperatura throughput/residence time – postotak/ vrijeme prerade formulation – formulacija
Effects Učinci	hygienisation – higijenizacija improvement of the pressability – poboljšanje svojstva tlačenja increase of the pellet - povećanje kakvoće peleta advance of the throughput – napredovanje protoka damage of additives? – oštećenje aditiva? pollution by components of combustion gases? – zagađenje komponentama plinova sagorijevanja
Arrangament Uređaj	

6. HYDROTHERMAL/MECHANICAL TREATMENT

Improvement of the treatment intensity and homogeneity can be achieved by the combination of the hydrothermal treatment with mechanical stress. This combination improves the reliability of the decontamination, has additional beneficial effects and it reduces the multiplying ability of the germs.

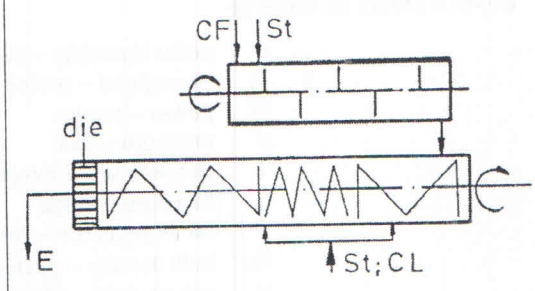
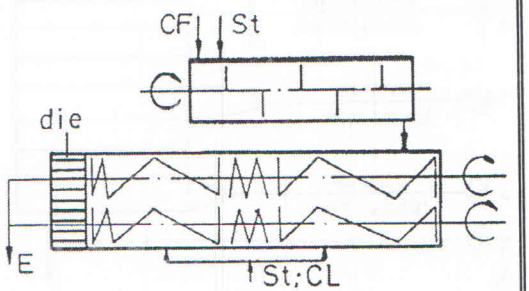
The Boa Compactor (Figure 5) realises the low mechanical stress after steam conditioning by pressing the feed mixture through the ring gap formed by the stator friction ring and the movable friction ring. The possible decontamination potential has not been investigated so far, probably because of its main application at manufacture of cattle feed in order to assure high quality of pellets.

Figure 5. Boa Compactor
Slika 5. Boa kompaktor



A = mixing chamber – prostor za miješanje
B = conditioning chamber – prostor za kondicioniranje
1 = stator friction ring – prsten frikcije statora
2 = movable griction ring – pomični prsten frikcije
3, 4 = hydraulic system – hidraulični sustav
5 = V-belt – V-vrpca/pojas
6 = overloading assurance – osiguranje na preopterećenje

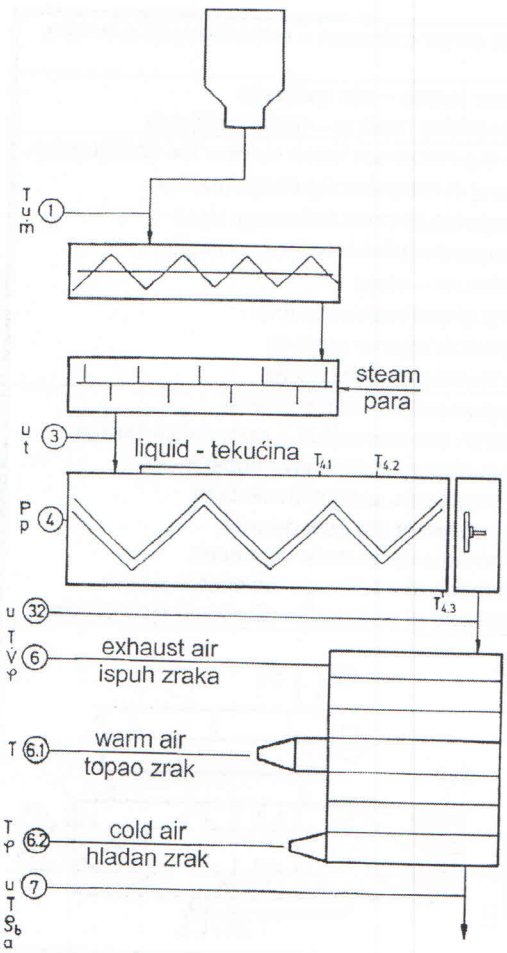
Figure 6. Principle of extrusion
Slika 6. Princip istiskivanja (ekstrudiranja)

Process – Proces	single screw extrusion – ekstrudiranje s jednim vijkom	twin screw extrusion – ekstrudiranje s dva vijka
Action – Djelovanje	shear forces – sile savijanja dissipative heating – rasipno grijanje	shear forces – sile savijanja dissipative heating – rasipno grijanje
Main parameters Glavni parametri	configuration/revolution number die configuration – broj okretaja/konfiguracija matrice temperature/presure/energy input – temperatura/tlak/unošenje energije moisture – vlaga throughput/residence time – protok/vrijeme prerade formulation – formulacija	configuration/revolution number die configuration – broj okretaja/konfiguracija matrice temperature/presure/energy input – temperatura/tlak/unošenje energije moisture – vlaga throughput/residence time – protok/vrijeme prerade formulation – formulacija
Efects Učinci	hygienisation - higijenizacija starch decomposition – rastvaranje škroba reduction of antinutritive substances – smanjenje antinutritivnih tvari decrease of the bulk density – smanjenje gustoće volumena damage of additives – oštećenje aditiva	hygienisation – higijenizacija starch decomposition – rastvaranje škroba reduction of antinutritive substances – smanjenje antinutritivnih tvari decrease of the bulk density – smanjenje gustoće volumena damage of additives – oštećenje aditiva damage of proteins? - oštećenje bjelančevina
Arrangement Uređaj		

Extrusion and expanding are typical processes for hydrothermal treatment in combination with mechanical shear stress and heating by energy dissipation. Because of the treatment at pressures which are much higher than the ambient pressure, high treatment intensity with temperatures higher than 100 °C (boiling point) at extremely short residence time is possible. The intensity level and the homogeneous distribution of the treatment intensity on the material volume assures high decontamination rates, low multiplying ability of the germs and sufficient reliability.

Single screw and twin screw extruders (Figure 6) include the shaping process by pressing the material through a die. Since the final product using relatively high fineness and moisture (up to 20%) the integration of the extruder (Figure 7) is quite different from the installation of the modified conditioner, drying in addition to the cooling is necessary. Extrusion requires the highest investment costs and energy input. Depending on the realised treatment intensity maximum decomposition of starch and flexible treatment conditions are possible, but damage of sensible additives and partly proteins perhaps is to be expected. Summarising all facts, extrusion is mainly applied for manufacturing special animal feed such as petfood, fish feed a. o. which have high requirements of hygienisation and decomposition of starch.

Figure 7. Integration of the extruder
Slika 7. Integracija izbacivača (ekstrudera)



bin – posuda

feeder – posluživač

continuous - flow mixer – neprekidni tijek - mikser

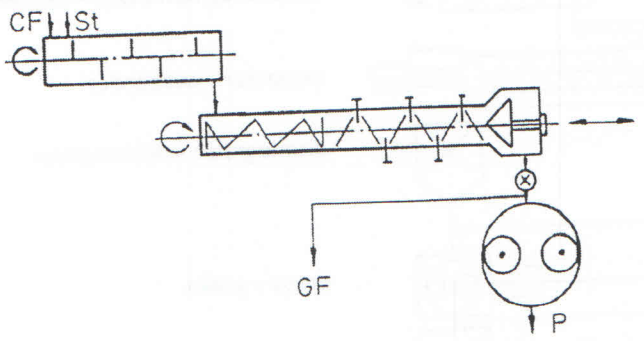
twin - screw – dvostruki vijak
extruder with cutter– izbacivač (ekstruder) s rezačem

cooler – uređaj za hlađenje

a	pellet durability – trajnost peleta
m	throughput – protok
P	power – snaga
p	pressure – tlak
T	tempetarure – temperatura
u	moisture – vlaga
φ	rel air moisture – relativna vlaga zraka
ϱ_b	bulk density – gustoća volumena
V	volum. flow – volumen protoka

Expanding (Figure 8) takes an increasing field of application at compound-feed production. Considered as the low-cost single screw extruder without shaping processe the expander enables variable operational conditions (e. g. energy input, temperature level) and high decontamination rates (Heidenreich, 1994). Figure 9 shows the possible decontamination rate for broiler feed of more than 10^6 using the expander as a pressure conditioner (Figure 10) and operational conditions of 105 to 115 °C and 13.9% moisture[1]. In comparison to double pelleting the portion of positive findings is significantly reduced after expanding (Figure 11). Because of the increased throughput no significant increase of the specific energy consumption will be caused so that only additional investment cost are neeed. Starch decomposition, reduction of antinutritive substances, essential improvement of the pellet quality, discharge of the pellet press (prolongation of its life) and increase of the throughput are benefits in addition to the hygienisation effect and demonstration of the multiple effects obtained by expanding. Depending on the realised temperature the damage of sensible additives has to be controlled taking into account that the residence time of the material in the zone of high intensity is only a few seconds.

Figure 8. Principle of expanding
Slika 8. Princip širenja (ekspandiranja)

Process – Proces	Expanding – Širenje (ekspandiranje)
Action – Djelovanje	shear forces – sile savijanja dissipative heating – rasipno grijanje
Main parameters Glavni parametri	configuration/revolution number – konfiguracija/broj okretaja temperature/presure/energy input – temperatura/tlak/unošenje energije moisture – vlaga throughput/residence time – protok/vrijeme prerade formulation - formulacija
Efects – Učinci	hygienisation – higijenizacija starch decomposition – razgradnja škroba reduction of antinutritive substances – smanjenje antinutritivnih tvari increase of throughput – povećanje protoka improvement of the pellet quality – poboljšanje kakvoće pelete disharge of the pellet press – izbacivanje tijestenog peleta damage of additives? – oštećenje aditiva?
Arrangement – Uređaj	

[1] The specific energy consumption of the used 1 t/h-expander is relative high because of the high portion of energy losses for small machines).

Figure 9. Relative number of germs vs. treatment temperature and spec. energy input by pressure conditioning
Slika 9. Relativni broj klica prema temperaturi testiranja i unos posebne energije kondicioniranjem pod tlakom

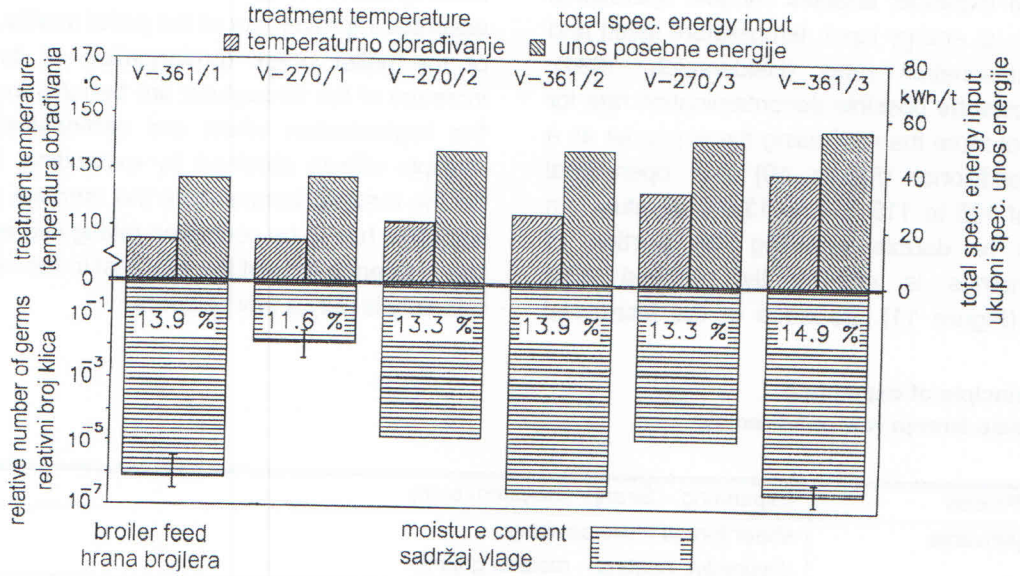
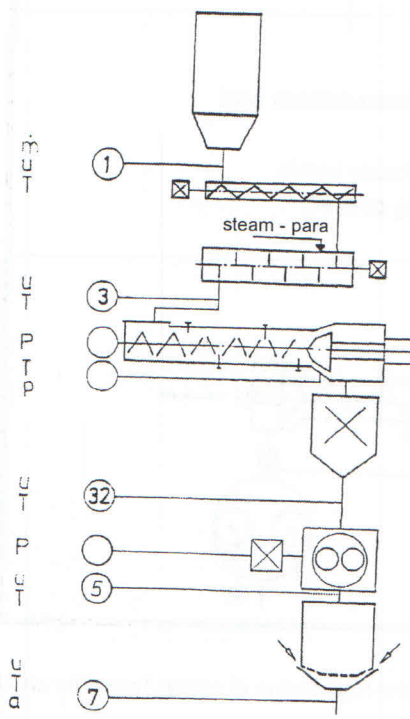


Figure 10. Integration of the expander as pressure conditioner
Slika 10. Integracija ekspandera kao regeneratora tlaka



bin – posuda

feeder – posluživač

continuous-flow mixer – neprekidni tijek - mikser

expander – ekspander

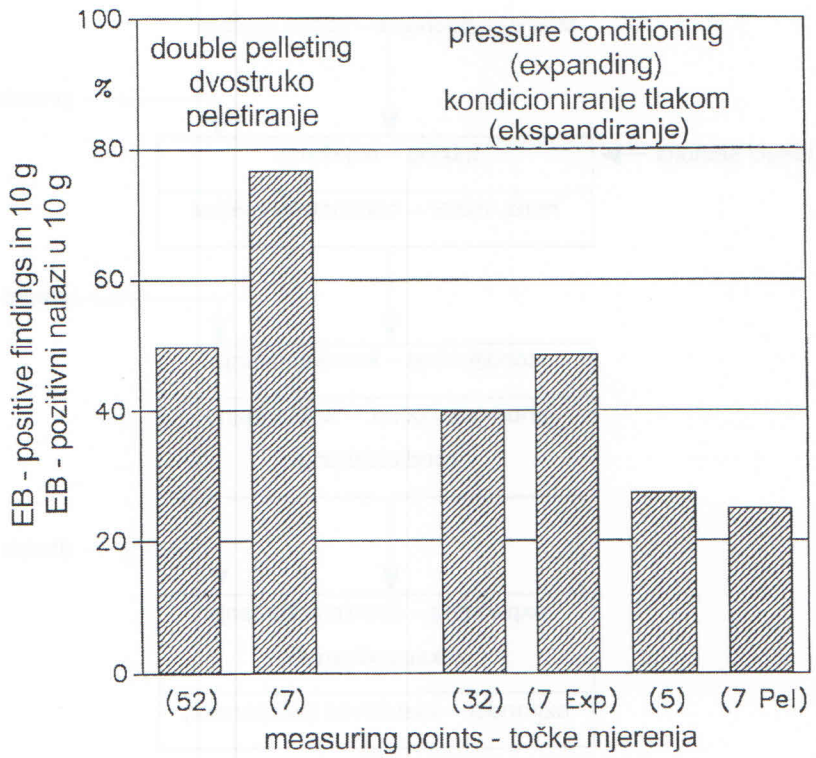
disintegrator – dezintegrator

press – preša

belt cooler – uređaj za hlađenje

a pellet durability – trajnost peleta
m throughput – postotak
P power – snaga
p pressure – tlak
T tempetarure – temperatura
u moisture – vlaga

Figure 11. EB – positive findings in 10 g feed stuff after double pelleting and pressure conditioning
Slika 11. EB - pozitivni nalazi u 10 g hrane nakon dvostrukog peletiranja i kondicioniranja tlakom



sampling points – točka uzorkovanja

(52) pellets after 2. pell. mill, uncooled – pelete nakon 2. obrađivanja, neohlađene
(7) pellets after 2. pell. mill, cooled – pelete nakon 2. obrađivanja, ohlađene
(32) expanded product, uncooled – ekspandirani prošireni proizvod, neohlađen
(7 exp) expanded product cooled - ekspandirani prošireni proizvod ohlađen
(5) expanded product pelleted uncooled - ekspandirani prošireni proizvod neohlađen
(7 pel) expanded product pelleted cooled - ekspandirani prošireni proizvod ohlađen

EB: enterobacteriaceae

In order to obtain the mentioned multiple effects the application of the expanding process for manufacture of finished animal feed does not need pelleting. This alternative concept (Figure 12) is partly realised at industrial production of well-structured feed for piglets and pigs having excellent properties as mash feed. Similar technology without pelleting can be used for manufacture of the layer feed assuring decontamination rate of more than 10^6 as it can be seen in Figure 13 for the operational conditions of 115 °C and 13.1% moisture. Expanded feed as final product is relatively porous and it has a reduced bulk density by approximately 25%. The porous structure gives suitable conditions for liquid application of additives.

Figure 12. Integration of the expanding process without pelleting
Slika 12. Integracija procesa ekspandiranja bez peletiranja

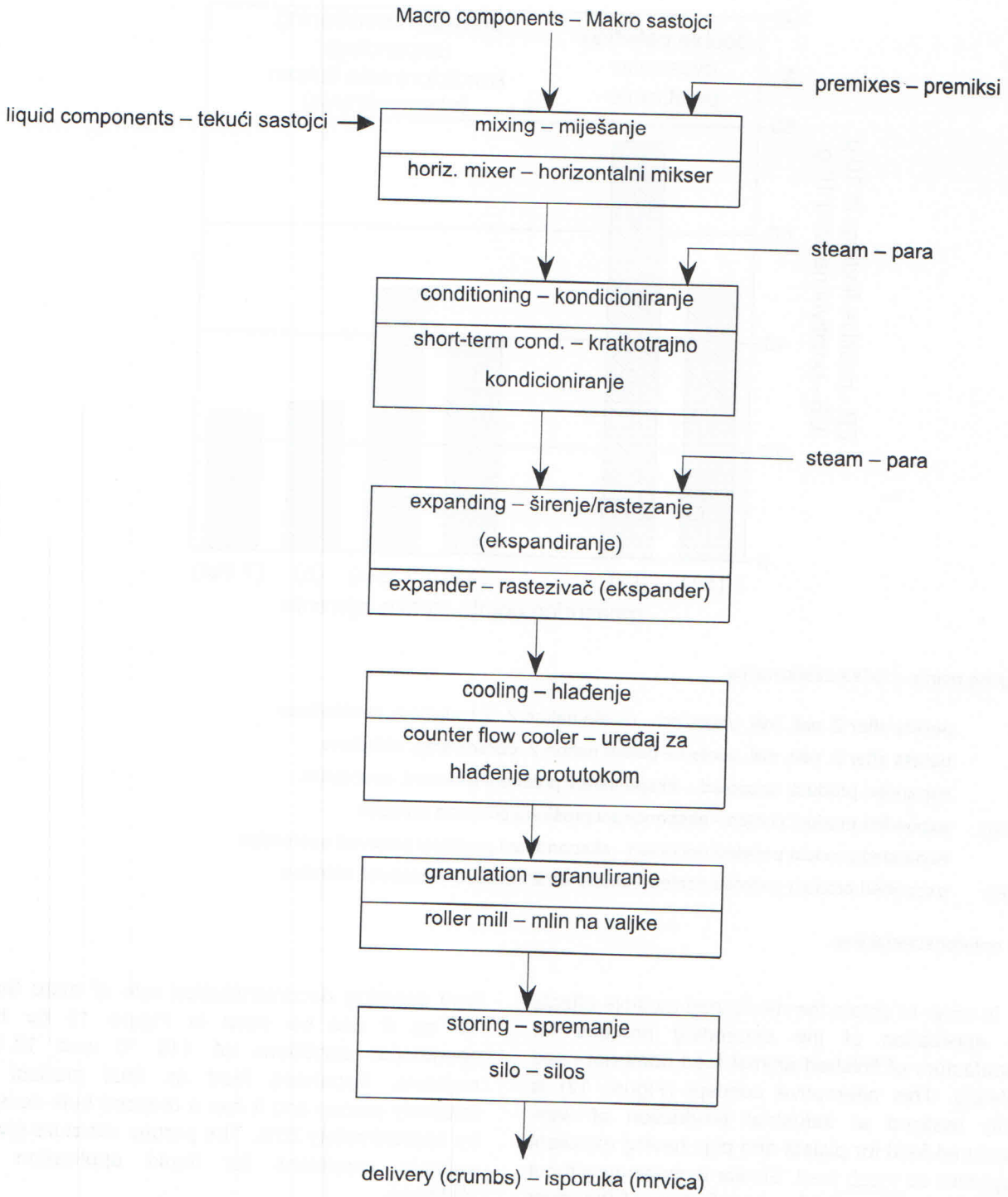
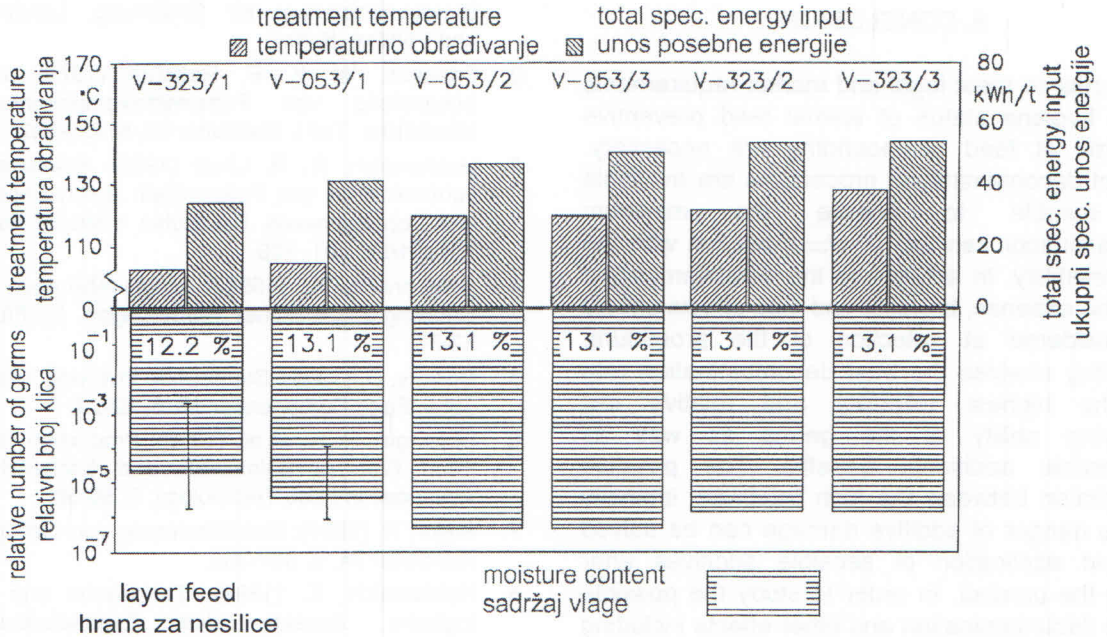


Figure 13. Relative number of germs after expanding vs. treatment temperature and spec energy input for the layer feed

Slika 13. Relativni broj klica nakon širenja (ekspandiranja) prema temperaturi postupka i spec. unosu energije u hrani za nesilice



7. HYGIENE REGIME

For protection of the hygiene status of the treated feed the installation of an effective hygiene regime at the feed mill is recommended because of the high probability of reinfection. The main requirement of this hygiene regime is the consequent division of the feed mill into the dirty and into the clean part (Renggli, 1995). The clean part should begin with the heat treatment process and it should assure the relative closed handling of the treated feed, i. e.

- minimisation of the contact possibilities with the feed
- conservation of the feed by organic acids with a little higher concentration than usual (≈0.5...0.8%)
- hygienic control of the cooling air
- no residues in the silos for final products, realisation of the "first in - first out" principle and avoidance of local condensation in the silo by temperature differences
- cleaning control of silo trucks and big bags.

Additional elements of the effective hygiene regime should be:

- specifications of the hygiene status of raw materials and premixes to the supplier
- no utilisation of unknown or doubtful materials
- avoidance of residues and realisation of cleaning cycles for production areas, silos, bins, conveyers, mixers, conditioners, pellet presses and coolers
- cleaning before periods of standstill (e. g. weekend, holidays)
- active control of pests, pigeons and rodents
- hygienic behaviour of the personnel, cleanness of the sanitary equipment
- organisational measures for limiting the access to production area and store rooms by unauthorised persons

The elements of the hygiene regime are components of the quality management system according to ISO 9000.

8. CONCLUSION

In order to meet legal and market requirements for the hygiene status of animal feed preventive measures at feed compounding are necessary. Different decontamination procedures are available and suitable to ensure the minimum decontamination rate of 10^3 cfu/g, but not with the same reliability. In addition to the decontamination effect the expense, benefits and side effects should be considered at selection of the procedure. Expanding enables the best decontamination rate with the highest reliability and relative low multiplying ability of the germs as well as considerable additional benefits. The possible contradiction between the high treatment intensity and the danger of additive damage can be solved by liquid application of sensible additives after cooling the product. In order to study the possible reliable decontamination and other effects including the necessary energy expense for most of the decontamination procedures systematic investigations have to be carried out.

Each hygienic treatment is useless if no effective hygiene regime is installed in order to prevent reinfection.

REFERENCES

1. Pietzsch, O. et al. (1981): Abschlußbericht des Forschungsvorhabens "Salmonella-Dekontamination von Futtermitteln durch Zusatz von Propionsäure". Bundesministerium für Ernährung, Landwirtschaft und Forsten, Bonn.
2. Friedrich, W. K. F. Robohm (1975): Hygiene-behandlung von Futtermittelkomponenten und Mischfutter, Teil I. Kraftfutter 58, 6, 229-232.
3. Heidenreich, E., R. Löwe (1994): Salmonellen-Dekontamination von Futtermitteln durch Expandieren und Doppelpressen. Die Mühle + Mischfuttertechnik 131, 51/52, 701- 709.
4. Heidenreich, E. (1996): Problemlösungen für die Erfüllung hygienischer Forderungen. Kraftfutter 97, 52-57.
5. Donelly, D. (1995): Sterilisation Involving Retention & Time. Feed Compounder 15, 5, 22-23.
6. Ekperigin, R. H. et al. (1990): Production of Poultry Feed Free of Salmonella and Escherichia coli. Advances in Feed Technology, 3, 50-58.
7. Major, R. (1991): Konditionierung von Geflügelfutter. Kraftfutter 74, 8, 357-362.
8. Heidenreich, E. (1994): Technische und technologische Aspekte des Expandierens und Extrudierens. Die Mühle + Mischfuttertechnik, 131, 7, 75-79.
9. Renggli, F. (1995): Post Treatment handling of Feed and Feedstuffs to Prevent Recontamination. Proceedings to the 10th European Symposium on Poultry Nutrition, Antalya (Turkey), October 1995, 154-158.

ZAKLJUČAK

Da bi se udovoljilo pravnim i tržišnim zahtjevima za higijenu hrane za životinje potrebne su preventivne mjere kod njezinog sastavljanja. Postoje razni prikladni postupci za dekontaminaciju da se osigura minimalna dekontaminacija od 10^3 cfu/g, ali oni nisu jednako pouzdani. Osim učinka dekontaminacije, pri izboru postupka valja razmotriti troškove, prednosti i popratno djelovanje. Ekspandiranje omogućuje najbolju dekontaminaciju s najvećom pouzdanošću i relativno nisku sposobnost razmnožavanja klica kao i druge prednosti. Mogući raskorak između visokog intenziteta postupka i opasnosti dodatnog oštećenja mogu se riješiti tekućom primjenom prikladnih aditiva nakon hlađenja proizvoda. Da bi se proučila moguća pouzdana dekontaminacija i drugi učinci, uključujući potreban utrošak energije za većinu postupaka dekontaminacije potrebna su sistematska istraživanja.

Svaki higijenski postupak je beskoristan ako se ne uvede djelotvoran režim higijene da se spriječe ponovna zagađenja.