ISSN 1407-4427

LATVIJAS LAUKSAIMNIECĪBAS UNIVERSITĀTE

RAKSTI

PROCEEDINGS OF THE LATVIA UNIVERSITY OF AGRICULTURE

Nr. 10 (305), 2004
JELGAVA

SATURS / CONTENTS

Ar akūto ketozi slimojošu liellopu gremošanas trakta morfofunkcionālais raksturojums / Morphofunctional Characterization of the Digestive Tract of Cattle with Acute Ketosis: *Māra Pilmane, Anastasija Suhova, Jurijs Nazarovs, Inese Zītare, Aleksandrs Jemeļjanovs* 1

Glijas šūnu morfofunkcionālais raksturojums govju centrālajā nervu sistēmā (CNS) / Morphofunctional Characteristic of Glial Cells in the Cattle Central Nervous System: *Māra Pilmane, Inese Zītare, Aleksandrs Jemeļjanovs* 8

The Effect of Nitrogen Use on Perennial Ryegrass Seed Yield and Forage Quality Parameters / Slāpekļa mēslojuma ietekme uz ganību airenes sēklu ražu un lopbarības kvalitātes rādītājiem: *Skaidrite Bumane, Peteris Berzins, Richard H. Leep, Timothy Dietz* 13

Analysis of Dry Matter Yield Stability Parameters in Different Varieties of Forage Grasses / Sausnas ražas stabilitātes analīze dažādām stiebrzāļu sugām un šķirnēm: *Pavelas Tarakanovas, Juozas Kanapeckas, Nijole Lemeziene, Steponas Nekrosas* 19

Agronomic Performance of Doubled Haploid Spring Barley Lines / Vasaras miežu dihaploīdo līniju agronomiskās īpašības: *Algė Leistrumaitė, Birutė Basiulienė* 26

Kviešu maizes ar auzu un griķu miltu piedevu sensorā novērtēšana / Sensory Evaluation of Wheat Bread with Oat and Buckwheat Addition: *Dace Kļava, Envija Strautniece, Daina Kārkliņa* 32

Procesu kontroles un ražošanas monitoringa sistēmas pārtikas uzņēmumos / Process Control and Monitoring of Production in the Food Industry: *Juris Vanags, Uldis Viesturs, Ēvalds Putniņš* 38

Reflections on an Ethic Development for Rural Areas / Lauku ētikas veidošanās atspoguļojums: *Carmelo Cannarella* 46

Konveijera ķēdes iekārtas darbības pētījumi / Investigations into the Operation of Conveyor Chain Equipment: *Guntars Uzkliņģis* 57

REDKOLĒĢIJA / EDITORIAL BOARD

ATBILDĪGAIS REDAKTORS / RESPONSIBLE EDITOR

LLU Raksti (Proceedings of the Latvia University of Agriculture) is a scientific journal published by the Latvia University of Agriculture since 1946. The Proceedings operates on a non-profit basis.
Editorial Office: Latvia University of Agriculture, Lielā iela 2, Jelgava, LV-3001, Latvia;
phone: +371-30-05671; fax: (371) 3027238; e-mail: skuja@cs.llu.lv.
Printed and bound in Jelgava by Jelgavas tipogrāfija.

For information about article submission to LLU Raksti (Proceedings of LLU), visit our Web page at *www.cs.llu.lv/lu/research.htm*

Ar akūto ketozi slimojošu liellopu gremošanas trakta morfofunkcionālais raksturojums
Morphofunctional Characterization of the Digestive Tract of Cattle with Acute Ketosis

Māra Pilmane, Anastasija Suhova, Jurijs Nazarovs
Anatomijas un antropoloģijas institūts, Rīgas Stradiņa Universitāte,
e-pasts: pilmane@latnet.lv
Institute of Anatomy and Anthropology, Riga Stradins University,
e-mail: pilmane@latnet.lv
Inese Zītare, Aleksandrs Jemeļjanovs
LLU Zinātnes centrs "Sigra", e-pasts: sigra@lis.lv
Research Centre "Sigra", LLU, e-mail: sigra@lis.lv

Abstract. The clinical investigations were carried out on 42 3rd and 4th lactation dairy cattle in wintering period. Ketosis was loboratory affirmed on 8 cows. Different organs of digestive tract were examined after animals' compulsory slaughtering. The results showed the main changes in animal's forestomach (saccus caecus ventralis region on rumen), abomasum, and small intestine (ileum). The animals with acute ketosis possessed atrophic changes in the ruminal villi. The regional inflammation and parakeratosis correlated to the decrease of morphofunctional activity in this part of the digestive tract. The small intestine villi displayed atrophic changes. Massive conglomerates of inflammatory cells in some cases were seen among squamous cells. All these findings indicated disturbed absorbtion processes in the digestive tract of cattle with acute ketosis. Essential changes were found in the cattle digestive tract innervation. The neuropeptide-containing innervation was week, scarse and inqualitative within all digestive tract of cows with acute ketosis.
Key words: structure, neuropeptides, digestive tract, ketosis, cattle.

Ievads

Latvijas zemnieku saimniecībās govīm, īpaši augstražīgām, kurām ir spraiga vielu maiņa, bieži vien nav nodrošināti optimāli ēdināšanas un turēšanas apstākļi (Pilmane u.c., 2001). Tādēļ joprojām aktuāli ir vielu maiņas traucējumi, starp kuriem ketoze ieņem vienu no pirmajām vietām citu slimību vidū un parasti vērojama laktācijas pirmajos mēnešos (Rasmussen et al., 1999; Rukkwamsuk et al., 2000; Fleisher et al., 2001).

Ketozi raksturo izteikti traucējumi intermediārajā vielu maiņā (Smith et al., 1997; Ciaramella and Oliva, 1998; Zucca and Ferro, 2000), kas saistīti ar ketonvielu pastiprinātu veidošanos un izdalīšanos no organisma.

Liellopu ketožu izpētei, ārstēšanai un profilaksei svarīgi noskaidrot mikroskopiskās izmaiņas dzīvnieka organismā (Pilmane u.c., 2001; Pilmane et al., 2002). Literatūrā visvairāk pētīšanai min tādas histoloģiskās metodes kā gaismas mikroskopiju un elektronmikroskopiju. Visraksturīgākās pārmaiņas gan akūtās, gan hroniskās ketozes stadijās atrodamas iekšējos orgānos: aknas skar aknu taukainā infiltrācija un/vai taukainā deģenerācija (Rimeicāns, Brūveris, 1999), deģeneratīvas pārmaiņas atrod arī sirdī, nierēs, olnīcās. Hroniskos gadījumos konstatējama pat atrofija, piemēram, vairogdziedzera atrofija.

Gremošanas traktā ketožu gadījumos klīniski konstatēta izteikta priekškuņģa atonija (Andrews, 1998; Burgstaller, 1998). Orgānā atrodamas sausas barības masas. Glumeniekā un tievajās, resnajās zarnās vērojams neliels gļotādas pietūkums un asinsvadu pilnasinība. Nereti zarnās atrodams subakūts katarāls iekaisums. Pēc pārslimošanas gremošanas traktā izteikti redzamas pārmaiņas nav konstatējamas. Citi literatūras avoti (Jilg et al., 1997) min, ka govis ar akūtām vielu maiņas slimībām tomēr likvidējamas izteikto deģeneratīvo pārmaiņu dēļ iekšējos orgānos, jo turpmāk nav izmantojamas kā produktīvas. Minētās pretrunas dēļ mūsu darba mērķis bija noskaidrot dažādu gremošanas trakta daļu morfofunkcionālo stāvokli ar akūtu ketozi slimojošiem liellopiem.

Materiāls un metodes

2001. gadā dažādos republikas rajonos kūts turēšanas perioda beigās pēc atnešanās klīniski tika izmeklēti 42 liellopi – 3., 4. laktācijas govis. Ketozes diagnozi apstiprinājām laboratoriski, nosakot asinīs ketonvielu līmeni. Pēc piespiedu likvidācijas 8 govīm tika ņemti spurekļa sienas (saccus caecus ventralis), tievo zarnu beigu daļas (ileum), resno zarnu (colon) audu paraugi histoķīmiskiem un imunohistoķīmiskiem izmeklējumiem. Paraugus diennakti fiksēja maisījumā, kas sastāvēja no 2% formaldehīda un 0.2% pikrīnskābes

0.1 M fosfātbuferī (pH 7.2). Pēc tam audu gabaliņus 12 h skaloja tiroīdbuferī, kurā bija 10% saharozes, ieguldīja parafīnā un mikrotomā sagrieza 8 μm biezos slāņos. Griezumus gatavoja, lai ar biotīna un streptavidīna imūnhistoķīmisko metodi noteiktu proteīngēna peptīdu 9.5 (PGP 9.5, darba atšķaidījums 1:1600), neirofilamentus (NF, darba atšķaidījums 1:160, *Euro-Diagnostika*, Dānija), mielīnu (M, darba atšķaidījums 1:50, *Euro-Diagnostika*, Dānija), somatostatīnu (SOM, darba atšķaidījums 1:50, *Euro-Diagnostika,* Dānija), izmantojot Hsu et al. (1981) imūnhistoķīmijas metodi. Audu gabaliņi tika ņemti arī rutīnai pārskata gaismas mikroskopijai. Šim nolūkam audus fiksēja 12% formalīnā, ieguldīja parafīnā un sagrieza 8 μm biezos griezumos, ko krāsoja ar hematoksilīnu un eozīnu, bet izskatīja Zeisa mikroskopā.

Rezultāti

19 % gadījumos govīm pēcatnešanās periodā konstatējām ketozi. Ketonvielu līmenis asinīs slimajiem dzīvniekiem grupā vidēji bija 12.5±0.43 mg%.

Pārskata griezumos tikai vienā gadījumā 3 gadus vecai govij visu pētīto orgānu struktūra atbilda relatīvai normai. Piecām dažādas laktācijas govīm redzējām izteiktu priekškuņģu gļotādas atrofiju – bārkstiņas vai nu nebija, vai dažkārt bija atrodamas nelielu pauguru veidā (1.a att.). Vienlaicīgi atsevišķās vietās konstatējām dažādi izteiktu parakeratotiska epitēlija bazālo šūnu hiperplāziju (1.b att.). Perēkļveida iekaisuma šūnu infiltrāciju pārstāvēja neitrofilie leikocīti, limfocīti un reti makrofāgi. Vietumis atradām starpmuskuļu ganglijšūnu vakuolizāciju.

Pārmaiņas tievajā zarnā septiņiem liellopiem bija relatīvi līdzīgas. Bārkstiņas raksturoja izteikta morfofunkcionālā daudzveidība – tās bija tievas, garas, dziļi iesniedzās zarnas lumenā. Bieži bārkstiņas saplūda, veidojot konglomerātus. Vienlaikus novērojām masīvu epitēlijšūnu atlobīšanos lumenā. Tievo zarnu sieniņu, īpaši gļotādu, infiltrēja bagātīgs daudzums iekaisuma šūnu (1.c att.). Interesanti, ka vietās, kur iekaisuma šūnu konglomerātu bija visvairāk un veidojās pat limfatiskie mezgliņi, zemgļotādas nervu pinuma gangliji novietojās tuvu virsmas epitēlijam. Zemgļotādas nervu gangliju šūnas būtiskas struktūras pārmaiņas neuzrādīja, bet starpmuskuļu ganglijos nereti konstatējām kodolu vakuolizāciju (1.d att.). Iekaisuma šūnas pārstāvēja limfocīti, neitrofilie un eozinofilie leikocīti, makrofāgi un plazmocīti (2.a att.).

Resnās zarnas sieniņas gļotādā izteikta bija iekaisuma reakcija, bet zemgļotādu pildīja sekundāro mezgliņu konglomerāti (2.b att.).

Kopumā pēc inervācijas tipa atradām 5 vāji inervētus priekškuņģus. Fragmentāru un vājas intensitātes neirofilamentu un mielīna krāsojumu konstatējām šo priekškuņģu nervšķiedrās. Vienā gadījumā abu nervu struktūru marķieru daudzums priekškuņģī bija vidējs, bet divos gadījumos konstatējām hiperinervāciju. Intensīvi, lai gan fragmentāri, ar NF un M iezīmētās nervšķiedras atradām starpmuskuļu nervu pinumā. Somatostatīnu saturošos nervu elementus priekškuņģos nekonstatējām.

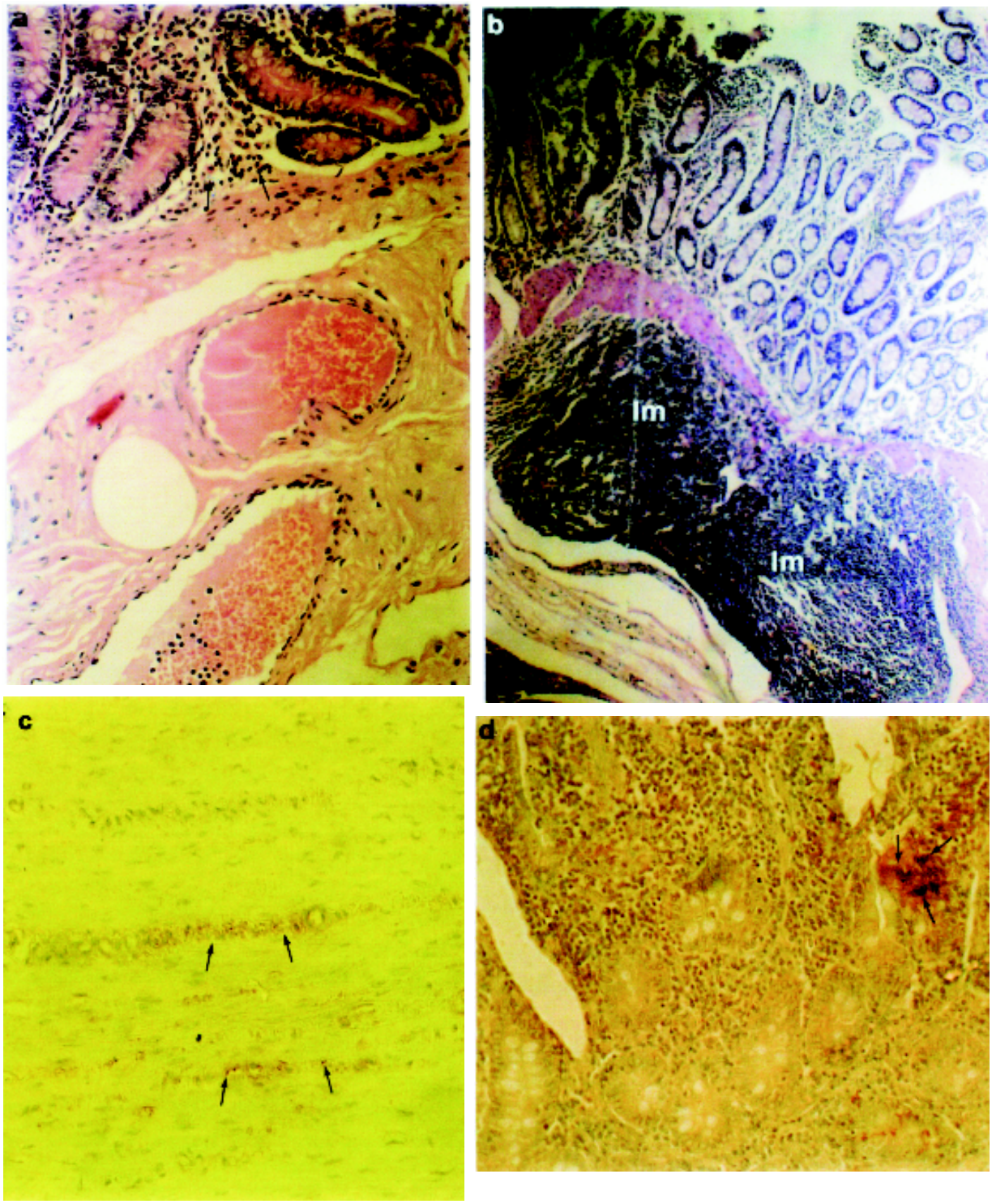
Zarnu sieniņu nervšķiedrās bija maz vai vidēji daudz NF un M saturošas nervšķiedras (2.c att.). Gangliju šūnas neuzrādīja nevienu izmantoto antivielu imūnreaktivitāti. SOM saturošas šūnas atradām nelielā skaitā, galvenokārt tievo zarnu virsmas epitēlijā, rajonos, kur bija izteikta iekaisuma šūnu infiltrācija (2.d att.).

Statistiskos šūnu aprēķinos konstatējām šādas tendences: vidējam limfocītu skaitam redzes laukā bija tendence palielināties virzienā no priekškuņģa gļotādas uz resno zarnu. Līdzīga tendence bija arī makrofāgiem, eozinofilajiem leikocītiem un plazmocītiem, kamēr neitrofilo leikocītu visvairāk bija priekškuņģī, un samazināšanās tendence šīm šūnām bija vērojama tievajās zarnās un resnajās zarnās (1. tabula un 3. attēls).

Diskusija

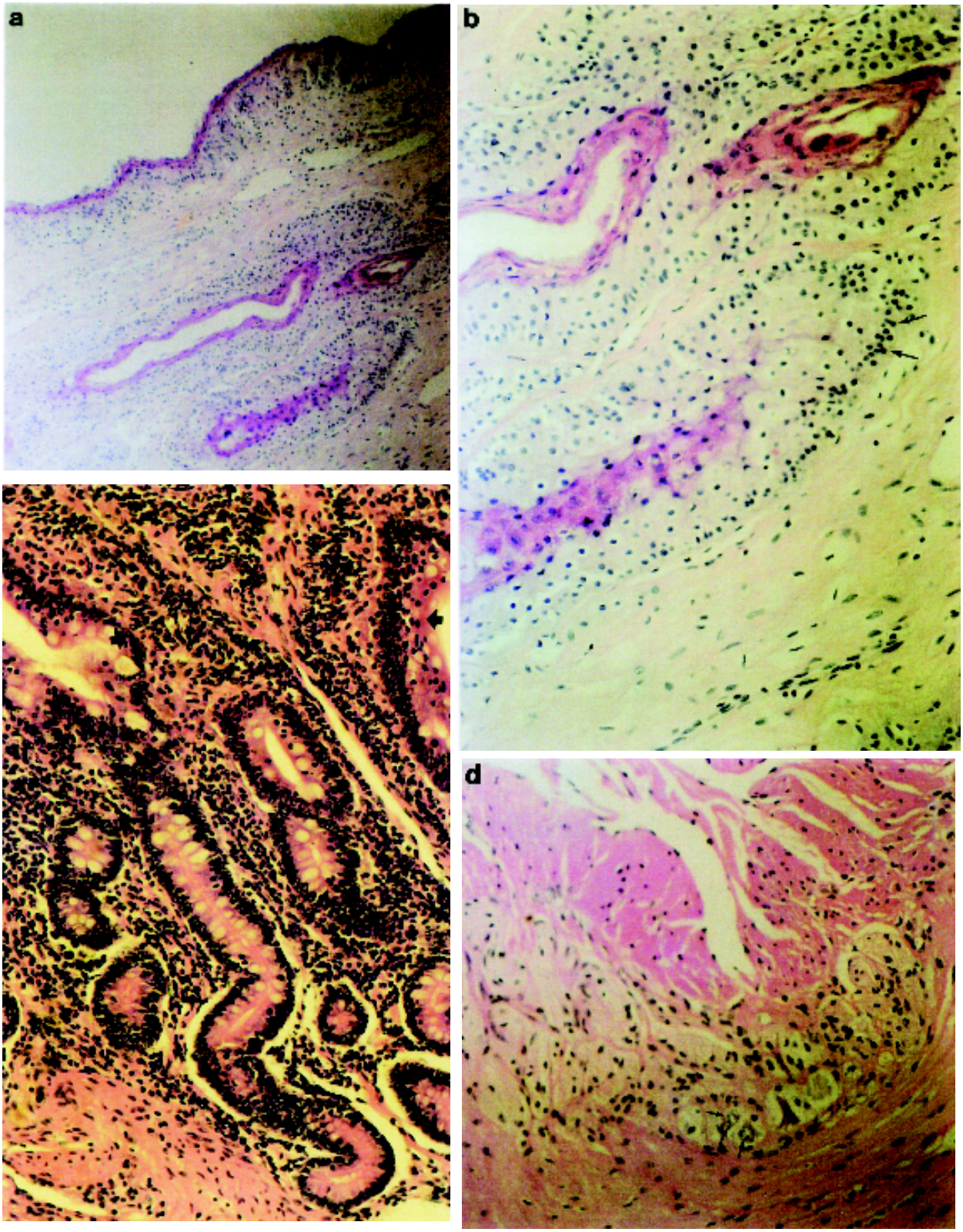
Galvenās pārmaiņas mūsu pētītajiem dzīvniekiem skāra priekškuņģi (saccus caecus ventralis rajonā) un tievo zarnu. Priekškuņģī vērojām atrofiju, ko raksturoja bārkstiņu reducēšanās, parakeratotisks epitēlijs un perēkļveida iekaisuma aina, norādot uz morfofunkcionālās aktivitātes samazināšanos skartajā vietā. Minētās pārmaiņas, šķiet, uzskatāmas par diezgan konstantām liellopiem ar vielu maiņas slimībām un parādās ne tikai ketozes gadījumā (Pilmane et al., 2000). Interesanti, ka nozīme ir pašām pārmaiņām struktūrā, nevis priekškuņģa rajonam, kas tiek skarts. Grīnvuds (Greenwood et al., 1997) min, ka, piemēram, keratozes palielināšanās tad arī norāda uz metabolās aktivitātes samazināšanos konkrētā vietā. Joprojām diskutabls ir jautājums, kas izraisa priekškuņģa pārmaiņas; dažādu faktoru starpā kā galvenais tiek minēta rupja, nesabalansēta barība (Jubb et al., 1985; Trailinek, 2000). Autori norāda, ka šūnu hiperplāzija un hiperkeratoze neparādās, ja rupjās barības daļa devā ir ne vairāk kā 15%. Tādejādi iespējams, ka mūsu pētītajiem dzīvniekiem priekškuņģa pārmaiņu izraisītājfaktoru vidū aktuāla ir gan slimība (ketoze), gan arī nesabalansēta barība. Savukārt par vēl saglabāto epitēlija reģenerāciju liecina perēkļveida bazālo šūnu hiperplazija.

Tievās zarnas bārkstiņu daudzveidība (atrofiskas, izteikti garas, konglomerāti, masīva šūnu atslāņošanās), mūsuprāt, norāda uz traucētiem absorbcijas procesiem praktiski visiem ar ketozi slimojošiem dzīvniekiem. Vesela dzīvnieka tievo zarnu bārkstiņu garums variē atbilstoši sugai, vecumam, zarnu mikroflorai un imūnajam statusam (Lipkin, 1981; Kilshaw and Slade, 1982). Saslimšana un imūnā satusa pārmaiņas, uz ko norāda pastiprinātā iekaisuma šūnu infiltrācija, varētu būt pārmaiņu iemesls mūsu pētītajiem dzīvniekiem, kaut gan izslēdzami nav arī citi faktori. Interesanti, ka tādiem



1. att. Ar ketozi slimojošu liellopu spurekļa (a-b) un tievo zarnu (c-d) gaismas mikrofotogrāfijas. Hematoksilīns un eozīns:a) spurekļa gļotāda ar parakeratotisku epitēliju un gļotādas pauguriem bārkstiņu vietā (X 160); b) bultiņas norāda parakeratotiskā epitēlija bazālo šūnu perēkļveida hiperplāziju (X 250); c) ar iekaisuma šūnām izteikti infiltrētas tievo zarnu bārkstiņas veido saplūdušu konglomerātu (bultiņas) (X 250); d) bultiņas norāda starpmuskuļu gangliju kodolu vakuolizāciju (X 250).

Fig. 1. Light micrographs of rumen (a - b) and small intestine (c -d) of cattle with acute form ketosis. Haematoxylin and eosin: a) rumen mucosa with parakeratotic epithelium and buds of mucosa instead of villi (X 160); b) hyperplasia of basal cells in parakeratotic epithelium (arrows) (X 250); c) intensively expressed inflammatory cells form amalgamated conglomerates (arrows) in small intestine villi (X 250); d) vacuolisation in intramuscular ganglion of muscles (X 250).


a
b
d

1. tabula/Table 1

Vidējais iekaisuma šūnu skaits redzes laukā liellopu priekškuņģos, tievajās un resnajās zarnās
Average count of inflammatory cells in the field of vision in walls of cattle forstomach, small and large intestines

	Limfocīti Lymphocytes	Neitrofilie leikocīti Neutrophil leukocytes	Makrofāgi Macrophages	Eozinofilie leikocīti Eosinophil leukocytes	Plazmocīti Plasma cells
Priekškuņģis Forestomach	35.0±11.52	21.6±6.29	13.0±5.53	4.0±2.41	8.8±3.0
Tievās zarnas Small intestine	54.8±15.39	12.4±5.93	22.6±9.96	14.8±4.92	4.52±4.52
Resnās zarnas Large intestine	59.2±9.86	4.4±2.16	27.8±11.89	16.2±7.49	9.8±4.37

visēdājiem kā sivēniem, mainot barības veidu, novērota tievo zarnu bārkstiņu garuma samazināšanās, kā arī šūnu funkcionālā tipa nomaiņa (Hampson and Kidder, 1986).

Būtiskas gremošanas traktā bija inervācijas pārmaiņas – tās samazināšanās, kā arī nervu elementu fragmentārais un vājais krāsojums ar mielīnu un neirofilamentiem, kas norādīja uz nervu struktūru kvalitātes samazināšanos. Līdzīgas pārmaiņas bijām jau konstatējuši iepriekšējos pētījumos (Pilmane et al., 2000). Tomēr interesanta ir ganglija šūnu "augšupvirzība", tuvāk izteikta iekaisuma skartām tievo zarnu bārkstiņām. Iekaisuma mediatoru ietekme uz nervu struktūrām ir jau pierādīta (Holzer, 1988), bet mūsu pētāmajiem dzīvniekiem iepriekšminētā atradne, mūsuprāt, norāda uz imūnās un neiroendokrīnās sistēmas saistību. To pamato izteiktā plazmocītu un limfocītu atradne un fakts, ka somatostatīnu saturošās šūnas (peptīdam zināma pretiekaisuma darbība) tika atrastas virsmas epitēlijā vietās, kur tuvu gļotādai novietojās zemgļotādas gangliju šūnas.

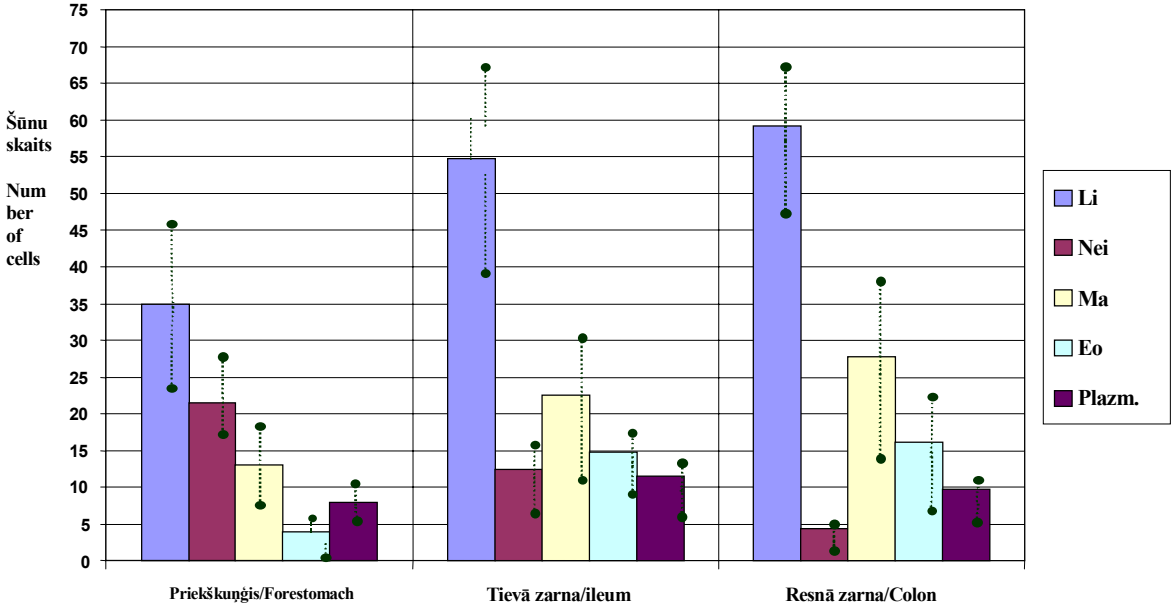
Kopumā iekaisuma šūnu analīze parādīja, ka neitrofilo leikocītu skaits samazinās audos virzienā no priekškuņģiem uz resno zarnu, bet eozinofilo leikocītu, limfocītu un makrofāgu skaitam minētajā virzienā ir tendence palielināties. Izteikts neitrofilo leikocītu daudzums spurekļa gļotādā tika aprakstīts jau agrāk veiktajos pētījumos (Pilmane et al., 2002) un acīmredzot saistāms ar barības sastāvu un vieglo audu traumatizācijas iespēju. Savukārt tievo zarnu šūnu infiltrācijas sastāva maiņa liecina par izteiktu antigēno stimulāciju. Tas atbilst Movata un Fergusona (Mowat and Ferguson, 1981) uzskatam par to, ka tieši tievo zarnu antigēnā stimulācija veicina iekaisuma infiltrāciju reizē ar šūnu proliferāciju un kopumā norāda uz tievo zarnu šūnu regulēto hipersensitivitāti.

Secinājumi

Ar akūtu ketozi slimojošu govju gremošanas traktā izteiktas morfofunkcionālās pārmaiņas atrodamas priekškuņģī (forestomach), kuņģī (abomasum), tievajā zarnā (ileum). Priekškuņģī pārskata griezumos tika atrasta izteikta gļotādas atrofija (bez bārkstiņām vai tikai to iezīmes pauguriņu veidā), atsevišķās vietās –

2. att. Ar ketozi slimojošu liellopu tievās zarnas (a), resnās zarnas (b) (hematoksilīns un eozīns) un tievo zarnu biotīna-streptavidīna imūnhistoķīmijas (c - mielīna; d - somatostatīna) mikrofotogrāfijas: a) bultiņas norāda tievās zarnas gļotādu, kas bagātīgi infiltrēta ar eozinofilajiem leikocītiem, plazmocītiem, limfocītiem. Kriptās redzami intraepiteliālie limfocīti (X 250); b) resnās zarnas gļotādas infiltrācija un limfatiskie mezgliņi (lm) zemgļotādā (X 160); c) bultiņas norāda smalkas mielīnu saturošas nervšķiedras starpmuskuļu nervu pinumā (X 150); d) bultiņas norāda somatostatīnu saturošo šūnu neiroepiteliālo ķermenīti virsmas epitēlijā (X 250).

Fig. 2. Light micrographs on ketosis disordered cattle small intestine (a), large intestine (b) (stained with haematoxylin and eosin) and small intestine (biotin-streptavidin immunohistochemistry: c – myelin stained, d – somatostatin): a) richly infiltrated small intestine mucosa with eosinophil leukocytes, plasma cells, and lymphocytes (arrows). The intraepithelial lymphocytes are seen in crypt (X 250);
b) infiltration of large intestine mucosa and lymphoid nodules in submucosa (X 160);
c) thin myelin-containing nerve fibres (arrows) in intramuscular nerve plexus (X 150);
d) somastotatin-containing neiroepithelial body (arrows) in epithelium of surface (X 250).



3. att. Vidējais šūnu skaits priekškuņģa, tievās un resnās zarnas gļotādā.
Fig. 3. Average count of inflammatory cells in mucosa of the cattle forestomach, small and large intestines.

parakeratotiska epitēlija bazālo šūnu hiperplāzija, citās – perēkļveida iekaisuma šūnu infiltrācija. Pārmaiņas tievajā zarnā raksturojās ar bārkstiņu morfofunkcionālu daudzveidību, bārkstiņu saplūšanu, veidojot konglomerātus, vietām – masīvu epitēlijšūnu atlobīšanos lumenā. Gļotādā bija bagātīgs daudzums iekaisuma šūnu.

Resnās zarnas sieniņas gļotādā izteikta arī bija iekaisuma reakcija.

Ar ketozi slimu dzīvnieku spurekļiem raksturīga vairāku tipu inervācija (normāla, vāja, hiperinervācija). Konstatēts tika arī neiropeptīdu trūkums nervu elementos.

Literatūra

1. Andrews, T. (1998) Ketosis and fatty liver in cattle. *In Practice*, United Kingdom, vol. 20(9), pp. 509-513.

2. Burgstaller, G. (1998) "Metabolism derangements" of the high-performance cow due to feeding can be prevented. Information on mixed feed. *Muehle+Mischofuttertechnik*, vol. 135 (16), pp. 543-544.

3. Ciaramella, P., Oliva, G. (1998) La sindrome chetosica del bovino. *O & DV Obiettivi e Documenti Veterinari (Italy),* Feb vol. 19(2), pp. 31-42.

4. Fleisher, P., Hoedemaker, M., Metzner, M., Slosarkova, S., Skrivanek, M. (2001) Clinical disorders in Holstein cows: incidence and associations among lactational risk factors. *Acta Veterinaria (Czech Republic),* vol. 70 (2), pp. 157-165.

5. Greenwood, R. H., Morrill, J. L., Titgemeyer, E. C., Kennedy, G. A. (1997) A new method of measuring diet abrasion and its effect on the development of the forestomach. *Journal of dairy science*, vol. 80(10), pp. 2534-2541.

6. Hampson, D. J. and Kidder, D. E. (1986) Influence of creep feeding and weaning on brush border enzyme active in the piglet small intestine. *Research in Veterinary Science*, vol. 40, pp. 24-31.

7. Holzer, P. (1988) Local effector functions of capsaicin-sensitive sensory nerve endings: involvement of tachykinins, calcitonin gene related peptide and other neuropeptides. *Neuroscience*, vol. 24, pp. 739-768.

8. Hsu, S. M., Raine, L., Fanger, H. (1981) The use of antiavidin antibody and avidin-biotin peroxidase complex in immunoperoxidase technics. *Am. J. Clin. Pathol.,* vol. 75, 816 pp.

9. Jilg, T., Riedel-Caspari, G., Unglaub, W. (1997) Early prevention of metabolic disorders. Ketosis – occupation disease of the dairy cow. *Rinderwelt*, vol. 22 (6), pp. 16-17.

10. Jubb, K. V. F., Kennedy, P. C., Palmer, N. (1985) Pathology of Domestic Animals. In: *Digestive system*. Academic Press, Inc., 3rd ed., vol. 2, p. 29.

11. Kilshaw, P. J. and Slade, H. (1982) Villus atrophy and crypt elongation in the small intestine of

preruminant calves fed with heated soyabean flour or wheat gluten. *Res. Vet. Sci*., vol. 33, pp. 305-308.

12. Lipkin, M. (1981) Proliferation and differentiation of gastrointestinal cells in normal and disease states. In: *Physiology of the Gastrointestinal Tract*. L.R.Johnson (ed.), New York, Raven Press, pp. 145-168.

13. Mowat, A. M. and Ferguson, A. (1981) Hypersensivity in the small intestinal mucosa. Induction of cell-mediated immunity to a dietary antigen. *Clinical and Experimental Immunology*, vol. 43, pp. 574-582.

14. Rasmussen, L. K., Nielsen, B. L., Pryce, J. E., Mottram, T. T., Veerkamp, R.F. (1999) Risk factors associated with the incidence of ketosis in dairy cows. *Animal Science*, vol. 68 (3), pp. 379-386.

15. Rukkwamsuk, T., Kruip, T. A. M., Wensing, T. (2000) Relationship between overfeeding and overconditioning in the dry period and the problems of high producing dairy cows during the postparturient period. Review paper (Hungary). *Magyar Allatorvosok Lapja*, vol. 122 (1), pp. 15-20.

16. Pilmane, M., Zītare, I., Jemeļjanovs, A. (2001) Latvijas liellopu priekškuņģa pārmaiņas un vielmaiņas slimības. *Latvijas Ārstu Žurnāls*, Nr. 4, 36.-39. lpp.

17. Pilmane, M., Jemeļjanovs, A., Zītare, I. (2002) Liellopu gremošanas trakta morfofunkcionālās un histoķīmiskās pārmaiņas aktuālāko vielu maiņas slimību patoģenēzē. Starptautiskās zinātniskās konferences "Dzīvnieki. Veselība. Pārtikas higiēna." raksti, Jelgava, 2002.gada 14. novembrī. *Veterinārmedicīnas raksti*, Jelgava, 215.-218. lpp.

18. Pilmane, M., Zītare, I., Jemeļjanovs, A. (2000) Liellopu priekškuņģu difūzā neiroendokrīnā sistēma. *LLU Veterinārmedicīnas raksti,* 140.-144. lpp.

19. Rimeicāns, J. un Brūveris Z. (1999) Problems of hepatosis treatment of dairy cows. *26th world Veterinary Congress, Lion,* p. 101.

20. Smith, T. R., Hippen, A. R., Beitz, D. C., Young, J. W. (1997) Metabolic characteristics of induced ketosis in normal and obese dairy cows. *Yournal of dairy science*, vol. 80 (8), pp. 1569-1581.

21. Trajlinek, J. (2000) Nutrition of high producing dairy cows as related to ketosis incidence. Breeding, nutritional and technological aspects of milk production and quality. Proceedings. Summary (En). *Slechtitelske, vyzivarske a technologicke aspekty produkce a kvality mleka. Sbornik prispevku. Rapotin (Czech Republik). Svaz Vyrobcu Mleka (Czech Pepublic),* 144 pp. (UZLK D 89.078) pp. 75-78.

22. Zucca, E., Ferro, E. (2000) Valutazione dei corpi chetonici nella bovina affetta da chetosi (vacche da lattel). *Obiettivi e Documenti Veterinari Italy*, vol. 21 (2), pp. 22-26.

Glijas šūnu morfofunkcionālais raksturojums govju centrālajā nervu sistēmā (CNS)
Morphofunctional Characteristics of Glial Cells in the Cattle Central Nervous System

Māra Pilmane
Anatomijas un antropoloģijas institūts, Rīgas Stradiņa Universitāte,
e-pasts: pilmane@latnet.lv
Institute of Anatomy and Anthropology, Riga Stradins University,
e-mail: pilmane@latnet.lv
Inese Zītare, Aleksandrs Jemeļjanovs
LLU Zinātnes centrs "Sigra", e-pasts: sigra@lis.lv
Research Centre "Sigra", LLU, e-mail: sigra@lis.lv

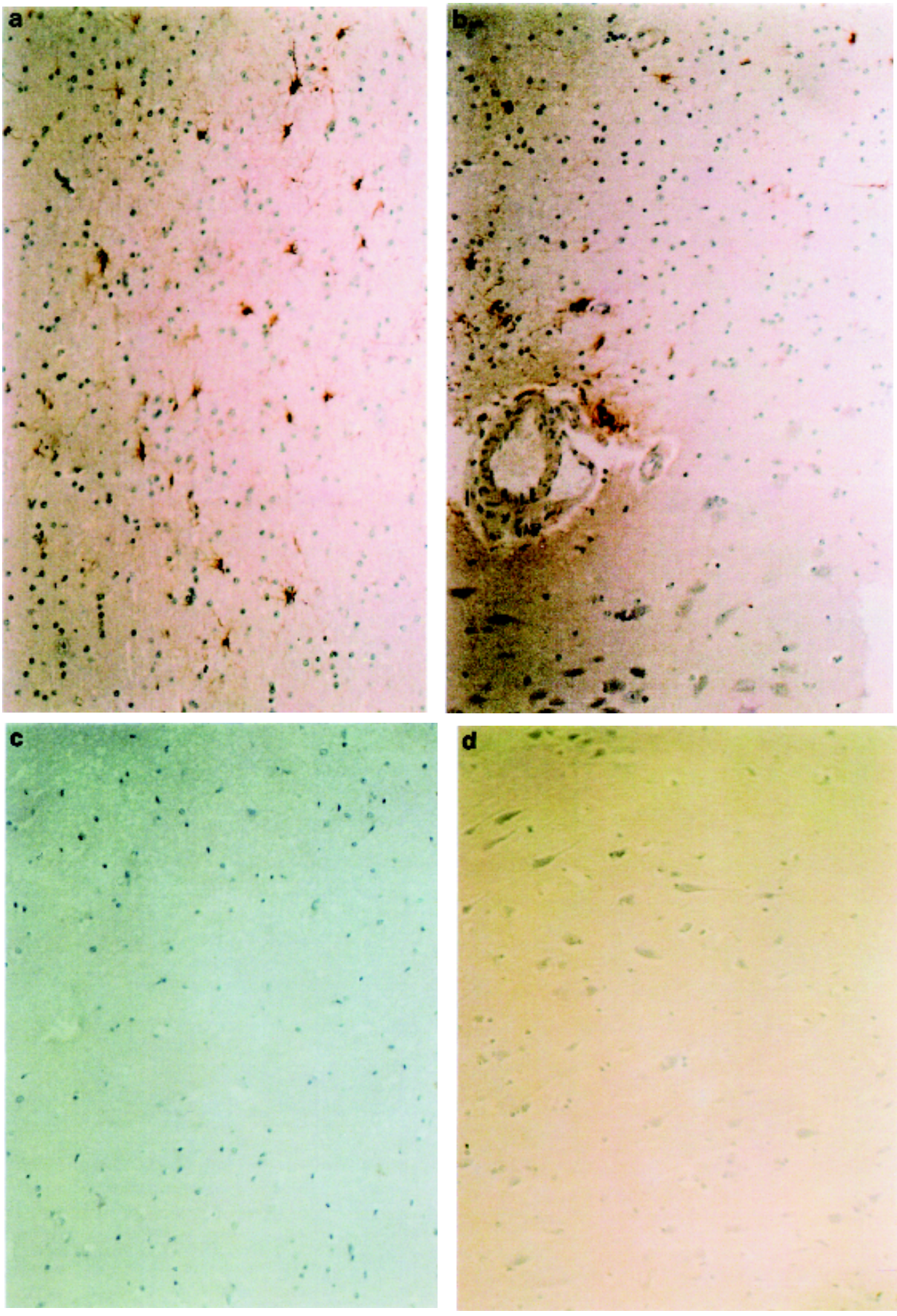
Abstract. Astrocytes belong to the glial cells and provide many functions in brain tissues including transport of liquid and ions, development of barrier structures, proliferation in injury, phagocytosis. Astrogliosis with following destruction of glial cells is one of morphological phenomena observed in neurodegenerative brain disease like bovine spongioform encephalopathy (BSE). Thus, the aim of this study was detection of qualitative and quantitative changes in cattle brain glial astrocytes in screening animals for BSE in Latvia by use of immunohistochemistry (glial acidic fibrillar protein, GAFP, working dilution 1:100, DAKO, Denmark). GAFP-containing cells were seen only in brain white matter, especially on the border between white and grey matter. The cells demonstrated long specifically stained processess and were located regularly without clustering in most cases. The proliferation of astrocytes near blood vessels and partial fragmentation of processes was observed in three animals. At the same time, GAFP was not observed in white matter glia. However, some animal's brain cortical molecular layer contained occasional GAFP-containing cells. Massive tissue vacuolisation, absence of neurones, astrocytosis, breakdown of astrocytes typical in brain cortex, and medulla of animals with BSE were not seen in any of the investigated animals. In conclusion, no changes characteristic to BSE were observed in screening cattle brain in Latvia. Changes connected with regional proliferation of glia around the blood capillaries might be connected with local trauma or beginning of neurodegenerative disease.
Key words: astrocytes, brain, glial cells, bovine spongioform encephalopathy, cattle.

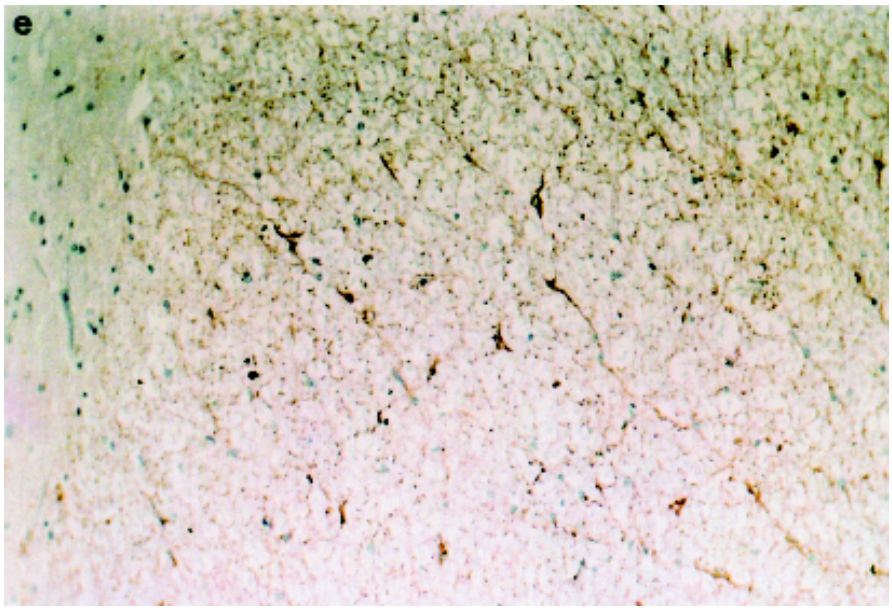
Ievads

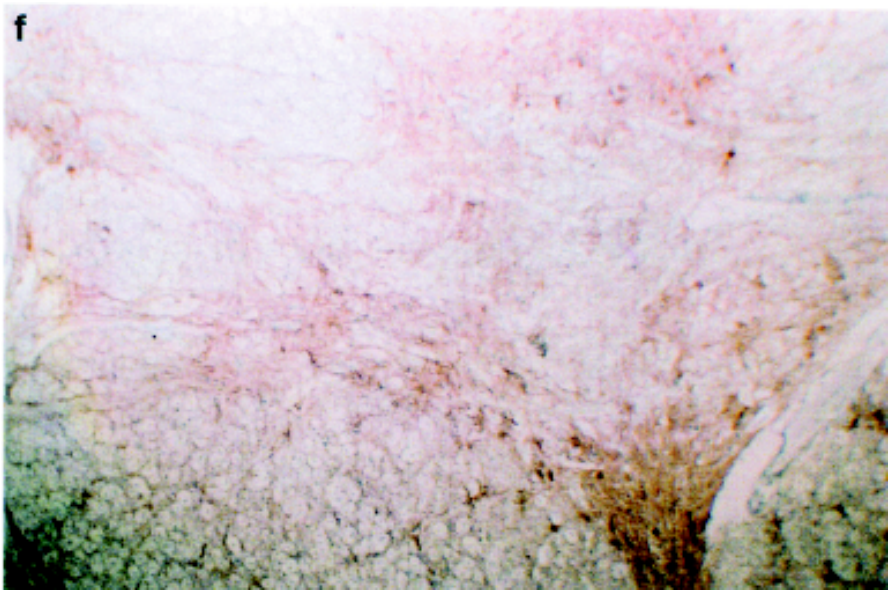
Astrocīti ir glijas šūnu veids, kuram CNS izšķir divus galvenos veidus – fibrozās jeb garstarainās šūnas, kas atrodamas gan baltajā, gan pelēkajā vielā, bet pārsvarā lokalizējas baltajā vielā un zem *pia mater*, un protoplazmatiskos jeb īsstarainos astrocītus, kas lokalizējas pelēkajā vielā. Minētās šūnas veic daudzas svarīgas funkcijas: šķidruma un jonu transportu, proliferē bojājuma gadījumā, nodrošinot aizsargfunkciju, piedalās dažādu barjeru veidošanā un spēj arī fagocitēt

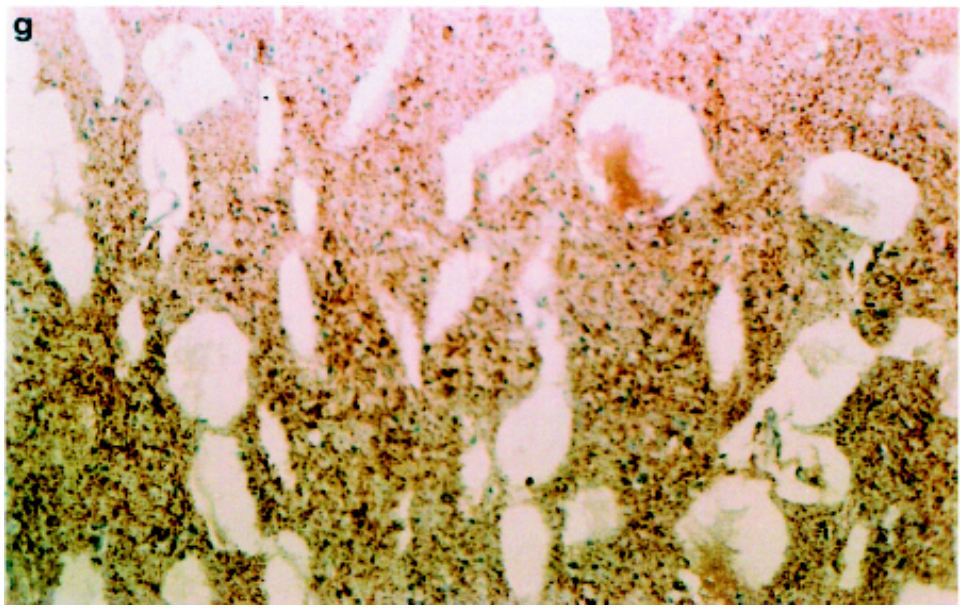
1. att. Govju galvas smadzeņu lielo pusložu biotīna un streptavidīna imūnhistoķīmija:
a) baltās vielas garstarainie astrocīti satur glijas skābo fibrillāro proteīnu (X 240); b) ar glijas skābo fibrillāro proteīnu iezīmēto garstaraino astrocītu perēkļveida proliferācija ap asinsvadu uz baltās un pelēkās vielas robežas (X 240); c) glijas skābais fibrillārais proteīns nav konstatēts ne baltās vielas astrocītos (X 160); d) ne pelēkās vielas šūnās (X 240); e) glijas skābo fibrillāro proteīnu saturošas nervšķiedras iegareno smadzeņu baltajā vielā (X 160); f) bagātīga glijas skābā fibrillārā proteīna atrade iegareno smadzeņu astrocītos un šķiedrās (X 160); g) ar govju spongiozo encefalopātiju slimojošu govju lielo pusložu garozā un iegarenajās smadzenēs vērojama vakuolizācija, neironu trūkums un astrocītu glijas sabrukšana (X 160).

Fig. 1. Light micrographs of avidin-streptavidin immunohistochemistry:
a) fibrillar astrocytes of brain white matter containing glial fibrillar acidic protein (X 240); b) proliferation of GAFP positive astrocytes around blood vessel on border of white and grey matter (X 240); c) lack of GAFP in glial astrocytes in brain white matter (X 160) and d) also in grey matter cells (X 240); e) GAFP-containing astrocytes in nerve fibres of *medulla ablongata* white matter (X 160); f) abundance of GAFP in *medulla ablongata* astrocytes and nerve fibres (X 160); g) vacuolisation, absence of neurones and degeneration of glial astrocytes in brain cortex of cattle with bovine spongioform encephalopathy (X 160).


a
b
c
d


e


f


g

(Fletcher, 1993). Astroglioze pieder pie nespecifiskajām smadzeņu audu atbildes reakcijām, kairinājumiem, kas pārsvarā ir lokāli, piemēram, cistas gadījumā (Jubb et al., 1985). Minētās šūnas dažādu neirodeģeneratīvu slimību gaitā spēj reaģēt difūzi, piemēram, liellopu spongiozās encefalopātijas gadījumā novērojama astrocitoze ar šādu šūnu sabrukšanu (Janovic, 2001). Latvijā līdz šim nav veikti pētījumi par astrocītu glijas pārmaiņām liellopu smadzenēs, tādēļ mūsu darba mērķis bija šo šūnu kvalitatīvi kvantitatīvo pārmaiņu izpēte uz liellopu spongiozo encefalopātiju pārbaudītu nejaušā skrīninga govju centrālajā nervu sistēmā.

Materiāls un metodes

Materiāls iegūts 2001. gadā dažādos Latvijas republikas rajonos no astoņām 3. un 4. laktācijas govīm. Audi paņemti tūlīt pēc dzīvnieku nokaušanas no pieres daļas garozas, pakauša daļas garozas un iegarenajām smadzenēm. Paraugus diennakti fiksēja maisījumā, kas sastāvēja no 2% formaldehīda un 0.2% pikrīnskābes 0.1 M fosfātbuferī (pH 7.2). Pēc tam audu gabaliņus 12 h skaloja tiroīdbuferī, kurā bija 10% saharozes, ieguldīja parafīnā un mikrotomā, sagrieza 8 mm biezumā. Griezumos ar biotīna un streptavidīna imūnhistoķīmisko metodi noteica glijas skābo fibrillāro proteīnu (GSFP), izmantojot Hsu et al. (1981) metodi. Audu gabaliņi tika ņemti arī rutīnai pārskata gaismas mikroskopijai, krāsojot tos ar hematoksilīnu un eozīnu. Paraugus izskatīja Leica mikroskopā.

Ar liellopu spongiozo encefalopātiju slimojošas govs lielo pusložu garozas demonstrācijas mikrofotogrāfijas tika iegūtas no ārzemēm saņemtiem audu paraugiem (Institute for Animal Health, Berkshire).

Rezultāti

Pieres daļas garozā novērojām glijas intracelulāru un ārpussūnu matrices tūsku. Vidēji izteikta bija kapilāru pilnasinība, visos gadījumos atradām perivaskulāru tūsku. Neironu orientācija bija saglabāta, daļai dzīvnieku neironu kodoli saturēja vakuolas.

Pakauša daļas garozā minētās neironu vakuolizējoša rakstura un tūskas parādības nenovērojām praktiski nevienā gadījumā. Pieņemot, ka pieres daļas garozā atrastā aina saistāma ar elektrošoka izraisītajām pārmaiņām, imūnhistoķīmiskajā analīzē aplūkojām tikai pakauša daļā konstatētās pārmaiņas. GSFP iekrāsoja praktiski tikai garstarainos astrocītus tikai baltajā vielā vai arī uz robežas starp balto un pelēko vielu (1.a att.). Trim dzīvniekiem novērojām astrocītu glijas perēkļveida proliferāciju galvenokārt asinsvadu tuvumā (1.b att.). Tajā pašā laikā minētajiem dzīvniekiem lielākajā daļā baltās vielas GSFP astrocītus neiekrāsoja (1.c att.). Garozā GSFP saturošus astrocītus nekonstatējām nevienam dzīvniekam (1.d att.).

Iegarenajās smadzenēs GSFP bagātīgi lokalizējās baltās vielas nervšķiedrās visiem dzīvniekiem (1.e att.). Vienlaicīgi GSFP iekrāsoja pelēkās vielas gliocītus (1.f att.).

Ar liellopu spongiozo encefalopātiju slimojošiem dzīvniekiem galvas smadzeņu garozas tipiskās pārmaiņas ietvēra masīvu audu vakuolizāciju, praktiski neironu trūkumu, astrocitozi un astrocītu sabrukšanu (1.g att.).

Diskusija

Pieres daļas garozas pārmaiņas, kas pētāmajiem dzīvniekiem galvenokārt bija izteiktas tūskas veidā, saistījām ar kaušanas brīža elektrošoku, tādēļ vērā neņēmām. Pakauša daļas garozā lielākajai daļai mūsu pētīto dzīvnieku būtiskas novirzes no normas neatradām, tomēr uzmanības vērta, mūsuprāt, bija perēkļveida astrocītu proliferācija baltajā vielā, kā arī uz baltās un pelēkās vielas robežas asisnvadu tuvumā. Minētā parādība varētu liecināt par vietēja rakstura jau pārciestu bojājumu, piemēram, traumu. Jubb et al. (1985) norāda, ka astrocītu atbilde uz kairinājumu var izpausties deģenerācijas, nekrotizācijas un/vai proliferācijas veidā. Deģeneratīvās pārmaiņas visbiežāk atrodamas pēc traumas, išēmiska bojājuma, atmiekšķēšanās vai akūta iekaisuma. Tās raksturo astrocītu izaugumu sabrukšana, šūnas ķermeņa tūska, kodola piknotizācija un fragmentācija. Šāds bojājums var izraisīt protoplazmatisko astrocītu pārveidošanos par fibrozajiem (Luse, 1958).

Savukārt proliferācija ne vienmēr ir astrocītu atbildes reakcija uz blakus esošo audu bojājumu, kaut gan vienmēr to novēro Valeriāna deģenerācijas gadījumā. Tieši vietējs bojājums vai audu deģenerācija izraisa ātru astrocītu proliferāciju (Maxwell and Kruger, 1965).

Mūsu pētītajiem dzīvniekiem liellopu spongiozo encefalopātiju nekonstatējām. Šīs slimības raksturīgākās audu pārmaiņas atrodamas smadzenēs, smadzenītēs un izpaužas ar vakuolizāciju, specifisku šķiedru un amiloido plātnīšu veidošanos (Peerasak et al., 1997; 1998), kam pievienojas imūno reakciju samazināšanās un trūkums un neironu degradācija (Janovic, 2001). Mūsdienās paplašinājies skarto dzīvnieku sugu, orgānu un audu spektrs. Tā, kazām raksturīgā bojājuma vieta ir iegarenās smadzenes, tilts, lielās puslodes (Caramelli et al., 1999), bet primātiem priona peptīds diagnosticējams mandelēs, kuņģa un zarnu traktā, muguras smadzeņu ventrālajos un dorsālajos ragos (Bons et al., 1999). Tādēļ veiksmīgi tiek veidoti eksperimentālie modeļi šīs slimības pētīšanai (Laude et al., 2000). Tomēr, diagnosticējot to dzīvniekiem, noteicošais ir ilgais inkubācijas periods, specifiskā klīnika un pozitīva specifiskā diagnostika (Aleksandrov et al., 2001).

Literatūra

1. Aleksandrov, M., Lazarova, S., Kamenov, P., Ivanov, Ya., Kadijski, D. (2001) Diagnosis of bovine

spongioform encephalopathy. *Veterinarna Sbirka*, vol. 109 (7-8), pp. 8-15.

2. Bons, N., Mestre-Frances, N., Belli, P., Cathala, F., Gajdusek, D. C., Brown, P. (1999) Natural and experimental oral infection of nonhuman primates by bovine spongioform encephalopathy agents. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 96 (7), pp. 4046-4051.

3. Caramelli, M., Casalone, C., Bozzetta, E., Troiano, P., Di Bari, M., Busini, L., Agrimi, U. (1999) Immunohistochemical and immunobiochemical findings in goats with scrapie. *Obiettivi e Documenti Veterinari Italy*, vol. 20 (11), pp. 51-55.

4. Chantaraprateep, P., Kanchanapangka, S., Tanticharoenyos, P., Tunsaringkarn, K., Rungphitackchai, B. (1997) Etiology and current status of bovine spongioform encephalopathy (mad cow disease). In: *Univ. Office. Research Promotion and Coordination Div. Research abstracts*, pp. 222-223.

5. Chantaraprateep, P., Kanchanapangka, S., Tanticharoenyos, P., Tunsaringkarn, K., Rungphitackchai, B. (1998) *Etiology and current status of bovine spongioform encephalopathy (mad cow disease*). Bangkok, 127 pp.

6. Fletcher, T. P. (1993) Nervous system. In: *Textbook of veterinary histology* (ed. By H-Dieter Dellmann). Lea and febiger, Philadelphia, the 4th ed., pp. 92-105.

7. Hsu, S. M., Raine, L., Fanger, H. (1981) The use of antiavidin antibody and avidin-biotin peroxidase complex in immunoperoxidase technics. *Am. J. Clin. Pathol*., vol. 75, 816 pp.

8. Janovic, M. (2001) Spongioform encephalopathies of animals and humans. *Meat Technology*, vol. 42 (3-4), pp. 189-199.

9. Jubb, K. V. F., Kennedy, P. C., Palmer, N. (1985) Pathology of Domestic Animals. In: *The Liver and Biliary system*. Academic Press, Inc., 3rd ed., vol. 2, pp. 226-327.

10. Laude, H., Vilette, D., Le Dur, A., Archer, F., Soulier, S., Besnard, N., Essalmani, R., Vilotte, J. L. (2002) New in vivo and ex vivo models for the experimental study of sheep scrapie: development and perspectives. *Comptes rendus Biologies*, vol. 325 (1), pp. 49-57.

11. Luse, S. A. (1958) Ultrastructure of reactive and neoplastic astrocytes. *Lab Invest*, vol. 7, pp. 401-417.

12. Maxwell, D. S. and Kruger, L. (1965) The fine structure of astrocytes in the cerebral cortex and their response to focal injury produced by heavy ionizing particles. *J. Cell biol*., vol. 25, pp. 141-157.

The Effect of Nitrogen Use on Perennial Ryegrass Seed Yield and Forage Quality Parameters
Slāpekļa mēslojuma ietekme uz ganību airenes sēklu ražu un lopbarības kvalitātes rādītājiem

Skaidrite Bumane, Peteris Berzins
Skriveri Research Center, Latvia University of Agriculture, e-mail: skbumane@sveiks.lv
LLU Skrīveru Zinātnes Centrs, e-pasts: skbumane@sveiks.lv
Richard H. Leep, Timothy Dietz
Department of Crop and Soil Sciences, Michigan State University, e-mail: leep@msu.edu
Mičiganas Valsts universitātes Augsnes zinātnes un augkopības katedra,
e-pasts: leep@msu.edu

Abstract. Since 1988, Department of Agriculture of the Michigan State University (MSU) and the Latvia University of Agriculture (LLU) have had an agreement for cooperation in research and information exchange. The objective of the research described in this paper is to obtain productivity results for perennial ryegrass (*Lolium perenne* L.) at different rates of mineral nutrition in both Michigan and Latvia. The State of Michigan and Latvia's geographical locations are similar. The country of Latvia lies East of the Baltic Sea; Michigan, likewise, is located East of a large body of water, Lake Michigan, providing both locations similar weather patterns. Although the experiments were carried out independent of each other and the measured results were analyzed for each location, this paper compares the similarities and differences in both location outcomes. Field experiments in Latvia – at the Skriveri Research center, LLU were carried out on sod podzolic sandy loam soil (Argiaquic Argiaboll) in the year 2001. The following mineral fertilizer rates were used: N and P_2O_5, each 0, 30, 60, 90, 120, K_2O – 0, 40, 80, 120, 160 kg ha^{-1}. This research examines the effects of varying mineral fertilizer rates on forage quality, seed and straw yields by using the perennial ryegrass cultivars 'Spidola'. In Michigan, field trials were conducted on a Capac loam soil (fine-loamy, mixed, mesic Aeric Achraqualfs) at the Michigan State University Research farm in East Lansing Michigan. Five levels of N fertilizer rates were used: 0, 112, 224, 336, and 448 kg ha^{-1} of N. Diploid cultivars 'Aries' and tetraploid cultivars 'Quartet' were used in the field experiments. The average biomass yield from perennial ryegrass 'Spidola' was 1.96-4.28 t ha^{-1} (on dry matter basis), but the average seed yield was 0.423-0.835 t ha^{-1} and straw yield – 2.852-6.940 t ha^{-1} in the 1st year stand. The average biomass yield from perennial ryegrass 'Aries' was 5.96-14.85 t ha^{-1}, from cultivar 'Quartet' – 6.56-16.64 t ha^{-1}, but crude protein (CP) ranged between 165-235 and 162-231 g kg^{-1}, respectively.
Key words: fertilizer use, perennial ryegrass, forage quality, seed yield.

Introduction

Perennial ryegrass is a short-lived bunch-grass with shallow root system. The plant is nutritious and palatable and stands up to hard grazing. It will not do well under poor conditions, where fertility or rainfall is low. It requires an annual rainfall of between 850 and 1030 mm and a middle climate during the growing reason. However, it has the ability to survive long, cold winters (Peter D. Walton, 1983). The temperature optimum for growth of perennial ryegrass was reported to be 18 to 20^0C (Mitchell, 1956).

In temperate areas where ryegrass is well adapted, it is the primary grass used for pasture and silage in dairy and animal production. Many diploid and tetraploid cultivars of perennial ryegrasses have been bred for use in pasture mixtures or for silage. In Michigan and Latvia, cultivars are the predominant component in nearly all pasture mixtures, with perennial ryegrass and white or red clover forming the basis for permanent pastures for dairy production and cattle. The significance of ryegrasses to agriculture is reflected by the huge investments in research (Van Wijk, Reheul, 1991).

Some ryegrass cultivars are able to recover from drought faster than others. Van Wijk (1988) concluded from observations in Belgium and Great Britain that tetraploid ryegrasses were somewhat more drought resistant than diploids. Diploids are more susceptible to snow mold than tetraploids.

More than 90% of N in leaves and stems of cool-season grasses is in cell protoplasm (Sanderson, Wedin, 1989b). Although the concentration of N in cell walls is lower in grasses than in legumes, N in cell walls accounts for a higher proportion of total N in grass than in legume leaves because of the higher cell wall concentration in grass leaves than in legume leaves. Sanderson and Wedin (1989a) reported N concentrations in leaf cell walls of alfalfa, red clover, timothy,

Table 1

Description of N fertility rates

Nitrogen rate, kg ha^{-1}	Timing, green up, first, second, third, fourth cutting
0	No application
112	56 green up + 56 after 1st cut
224	56 green up + 56 after 1st cut + 56 after 2nd cut + 56 after 4th cut
336	112 green up + 84 after 1st cut + 84 after 2nd cut + 56 after 4th cut
448	112 green up + 112 after 1st cut + 112 after 2nd cut + 56 after 3rd cut + 56 after 4th cut

and smooth bromegrass to be 9.8, 26.4, 8.6, and 6.4 g kg^{-1} NDF, respectively, and 4.2, 4.6, 3.2, and 2.4 g kg^{-1} NDF, respectively, for stems.

Perennial ryegrass is a major component in different seed mixtures that are used for grassland management and forage production. This grass species plays an important role in grassland productivity and forage quality. Perennial ryegrass species has great seed production potential.

Perennial ryegrass is common on pasture grass in Michigan and Latvia. Many cultivars and a number of hybrids, both diploid and tetraploid, are in use in both locations. Perennial ryegrass diploid cultivars 'Aries' and tetraploid 'Quartet' are developed in Oregon, but tetraploid cultivar 'Spidola' in Latvia.

Perennial ryegrass cultivar 'Spidola' was developed at the Skriveri Research Center of the Latvia University of Agriculture (LLU). It is a tetraploid cultivar developed from a diploid perennial ryegrass 'Priekuļu 59'. Spidola' shows a preference for certain growing conditions; is better suited for mineral soils, prefers loamy and loamy sand soils, and does quite well on clay soils, but is somewhat less responsive on light soils. Peat soils are not suitable as this cultivar of perennial ryegrasses has inadequate winter hardiness and does not have the ability to tolerate excessive moisture for the long growing season period. It is suitable for inclusion in seed mixtures planned for establishment of permanent pastures and is a late maturing pasture grass, good for late grazing.

Ryegrasses are used extensively throughout the world because they provide high yields and quality forage/pasture and excellent turf in a wide range of environments (Jung, Van Wijk, Hunt, Watson, 1996).

Materials and methods

In Michigan, field trials were conducted in 2002 on a Capac loam soil (fine-loamy, mixed, mesic, Aeric Achraqualfs) at the Michigan State University Research Farm in East Lansing. Soil fertility parameters: pH H_2O – 6.2, organic matter – 24 g kg^{-1}, plant available P_2O_5 (Bray P1) – 71, and K_2O (1 M NH_4OAc) – 206 mg kg^{-1}. A strip-block design with three replications was used to evaluate diploid and tetraploid perennial ryegrass cultivars. Cultivar was the main-plot and fertility level was subplot. Plots were seeded on August 12, 2001 with a 91 cm Carter Nursery Seeder (Carter Manufacturing, Inc., Brookston, IN) at 33.6 kg ha^{-1} Pure Live Seeds. Five levels of N fertilizer rates were used: 0, 112, 224, 336 and 448 kg ha^{-1} N applied as described in Table 1.

Ammonium sulfate fertilizer was applied using a Scotts 91 cm drop spreader (Scott's Co., Marysville, OH) at the prescribed intervals and elemental sulfur (97% S) was applied at 9.3 kg ha^{-1} to the 0 N rate treatment. Plots were clipped in the fall of the seeding year to reduce smothering and conditions which encourage fungal diseases.

Forage yield was collected using a 91 cm Carter Flail harvester (Carter Manufacturing, Brookston, IN) and ~300 g sub-samples of the forage harvested were collected to determine dry matter (DM) content. The samples were then ground to pass through a 1 mm screen in a Christy-Norris Grinding Mill (Christy-Norris Corp., UK). A sub-sample of ~20 grams was retained for nutritive analysis. Each sample was scanned with a 6500 near-infrared spectrophotometer (FOSS NIR Systems, Inc., Silver Spring, MD) with wavelengths between 800 and 2500 nm. Reflected wavelengths were recorded. A subset of samples was selected using the Select program from WinISI software (Infrasoft International, LLC., Port Matilda, PA.) to create equations for prediction of crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF). Total nitrogen was determined for the subset by the Hach modified Kjeldahl procedure (Watkins, 1987), and CP was estimated by multiplying total N by 6.25. The Goering and Van Soest (1970) method was used for NDF and ADF determination with the addition of one ml of alpha-amylase to the neutral detergent solution for the breakdown of starch. Dry matter (DM) content was determined by drying 0.5 g of sample in ceramic crucibles at 100˚C for 12 hrs. The samples were then ignited in a muffle furnace at 500˚C for 6 hrs to determine ash content.

Field experiments in Latvia were carried out in 2001 on sod podzolic sandy loam soil (Argiaquic Argiaboll), pH KCl – 6.5, plant available P_2O_5 – 110 and K_2O – 204 mg kg^{-1} (Egner–Riehm), soil organic matter – 21 g kg^{-1} (Tyurins' method). Randomized complete block design (plot size was 16 m2) with four field replicates and five broadcast fertilizer rates were tested. Perennial ryegrass

tetraploid cultivars 'Spidola', 12 kg ha^{-1} (Pure Live Seeds), were planted using "Nordsten" seed drill on May 15, 2001 after black fallow. The following mineral fertilizer rates were used: N and P_2O_5, each of them 0, 30, 60, 90, 120 kg ha^{-1}, K_2O – 0, 40, 80, 120, 160 kg ha^{-1} (ammonium nitrate, single superphosphate and potassium chloride). Weed control was performed using herbicides (1 l ha^{-1} of MCPA in the mixture with 8-10 g ha^{-1} of granstar).

Lodging of the perennial ryegrass stand was evaluated during the growing season using a scale from 1-9 (1 = the stand is completely lodged, 9 = lodging is not observable). The biomass, dry matter content, seed yield as well as its chemical composition were determined. Seed yield was recorded from the 1st year use. Analyses of yield components and other parameters were also recorded. The standard Kjeldahl procedure for total nitrogen determination and crude fiber *in vitro* was used. Analysis of variance (ANOVA) was conducted using the GLM procedure of SAS (SAS Inst., 1990) at P = 0.05 to test the effects of year, location, N treatment, and all interactions in models for forage DM yield.

Results and discussion

Forage quality has been defined as the amount of nutrient material that an animal can obtain from a feed in the shortest possible time. Ruminant animals require 8% to 10% of crude protein for maintenance and up to 15% of crude protein in the case of a high-producing dairy cow (Peter D. Walton, 1983).

Perennial ryegrass takes up nitrogen through most of its growth cycle requiring abundant supplies of nitrogen to be available throughout the growing season.

Phosphorus (P) is one of the major essential elements needed by perennial ryegrass for good growth. It plays a very important role in the growth of plants, especially for good grass and root growth (Darrell Miller, 1984).

Potassium is another of the major essential elements needed for ryegrass. It is used in larger amounts than phosphorus. Within live plant tissue, the average percentage of potassium is approximately 8 to 10 times that of phosphorus. Hay or dry matter contains up to 4 times as much potassium as phosphorus. Potassium aids in resisting disease, insects, cold weather, drought and functions in stomatal opening and closure and sugar transport (Darrell Miller, 1984).

In the Michigan field experiment, dry matter increased significantly (6.6-15.8 t ha^{-1}) with the diploid cultivar 'Aries' with increasing nitrogen rates up to 224 kg ha^{-1} and the tetraploid perennial ryegrass cultivar 'Quartet' increased significantly (7.2-18.4 t ha^{-1}) with increasing nitrogen rates up to 448 kg ha-1 (Table 2).

In addition to increasing dry-matter production, nitrogenous fertilizer applications increased the protein content in perennial ryegrass (Table 3).

A split application of nitrogen fertilizer (equal parts in the spring and after each harvest) resulted in a greater total recovery of nitrogen than did a single application of the same total amount at the beginning of the season.

In spring, as reproductive development proceeds, tiller numbers cease to increase and may even fall. Tiller numbers are lower at lower nitrogen rates, to increase nitrogen. Tetraploid plants of perennial ryegrass generally have wider and darker leaves, more robust tillers, a lower tiller population, and higher percentage DM than diploids (Van Wijk, 1988).

Table 2

Perennial ryegrass 'Aries' and 'Quartet' dry matter (DM) yield (2002)

Species	Cultivar	Fertilizer rate, kg ha^{-1}	Dry matter (DM), t ha^{-1}	Ground cover, rating*	Tillers, m^2 10 May	Tillers, m^2 23 Oct
Perennial ryegrass (diploid)	Aries	0	6.6	9	1450	1161
		112	9.7	9	1551	1440
		224	15.8	9	1551	1440
		336	15.8	9	1709	1245
		448	16.4	9	1626	1635
$LSD_{0.05}$		-	0.65	NS**	NS	NS
Perennial ryegrass (tetra)	Quartet	0	7.2	8.7	576	752
		112	10.4	8.3	1180	1152
		224	14.4	8.5	1003	1263
		336	17.4	8.2	1366	1282
		448	18.4	8.7	1570	1533
$LSD_{0.05}$		-	0.91	NS	613	NS

* – 1 to 9 rating with 9 being 100% stand;

** – NS – not significant.

Table 3

Perennial ryegrass 'Aries' and 'Quartet' forage quality (2002)

Species	Cultivar	Fertilizer rate, kg ha^{-1}	Season average*, g kg^{-1}		
			Crude protein (CP)	ADF	NDF
Perennial ryegrass (diploid)	Aries	0	165	260	512
		112	197	266	509
		224	219	25.7	491
		336	231	256	486
		448	235	255	494
$LSD_{0.05}$		-	39	NS	NS
Perennial ryegrass (tetra)	Quartet	0	162	255	501
		112	191	266	513
		224	210	267	505
		336	231	259	491
		448	227	261	498
$LSD_{0.05}$		-	26	NS	NS

* – five cuttings.

Table 4

Effect of mineral fertilizer rates of perennial ryegrass 'Spidola' forage quality (2002)

N	P_2O_5	K_2O	Dry matter (DM), t ha^{-1}	Crude protein (CP), g kg^{-1}	Crude fiber (CF), g kg^{-1}	Digestibility, g kg^{-1}
0	0	0	7.9	86	285	511
30	90	120	12.1	89	281	448
60	60	160	12.7	101	289	507
90	90	40	13.4	94	302	514
120	120	160	17.1	136	288	505
$LSD_{0.05}$			2.85	15.0	20.8	41.1

Diploid perennial ryegrass cultivar 'Aries' has a high tiller population and sward density and, consequently, the more open sward structure of tetraploid cultivar 'Quartet' has frequently resulted in underestimates of stand persistence (Table 2)

Neutral detergent fiber (NDF) is the content of cell wall material or plant structural components in a feed. Chemically, NDF includes cellulose, hemicellulose, lignin, and heat-damaged protein. More mature plant material will have a higher NDF concentration. Grasses have higher NDF concentrations than legumes. Very high quality legume hay would be considered hay with a maximum of 400-460 kg^{-1} NDF (Crampton, Harris, 1969).

Table 3 presents average crude protein of five cuttings, ADF and NDF percentage of diploid and tetraploid ryegrasses. The 224 kg ha^{-1} nitrogen rate resulted in a significantly higher crude protein content in both the cultivars 'Aries' and 'Quartet' compared to the 0 rate treatment. Increasing nitrogen rates above 224 kg ha^{-1} did not significantly increase the crude protein content.

Acid detergent fiber (ADF) contains cellulose, lignin, and heart-damaged protein. ADF is closely related to digestibility of forage. The lower the ADF relative content, the greater the digestibility of a feed or forage. ADF can be used to predict the energy value of forage. If crude protein and NDF levels are appropriate, hay with ADF less than 360 g kg-1 would be considered high quality (Crampton, Harris, 1969).

The digestibility of crude protein in forages varies widely, ranging from 45-80 %. Digestibility plays an important part in animal nutrition. If material is readily and quickly digested, the animal will start to feed again and the total daily intake will be substantially increased. Perennial ryegrass is one of the more digestible forage crops grown (Darrell Miller, 1984).

Highest digestibility (51.4 %) was obtained with N_{90} P_{90} and K_{40} mineral fertilizer, the lowest – 44.8 % was with rates $N_{30}P_{30}K_{120}$. High potassium and low nitrogen decreased the digestibility for about 2 % (Table4).

Seeds are necessary to provide the plants that will fulfill these needs. If soil type, available water, and

Table 5

Fertilizer application and perennial ryegrass 'Spidola' seed yield in the 1st year of use (2000)

N	P_2O_5	K_2O	Seed yield, t ha^{-1}	Straw yield, t ha^{-1}	Lodging resistance, scores
0	0	0	0.423	2.853	8.8
30	90	120	0.616	4.420	8.0
60	60	160	0.748	5.240	5.1
90	90	40	0.761	6.149	4.0
120	120	160	0.836	6.940	2.0
$LSD_{0.05}$			0.110	1.371	1.82

temperature are not limiting, the most critical factor affecting seed production is N fertilization. In most studies in the USA, from 80 to 160 kg ha^{-1} of single or split application of N gave beneficial yield responses over time depending on soil-water availability, grass species, and age of stand. Optimum rates for spring N fertilizer, applied at one date, were suggested as 60 kg ha^{-1} for red and meadow fescue and timothy and 90 to 120 kg ha^{-1} for orchardgrass and perennial ryegrass.

Increased NPK rates result in higher seed and straw production, but significantly decrease lodging resistance (Table 5). Lodging of perennial ryegrass seed crops is a big problem and therefore applied nitrogen is usually limited, because it is very difficult to harvest the seed yield; at the same time, P and K may help reduce lodging.

It is important to maintain the proper levels of P and K when additional nitrogen is applied. Ryegrass is similar to all other cool-season grasses, because of high levels of both P and K removal when additional nitrogen is applied (Darrell Miller, 1984).

Conclusion

Different N fertilizer rates were used in Michigan and Latvia, because in Latvia the objective was to evaluate the effects of N fertilizer rates upon seed production, while the objectives in Michigan were to evaluate N fertilizer effects upon dry matter yield and forage quality.

There were some differences between Michigan and Latvian vegetation period (growing season). In Latvia, three perennial grass cuttings were obtained, but in Michigan, because of a comparatively longer vegetation period – five.

From perennial ryegrass cultivars 'Aries', 'Quartet', and 'Spidola', high forage quality (crude protein and dry matter) was obtained at different fertilizer rates, which indicates different responses between diploid and tetraploid perennial ryegrasses.

Michigan perennial ryegrass tetraploid cultivar 'Quartet' resulted in a higher dry matter yield than diploid cultivar 'Aries'. 'Aries' dry matter yield increased significantly up to 224 kg ha^{-1}, while 'Quartet' dry matter yields increased with increasing N fertilizer rates up to 448 kg ha^{-1}. Increasing fertilizer rates to $N_{120}P_{120}K_{160}$ increased the seed yield from 0.423 to 0.836 t ha^{-1}, but significantly decreased lodging resistance – from 8.8 to 2.0 scores.

The optimum NPK rates recommended for seed production are $N_{60}P_{60}K_{120}$. Using this fertilizer rate will result in less lodging which is better for seed harvesting.

The research conducted at both locations has produced interesting results and further research is expected to provide new usable insights into the productivity of new cultivars at each location, for example, the productivity of cultivar 'Spidola' grown at MSU, and cultivars 'Aries' and 'Quartet' grown in Latvia. These comparisons for growths at both locations would be enhanced if the fertilization rates were the same in both locations. Future collaboration will enable researchers from each country to achieve optimal fertilizer recommendations for their respective regions.

References

1. Crampton, E.W., Harris, L.E. (1969) *Applied Animal Nutrition, 2nd edition*. W.H. Freeman and Company, San Francisco, USA, 753 pp.

2. Darrell A. Miller (1984) *Forage Crops*. New York, 530 pp.

3. Georing, H.K., Van Soest, P.J. (1970) Forage Fiber Analysis: Apparatus, Reagents, Procedures, and Some Applications. In: *USDA Agricultural Handbook 379*. U.S. Gov. Print. Office, Washington, DC.

4. Jung, G.A., Van Wijk, A.J.P., Hunt, W.F., Watson, C.E. (1996) Ryegrasses. In: *Cool-Season Forage Grasses, Agronomy Monograph,* No. 34, pp. 605-641.

5. Mitchell, K.J. (1956) Growth of pasture species under controlled environment. 1. Growth at various levels of constant temperature. *N.Z.J. Sci. Technol.,* 38A, pp. 203-216.

6. Peter D. Walton (1983) *Production and management of Cultivated Forages.* Reston Publishing Company, Inc. A Prentice-hall Company Reston, Virginia 22090, U.S.A., 336 pp.

7. Sanderson, M.A., Wedin, W.F. (1989a) Pheno-

logical stage and herbage quality relationships in temperate grasses and legumes. *Agron. J.,* 81, pp. 864-869.

8. Sanderson, M.A., Wedin, W.F. (1989b) Nitrogen concentrations in the cell wall and lignocellulose of smooth bromegrass herbage. *Grass Forage Sci.,* 44, pp. 159-168.

9. Van Wijk, A.J.P. (1988) Breeding tetraploid perennial ryegrass for forage. In: *Proc. 30th Grass Breed. Work Planning Conf., Sublimity*. Barker, R.E., Meyer, W.A. (eds.) Oregon, pp. 35-41.

10. Van Wijk, A.J.P., Reheul, D. (1991) Achievements in folder crops breeding in maritime Europe. In: *Proc. 16th Meet. Eucarpia Fodder Crops Sect.* Den Nijs, A.P.M., Elgersma, A. (eds.), Wageningen, the Netherlands, 18-22 Nov., 1990, pp. 13-18.

11. Watkins, K.L. (1987) Total Nitrogen Determination of Various Sample Types: A Comparison of the Hach, Kjeltec, and Kjeldahl Methods. *J. Assoc. Off. Anal. Chem.,* 70, pp. 3-9.

Acknowledgement

This study was supported by the Latvian Research Foundation (grants No. 01.0765 and 02.0013).

Anotācija

Divos izmēģinājumos, kas tika veikti Mičiganas Valsts universitātē un LLU Skrīveru zinātnes centrā, tika pētīti ganību airenes sēklu ražas un lopbarības kvalitātes rādītāji atkarībā no pielietotā slāpekļa mēslojuma. Ganību airene ir viena no svarīgākajām skrajceru apakšzālēm, kuru izmanto ilggadīgo kultivēto ganību zelmeņu kvalitātes nodrošināšanai lopbarības ražošanā gan ASV Mičiganas pavalstī, gan arī Latvijā. Pētījumi tika veikti LLU un Mičiganas Valsts universitātes sadarbības programmas ietvaros.

Analysis of Dry Matter Yield Stability Parameters in Different Varieties of Forage Grasses
Sausnas ražas stabilitātes analīze dažādām stiebrzāļu sugām un šķirnēm

Pavelas Tarakanovas, Juozas Kanapeckas, Nijole Lemeziene, Steponas Nekrosas
Lithuanian Institute of Agriculture, e-mail: pavelas@lzi.lt
Lietuvas Zemkopības institūts, e-pasts: pavelas@lzi.lt

Abstract. Dry matter yield peculiarities in five varieties of forage grasses from five species (*Dactylis glomerata* L., *Festuca pratensis* Huds., *Lolium perenne* L., *Phleum pratense* L. and *Poa pratensis* L.) have been studied in the period 1992-2002 at the Lithuanian Institute of Agriculture (Dotnuva). ANOVA and regression analysis were employed to draw the conclusions. Results of disperse analysis showed that dry matter yield was essentially ($P<0.01$) influenced by the year of herbage utilization, year of trials, varieties and their interaction. For the cocksfoot variety 'Asta' the yield of aftermath and for the common timothy variety 'Gintaras II' the first cut were the crucial factors that predetermined high ($P<0.01$) yields in both years of herbage utilization. The meadow fescue variety 'Dotnuva' and the perennial ryegrass variety 'Zvilge' are characterized by a high dry matter yield in the first year of herbage utilization and by its significant decline in the second year. The Kentucky blue grass variety 'Lanka' was characterized by low dry matter yields in both years of herbage utilization. According to response to cultivation conditions, the cocksfoot variety 'Asta' belongs to intensive types with a high phenotypical stability of dry matter yield. The perennial ryegrass variety 'Zvilge' ranks among the extensive types with a high phenotypical stability of yield. The Kentucky blue grass variety 'Lanka' belongs to intensive types with low phenotypical stability, especially in the first year of herbage utilization.
Key words: grass species, regression analysis, dry matter yield.

Introduction

A very important property of forage grasses is their ability to give stable high dry matter yields under different environmental conditions (Bidinger et al., 1996). The level of productivity depends on the genetic potential of the variety, which is controlled by the response limits of the genotype. Yield stability depends on the ability of a variety to respond to environmental conditions. There are varieties with high adaptability, which give stable but lower yields under different environmental conditions, whereas varieties with a low adaptability, yield high in favourable and low under unfavourable conditions (Borojevic, 1990).

In varieties-populations of forage grasses, adaptability depends on genetic homeostasis, which includes not only heterogenicity, but also heterozygosity, arising as a result of free repollination among the plants. Thus, varieties-populations consisting of numerous genotypes are characterized by a wide scope of response to environmental conditions. Separately should be mentioned Kentucky blue grass varieties, which are pure lines of the same genotype, and therefore their adaptability is based on individual buffering or physiological homeostasis regarding the restricting conditions of the environment. Nevertheless, varieties of different species of grasses differ in their response to environmental conditions. Reliable differences in response to varying conditions have been found in cocksfoot (Christie and Armstrong, 1968; Tarakanovas, 2001), common timothy (Casler, 1990, 1999), Kentucky blue grass (Ebdon et al., 1998), and perennial ryegrass (Baltfourier et al., 1997).

In perennial grass varieties, dry matter yield stability depends also on differences in the individual development of plants, time of sowing, age of herbage, trend of its utilization, wintering conditions and especially on sufficient humidity of soil in the period of active plant growth and development, as well as on other factors.

Yield stability is a measure of the variation in yield of a perennial grass variety over different environments in comparison with other varieties. Finlay and Wilkinson's (1963) b_i considers a cultivar stable if its response to environments is parallel to the mean response of all cultivars in the trial. On determining the parameters of dry matter yield stability it is possible to foresee their response to changes in environmental conditions and to recommend the adequate agrotechnical measures and varietal sortiment for obtaining optimal yields.

Varieties with the coefficient of regression $b_i=1.0$ exhibit a full correspondence between the yield dynamics and environmental changes. The higher the value of the coefficient $b_i > 1.0$, the higher the level of response of a variety. In the case when $b_i < 1.0$, a variety shows a weaker response to environmental conditions

than the average pool of the varieties under study. Eberhart and Russell's (1966) s_d considers a cultivar stable if the residual mean square from Finlay and Wilkinson's regression model is not significant. The less the sum of yield deviation squares is shown by a variety, the higher are its stability characteristics.

Studies on dry matter yield stability in varieties of different grass species have not been carried out in Lithuania thus far. The aim of the current study was to establish the parameters of ecological dry matter yield stability in varieties of different perennial grass species.

Materials and methods

To study the parameters of ecological stability, the following varieties of grasses registered in Lithuania were used: cocksfoot – 'Asta' (*Dactylis glomerata* L.), meadow fescue – 'Dotnuva I' (*Festuca pratensis* Huds.), perennial ryegrass – 'Zvilge' (*Lolium perenne* L.), common timothy 'Gintaras II' (*Phleum pratense* L.), and Kentucky blue grass – 'Lanka' (*Poa pratensis* L.). Variety testing experiments were carried out on a sod gleyic moderately heavy drained loam soil, with a pH value in the arable layer varying from 6.4 to 7.2 and the content of humus from 1.9 to 2.2%. The following crop rotation was used: 1) black fallow; 2) grasses of the sowing year; 3) grasses of the first year of use; 4) grasses of the second year of use; 5) spring cereals; 6) spring cereals.

Competitive variety trials of perennial ryegrass, meadow fescue, common timothy, cocksfoot and Kentucky blue grass were assessed over the period 1992–2002 (10 annual variety testing trials of each grass species).

The grasses were sown in the first half of June without a cover crop. In the year of use, the grass was cut three times with a Hege 212 field mower and 0.5 kg herbage samples were taken for dry matter content determination. The first cut was taken during the heading; the second and third cuts were harvested after regrowth of aftermath. According to the earliness of species and development of plants, the Kentucky blue grass variety 'Lanka' was cut first (most often at the end of the second ten-day period of May), followed cocksfoot ('Asta'), meadow fescue ('Dotnuva I'), perennial ryegrass ('Zvilge'), and the common timothy variety 'Gintaras II' was cut latest, usually in the middle of the second ten-day period of June.

Meteorological conditions during the experiment varied: 1997 and 1998 were most favourable, while 1993, 1994 and 2002 were unfavourable, droughty.

The experimental data were processed according to the Eberhart and Russell procedure (Eberhart and Russell, 1966) described in detail by Brewbaker (Brewbaker, 1996). A random-effects ANOVA model was used, assuming a random sampling of genotypes and years, to separate the components of variance for selecting the appropriate F-test. The particular η^2 (Eta Squared) coefficient was calculated according to the method described elsewhere (Čekanavičius and Murauskas, 2002). It allows determining a relative effect of each factor versus accidental errors.

The analysis of variance was used to indicate the presence of a significant genotype by environment interactions, and to determine whether the interactions were a linear function of the additive environmental component. The environmental index was calculated by taking the means of all genotypes grown in a particular year. The regression coefficient (b_i) measures the increase in the mean yield of a genotype per unit of increase in the environmental index. The standard deviation (s_d) of residuals about the regression line measures how well the predicted response agrees with that actually observed and includes genotype by environments analysis. A stable genotype has a regression coefficient (b_i) value nearly to 1 and deviations from regression are as small as possible ($s_d = 0$).

The following rating scale was used for the comparison of varieties for yield stability (Мартынов, 1997):

$b_i > 1.3$ intensive variety with a low phenotypic stability;

$1.1 < b_i < 1.2$ intensive, phenotypically stable variety;

$0.9 < b_i < 1.1$ intensive, phenotypically highly stable variety;

$0.8 < b_i < 0.9$ extensive, phenotypically highly stable variety;

$0.7 < b_i < 0.8$ extensive variety with reduced phenotypic stability;

$b_i < 0.7$ extensive variety with low phenotypic stability.

The determination coefficient R^2 shows whether the theoretical values of the linear regressions, calculated on the basis of the equation, are close to the actual (i.e., R^2 values should be high). The experimental data were processed by statistical methods, using programs from 'AGROS ver. 2.06' packages (Мартынов, 1997) and 'STATISTICA ver. 5.5' (Боровиков, 2001).

Results and discussion

Dispersion analysis results showed that dry matter yield in different varieties was reliably ($P < 0.01$) dependent on the year of herbage utilization, year of trial and their interaction. Dry matter yield of the first cut, aftermath and per year was most strongly dependent on the genotype (variety) of grasses (η^2=0.83-0.86), year of trial (η^2=0.76-0.80), and year of herbage utilization (η^2=0.52-0.74). For genotype-by-environment analysis, of particular significance is the presence of a reliable interaction of the year of trial and

the genotype (Yx G) for the first cut, aftermath and annual yield ($P < 0.01$), which allow further analysis (Table 1).

Dry matter yield was found to be strongly dependent on climatic conditions, in particular in the sum of precipitation in the years of trial. The highest dry matter yields, which reliably exceeded the average data of a trial, were observed for the first cut of the first year of herbage utilization in the years 1996 and 1997 ($P<0.05$) (Table 2). Conditions for obtaining high yields of aftermath in the first year of herbage utilization were favourable in 1993 and 1997-2001. Reliably high annual yields of grasses were obtained in 1996-1998 and 2001. The most favourable years for the development of grass plants and for high yields in the second year of utilization were 1995, 1997 and 1998.

Varieties that belonged to different species showed differences in the structure of dry matter yield formation. For instance, in the first year of herbage utilization the high annual dry matter yields for the varieties of meadow fescue and perennial ryegrass were predetermined by the higher yields of plants of the first cut (Table 3). The aftermath yield had played a crucial role in the formation of high yields of the variety 'Asta' both in the first and second years of herbage utilization. A good dry matter yield of cocksfoot aftermath in the first and second years of herbage use can be explained by an excellent regrowth of this grass species after cuts and good drought resistance (Tarakanovas, 1992; Kanapeckas et al., 2000). For the common timothy variety 'Gintaras II', the first cut was the core factor that favoured the formation of high ($P < 0.01$) yields in both years of herbage use. A significant reduction in the yield of the second year versus the first year was peculiar to the meadow fescue variety 'Dotnuva I' and the perennial ryegrass variety 'Zvilge'. The lowest dry matter yields in both years of herbage utilization were produced by the Kentucky blue grass variety 'Lanka'.

The ecological stability of a variety should be understood as its sensitivity to favourable conditions of the environment alongside a trend of lower yields in unfavourable conditions. Response of a variety to

Table 1

Mean squares relevant to the study of dry matter yields of genotypes (varieties) (1992 - 2002)

Source	df	1st cut		Aftermath		Annual	
		MS	η^2	MS	η^2	MS	η^2
Years of herbage utilization (YHU)	1	386.54**	0.74	144.23**	0.52	955.24**	0.74
Years of grass trials (Y)	9	56.82**	0.80	47.13**	0.76	125.94**	0.78
Genotypes (G)	4	163.04**	0.83	213.08**	0.86	424.75**	0.84
YHU x Y	9	17.74**	0.54	37.35**	0.72	40.72**	0.53
YHU x G	4	45.07**	0.57	14.11**	0.30	95.24**	0.54
Y x G	36	5.74**	0.60	14.99**	0.80	20.43**	0.69
YHU x Y x G	36	3.93**	0.51	5.52**	0.60	8.67**	0.49
Error (e)	297	0.45		0.45		1.10	

** – significant at the 0.01 probability levels.

Table 2

Mean dry matter yield performance (t ha^{-1}) for the first and second years of herbage utilization in different years (1992 - 2002)

Years of harvest	First year of herbage utilization			Second year of herbage utilization		
	1st cut	aftermath	annual	1st cut	aftermath	annual
1992	6.76	1.88	8.64	-	-	-
1993	5.12	6.25**	11.37	2.36	3.57	5.93
1994	6.23	5.12	11.35	4.37	4.21	8.58
1995	5.62	5.63	11.25	5.25**	5.34**	10.59**
1996	7.98**	4.79	12.77**	4.22	2.94	7.16
1997	9.36**	6.33**	15.69**	7.21**	4.61	11.82**
1998	6.03	6.23**	12.26*	5.86**	6.60**	12.46**
1999	5.64	5.86*	11.50	4.31	3.62	7.93
2000	4.9	7.24**	12.14	3.51	6.42**	9.93
2001	6.69	6.08**	12.77**	4.19	4.05	8.24
2002	-	-	-	3.37	2.04	5.41
Average	6.43	5.54	11.97	4.46	4.34	8.80

*, ** – indicate the highest differences from the average data significance at the 0.05 and 0.01 probability levels, respectively.

Table 3

Mean dry matter yield performance (t ha^{-1}) for the first and second years of herbage utilization over the period of ten years (1992 - 2002)

Species	First year of herbage utilization			Second year of herbage utilization		
	1st cut	aftermath	annual	1st cut	aftermath	annual
Cocksfoot, 'Asta'	5.69	8.27**	13.96**	5.46**	7.39**	12.85**
Meadow fescue, 'Dotnuva I'	7.26**	5.28	12.54**	4.33	3.60	7.93
Perennial ryegrass, 'Zvilge'	7.77**	5.30	13.07**	3.80	3.50	7.30
Common timothy, 'Gintaras II'	7.83**	4.82	12.65**	6.14**	3.04	9.18*
Kentucky blue grass, 'Lanka'	3.59	4.04	7.63	2.60	4.17	6.77
Average	6.43	5.54	11.97	4.47	4.34	8.81

*, ** – indicate the highest differences from the average data significance at the 0.05 and 0.01 probability levels, respectively.

Table 4

Regression and determination coefficients and standard deviation of residuals about the regression line for dry matter yield of the grass varieties over ten years (1992 - 2002)

Species	First year of herbage utilization			Second year of herbage utilization		
	b_i	R^2	s_d	b_i	R^2	s_d
Cocksfoot, 'Asta'	1.26	0.78**	1.60	1.05	0.64**	3.55
Meadow fescue, 'Dotnuva I'	1.21	0.56*	4.18	0.88	0.57*	3.32
Perennial ryegrass, 'Zvilge'	0.85	0.54*	2.26	0.86	0.80**	1.05
Common timothy, 'Gintaras II'	0.47	0.16	4.25	0.79	0.62**	2.22
Kentucky blue grass, 'Lanka'	1.19	0.47*	5.80	1.42	0.89**	1.44

*, ** – significant at the 0.05 and 0.01 probability levels, respectively.

changes in environmental conditions is characterized by the coefficient of linear regression of a trait versus the indices of the environment. Dispersion (standard deviations) with regard to regression characterizes yield stability in different environmental conditions. Table 4 shows the coefficients of regression, determination and standard deviations from the regression line according to dry matter yield. The coefficient of determination, calculated between the theoretical and factual dry matter yield values for all varieties over the ten years of study, was highly reliable ($P < 0.05$). An exception was only the common timothy variety 'Gintaras II' in the first year of utilization. Consequently, while analyzing the data on the productivity of the variety of common timothy, the linear regression model cannot be employed.

Comparing the varieties by the trait of stability, the cocksfoot variety 'Asta' can be distinguished as an intensive culture showing a rather high phenotypical stability (b_i=1.05-1.26), especially in the first year of herbage utilization. The meadow fescue variety 'Dotnuva I' shows different manifestations of this trait in different years of herbage utilization. In the first year it can be characterized as intensive with lowered stability (b_i=1.21 and s_d= 4.18) and in the second year as belonging to an extensive phenotypically stable type (b_i=0.88). As a result of the trials, perennial ryegrass can be ascribed to an extensive type characterized by high phenotypical stability (b_i=0.85-0.86). Data of the second year of trials showed the common timothy variety 'Gintaras II' to belong to an extensive type with reduced stability (b_i=0.79). According to response to environmental conditions, the Kentucky blue grass variety 'Lanka' belongs to an intensive type (b_i=1.19-1.42; average 1.305) characterized by low phenotypical stability, particularly in the first year of herbage utilization (s_d =5.80) (Table 4).

Variety breeders are interested first of all in a combination of productivity level and stability, which allows to foretell the response of a variety to changed conditions of cultivation.

Figure 1 graphically shows dry matter yield (t ha^{-1}) in the first year of utilization and the regression coefficient reflecting the stability of the varieties of different species. The lines of the average yield from trials (11.97 t ha^{-1}), and the coefficient of regression

(b_i=1) conditionally divide the study varieties of different species into four rectangles. The right-hand upper rectangle contains the cocksfoot variety 'Asta' and the meadow fescue variety 'Dotnuva I' characterized by high yields (exceeding the average level of the trial) and high (b_i>1) coefficients of regression. Both species belong to an intensive type, i.e., they respond well to improved environmental conditions. To obtain high yields of varieties of these species, a high agrotechnical background is needed.

The perennial ryegrass variety 'Zvilge' and the common timothy variety 'Gintaras II', situated in the right-hand lower rectangle in Figure 1, belong to extensive types. In the first year of herbage utilization they are characterized by a high dry matter yield (exceeding the average yield of a trial) and low coefficients of regression (b_i<1). Theoretically they ought to be rather high-yielding also in less favourable conditions of cultivation.

The Kentucky blue grass variety 'Lanka' stands out for a low dry matter yield (below the average level of a trial) and a high coefficient of regression. Low indices of dry matter yield stability show that yield prognosis in this variety is rather complicated.

In the second year of herbage utilization, the distribution of varieties according to productivity and stability differs from that of the first year (Fig. 2). The cocksfoot variety 'Asta' also in the second year of utilization preserved its positions in the upper right-hand corner of Figure 1. Variety 'Asta' differed from other varieties by the highest dry matter yield and the coefficient of regression, which was only insignificantly higher than unity (b_i=1.05). Thus, in the second year of herbage utilization the cocksfoot variety 'Asta' showed a high phenotypical stability of dry matter yield and belonged to the intensive types of grasses. The common timothy variety 'Gintaras II' in the second year of utilization by dry matter yield reliably exceeded the average level of the trial and had the coefficient of regression lower than unity. Like in the first year of

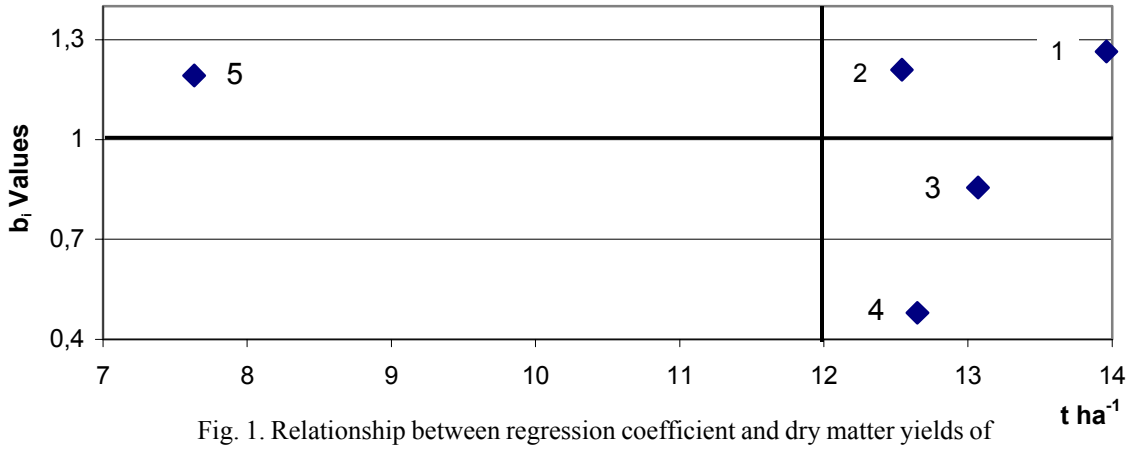


Fig. 1. Relationship between regression coefficient and dry matter yields of grass varieties in the first year of herbage utilization (1992 - 2001): 1 – cocksfoot, 'Asta'; 2 – meadow fescue, 'Dotnuva I'; 3 – perennial ryegrass, 'Zvilge'; 4 – common timothy, 'Gintaras II'; 5 – Kentucky blue grass, 'Lanka'.

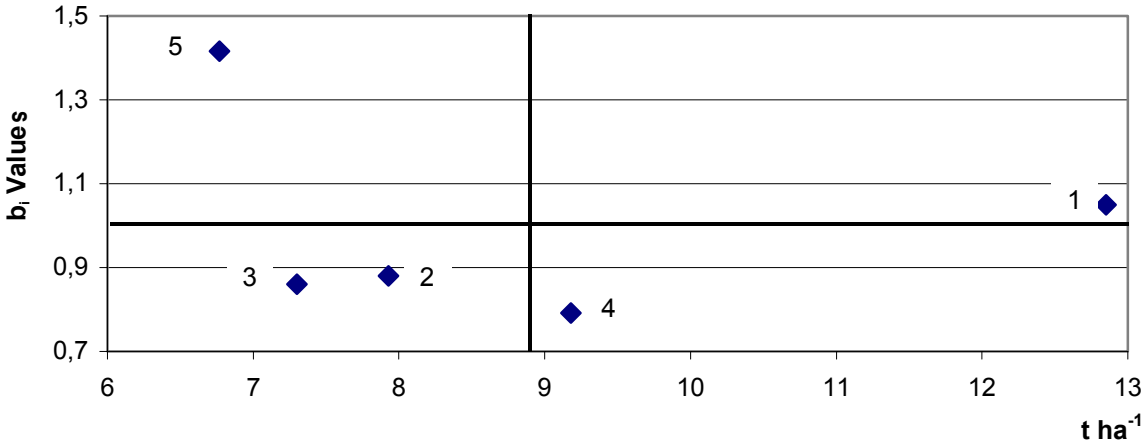


Fig. 2. Relationship between regression coefficient and dry matter yields of grass varieties in the second year of herbage utilization (1993 - 2002): 1 – cocksfoot, 'Asta'; 2 – meadow fescue, 'Dotnuva I'; 3 – perennial ryegrass, 'Zvilge'; 4 – common timothy, 'Gintaras II'; 5 – Kentucky blue grass, 'Lanka'.

utilization, it belongs to extensive types with reduced phenotypical yield stability The meadow fescue variety 'Dotnuva I' and the perennial ryegrass variety 'Zvilge' in the second year of utilization moved to the left-hand lower rectangle of Figure 2, because of a low dry matter yield (below the average level of the trial) and a low coefficient of regression (<1). According to these indices, in the second year of herbage utilization the study varieties of these species can be ascribed to extensive types exhibiting a high phenotypical stability of dry matter yield.

Like in the first year of herbage utilization, the Kentucky blue grass variety 'Lanka' had the lowest in the trial dry matter yield and the regression coefficient above unity. This combination of the parameters is characteristic of the intensive types of grasses.

Conclusions

1. The relationship of dry matter yield and its variation enables better understanding of varietal peculiarities of studied species.

2. Results of disperse analysis showed that dry matter yield was essentially ($P<0.01$) influenced by the year of herbage utilization, year of trials, varieties and their interaction.

3. For the cocksfoot variety 'Asta' the yield of aftermath and for the common timothy variety 'Gintaras II' the first cut were the crucial factors that predetermined high ($P<0.01$) yields in both years of herbage utilization. The meadow fescue variety 'Dotnuva I' and the perennial ryegrass variety 'Zvilge' are characterized by a high dry matter yield in the first year of herbage utilization and by its significant decline in the second year. The Kentucky blue grass variety 'Lanka' was characterized by low dry matter yields in both years of herbage utilization.

4. According to response to cultivation conditions, the cocksfoot variety 'Asta' belongs to intensive types with a high phenotypical stability of dry matter yield. The perennial ryegrass variety 'Zvilge' ranks among the extensive types with a high phenotypical stability of yield. The meadow fescue variety 'Dotnuva I' in different years of herbage utilization exhibited different response to enviromental conditions, which varied from intensive with reduced stability to an extensive, phenotypically stable type. Data of the second year of utilization allowed to ascribe the common timothy variety 'Gintaras II' to extensive types with reduced phenotypical stability. The Kentucky blue grass variety 'Lanka' belongs to intensive types with low phenotypical stability, especially in the first year of herbage utilization.

References

1. Baltfourier, F., Oliveira, J. A., Chamet, G., Arbones, E. (1997) Factorial regression analysis of genotype by environment interaction in ryegrass populations, using both isozyme and climatic data as covariates. *Euphytica*, 98, 1-2, pp. 37-46.

2. Bidinger, F. R., Hammer, G.L., Muchow, R.C. (1996) The physiological basis of genotype by environment interaction in crop adaptation. In book: *Plant Adaptation and Crop Improvement*. CAB International, pp. 329-348.

3. Borojevic, S. (1990) *Principles and methods of plant breeding*. Elsevier Science Publishing Company Inc., New York, 364 pp.

4. Brewbaker, J. L. (1996) *Quantitative genetics on a spreadsheet*. University of Hawaii, 163 pp.

5. Casler, M. D. (1990) Cultivar and cultivar x environment effects on relative feed value of temperate perennial grasses. *Crop Science*, 30, 3, pp. 722-728.

6. Casler, M. D. (1999) Repeated measures vs. repeated plantings in perennial forage grass trial: an empirical analysis of precision and accuracy. *Euphytica*, 105, 1, pp. 33-42.

7. Čekanavičius, V., Murauskas, G. (2002) *Statistika ir jos taikymai II*. Vilnius: TEV, 268 pp.

8. Christie, B. R., Armstrong, K. C. (1968) Genotype x management interations among plants of orchardgrass (*Dactylis gl*. L.). *Crop Science*, 8, 3, pp. 285-288.

9. Ebdon, J. S., Petrovic, A. M., Zobel, R.W. (1998) Stability of evapotranspiration rates in Kentucky blue grass cultivars across low and high evaporative environments. *Crop Science*, 38, 1, pp. 135-142.

10. Eberhart, S. A., Russel, W. Q. (1966) Stability parameters for comparing varieties. *Crop Science*, 6, 1, pp. 36-40.

11. Finlay, K. W., Wilkinson, G. N. (1963) The analysis of adaptation in a plant breeding programme. *Austral. J. Agr. Res*., 14, pp. 742-754.

12. Kanapeckas, J., Lemeziene, N., Tarakanovas, P., Nekrosas, S. (2002) Comparison of aftermath dry matter yield of different perennial grass species. *Agricultural Science*, 3, 'Academia', pp. 80- 87.

13. Tarakanovas, P. (1992) Cocksfoot. In book: *Field crop breeding in Lithuania*. Vilnius, pp.183-186.

14. Tarakanovas, P. (2001) Yield plasticity and stability assessment in orchardgrass varieties. *Agricultural Sciences*, 3, Vilnius, pp. 42-44.

15. Боровиков, В. (2001) *STATISTICA: Искусство анализа данных на компьютере. Для профессионалов.* Санкт Петербург, Питер, 656 с.

16. Мартынов, С. (1997) *Руководство пользователя пакета селекционно ориентированных и биометрико генетических программ AGROS 2.06*. Тверь, 76 с.

Anotācija

Lietuvas Zemkopības institūtā, Dotnuvā, 1992.-2002. gadā salīdzinātas 5 šķirnes no 5 stiebrzāļu sugām. Salīdzināto šķirņu sausnas ražas izmēģinājumu periodā, pēc dispersijas analīzes rezultātiem, būtiski ietekmēja izmantošanas un izmēģinājuma gads, šķirnes un to savstarpējā mijiedarbība.

Izmēģinājuma gados intensīva tipa ar stabilām sausnas ražām bija kamolzāles šķirne ‘Asta‘. Airenes šķirne ‘Zilge‘ bija ekstensīva tipa ar augstu ražības stabilitāti, bet pļavas auzenes šķirnei ‘Dotnuva I‘ - mainīga produktivitāte un stabilitāte izmēģinājuma gados. Pēc otrā izmantošanas gada rezultātiem timotiņa šķirne ‘Gintaras II‘ pieskaitāma ekstensīvām ar zemu fenotipisko stabilitāti. Pļavas lapsastes šķirne ‘Lanka‘ vērtējama kā intensīva tipa ar zemu fenotipisko ražas stabilitāti, it sevišķi pirmajā izmantošanas gadā.

Agronomic Performance of Doubled Haploid Spring Barley Lines
Vasaras miežu dihaploīdo līniju agronomiskās īpašības

Algė Leistrumaitė, Birutė Basiulienė
Lithuanian Institute of Agriculture, e-mail: alge@lzi.lt
Lietuvas Zemkopības institūts, e-pasts: alge@lzi.lt

Abstract. Methods of biotechnology are used to enhance the efficiency of spring barley (*Hordeum vulgare* L.) breeding. Anther culture method has been used for the production of spring barley DH lines at the Lithuanian Institute of Agriculture (LIA) since 1996. Androgenic plants were produced from the spring barley genotypes of Lithuanian origin. In 1998-2000 at the LIA, grain yield and other agronomic traits in spring barley DH lines, produced by anther culture, were evaluated. After three years evaluation, 4 DH lines notable for agronomic valuable traits were selected for breeding purposes. The spring barley DH lines 7533-26, 7456-39, 7456-33, 7456-46 were distinguished by a short straw, satisfactory tillering, good lodging resistance, high yield, 1000 kernel weight, spike length, high grain number per spike and high grain weight per spike. Those 4 DH lines will be included in the competitive yield trials and the spring barley breeding program. Also, DH lines 7533-26, 7456-39, 7456-33, 7456-46 will be passed on to a long-term seed storage in the Lithuanian Genebank. Variability of the examined traits in spring barley DH lines was established on the basis of analysis. The results showed that impact of meteorological conditions on variability of plant height, time of maturity, 1000 kernel weight and grain yield of spring barley DH lines was of greater importance compared with the influence of genetical background.
Key words: spring barley, anther culture, doubled haploid (DH), agronomic traits, variation.

Introduction

Barley (*Hordeum vulgare* L.) is one of the most common crops in Lithuania, covering 66.3 % of total spring cereal sowing area. The largest part of spring barley grain is used for livestock feeding, some part is used as human food and brewing malt. Barley varieties play an important role in increasing yield capacity of crops. The primary objectives of spring barley breeding are to develop high yielding varieties for malt and feed, with good resistance to lodging and diseases.

Conventional plant breeding is a slow process that requires at least 10 years to produce a new cereal variety. The main and most time-consuming period in self-pollinated crops breeding is from parental forms selection and crossing to pure-breeding lines evaluation. The methods of biotechnology are used to increase the efficiency of spring barley breeding. One of the most popular methods is haploidy. Anther culture is one of the most promising methods for obtaining doubled haploid plants in barley. Acceleration of the breeding cycle makes DH technique very attractive.

Production of doubled haploid lines (DH) via anther culture method depends on the breeding system of a crop. For self-pollinated crops, such as barley, anther culture can be most effectively applied to F_1 hybrids between two breeding lines with complementary characters of agronomic value to fix homozygosity in a single generation. This homozygosity eliminates environmental interactions, which simplifies the study of quantitative traits and allows easier selection of desirable traits. It saves the breeding program time and resources. The DH method enables plant breeders to shorten the breeding process by 3-5 years, compared with conventional techniques (Iyamabo, Hayes, 1995; Mannienen, 1997). Haploid tissue also facilitates the genetic variability, which allows recessive mutants to be easily detected (Bhojavani, Razdan, 1983; Devaux, 1992).

Anther culture method was used for production of spring barley DH lines at the Lithuanian Institute of Agriculture from 1996. Using anther culture method, DH lines have been developed and several of them included into the breeding program.

The objective of this study was to evaluate main components of grain yield and other agronomic traits of spring barley DH lines in field trials and to determine variability of examined traits in spring barley DH lines

Materials and methods

Anther culture method was used for production of spring barley DH lines, as described by Olsen (1987), Morrison and Evans (1988), Szarejko and Kasha (1991). Androgenic plants were produced from spring barley genotypes of Lithuanian origin – No. 7456 and No. 7533. The crossing was provided in field in 1995. For production of spring barley DH lines were used F_2 generation of genotypes in 1996. The best DH lines were evaluated agronomically in 1998-2000. Lines 7533-26, 7533-32, 7533-24, 7533-66, 7533-34 were developed by composite crossing KM 1192/'Ofir'//KM 1192/

'Mamie'/3/KM 1192/'Ofir'//'Maris Mink'/ 'Nadia'/4/Sj. 924505, lines 7456-39, 7456-46, 7456-10, 7456-21, 7456-33 were developed by composite crossing KM 1192/'Ofir'//KM 1192/'Mamie'/3/KM 1192/'Ofir'// 'Maris Mink'/'Nadia'/4/SW 90350. In the pedigree of lines entered German variety 'Nadia' and Czech line KM 1192, which are distinguished with good malting quality, and line KM 1192 with resistance to powdery mildew too. Other parent varieties 'Mamie' (France), 'Ofir' (the Netherlands), 'Maris Mink' (Great Britain), Sj. 924505 (Denmark), SW 90350 (Sweden) are high yielding, resistant to lodging and diseases. Lithuanian spring barley variety 'Ūla' was used as control variety. Spring barley DH lines were sown in 5-10 m^2 plots in 4 replications.

The soil of the experimental site was Endocalcari-Epihypogleyic Cambisoil (CMg-p-w-can) light loam. Preceding crop was seed clover of the 1st year. $N_{60}P_{60}K_{60}$ fertilization was used. The period 1998-2000 was rather good for spring barley DH lines evaluation because of the variable weather conditions (1998 – cool and rainy, 1999 – dry, 2000 – wet). It helped to achieve a versatile evaluation of the lines. In the trials we evaluated the period of maturity (days), plant height (cm), grain yield (t ha^{-1}), main yield components (spike length, grain per spike, grain weight per spike), 1000 kernel weight (g), volume weight (g l^{-1}).

The level of statistical significance of data was calculated by method of dispersion analysis and the variability of traits was characterized by the coefficient of variation (<10% – low, 10.1-20.0% – medium, >20% – high) (Доспехов, 1985). For calculation was used software ANOVA and STATENG developed at the Lithuanian Institute of Agriculture (Tarakanovas, 1999).

Results and discussion

Plant yield and quality traits are affected by the growth conditions on the basis of physiologic and metabolic processes occurring during plant vegetation. Table 1 shows data of agronomic traits of spring barley DH lines. The grain yield of the spring barley DH lines varied between the years. In cool and rainy year of 1998, the grain yield of DH lines was 3.70-4.80 t ha^{-1}. 1999 was dry and extremely unfavorable for barley, and DH lines produced rather poor yield – 2.49-3.27 t ha^{-1}. The year 2000 was the best for the spring barley DH lines that produced yields of 4.39-6.03 t ha^{-1}. Grain yield of DH lines was lower than that of control variety. The best DH lines were 7456-39 (4.43 t ha^{-1}), 7456-21 (4.22 t ha^{-1}) and 7456-33 (4.22 t ha^{-1}). These lines showed the highest yields in different years: in 1998 – line 7456-21 (4.80 t ha^{-1}), in 1999 – line 7456-33 (3.27 t ha^{-1}), and in 2000 – line 7456-39 (6.03 t ha^{-1}). These lines distinguished themselves by a high spike length and grain number per spike or high 1000 kernel weight.

Plant height is very closely related to lodging resistance, which influences plant yield and grain quality (Лукьянова и др., 1990). Plant height ranged from 38 to 82 cm depending on year and line (Table 3). DH line 7533-26 was characterized by the shortest straw throughout all the years of evaluation (38-57 cm). Increasing lodging resistance is one of the main ways to increase grain yield and quality. In 1998-1999, all DH lines showed resistance to lodging of 9 points (within scale 1-9, where 9 – very resistant). In the rainy 2000 year, DH lines had lodging resistance of 4-9 points. DH lines 7533-26, 7456-39 and 7456-33 had the best lodging resistance (7-8 points).

Tillering is one of the key components for high yield formation (Begum and Khatun, 1997). Tillering coefficient ranged between 2 and 5 depending on the year. Very poor tillering was in the dry 1999 year. The best tillering was shown by DH lines 7533-26, 7456-21 and 7533-66 (Table 1). But they weren't significantly superior to the control variety 'Ūla'.

Maturity time ranged between 72 and 92 days

Table 1

Agronomic traits of spring barley DH lines, average for 1998-2000

DH line	Plant height, cm	Tillering coefficient	Maturity, days	Grain yield, t ha^{-1}			
				1998	1999	2000	average
Ūla- st.	64	3.8	77	4.77	3.37	6.16	4.77
7533-26	50	4.4	83	4.14	2.56	4.61	3.77
7533-32	55	3.6	83	3.70	3.03	5.11	3.95
7533-24	67	3.8	82	4.35	2.49	5.49	4.11
7533-66	68	4.0	80	3.85	2.72	4.39	3.65
7533-34	66	3.6	80	4.28	2.83	4.86	3.99
7456-39	63	3.6	81	4.65	2.62	6.03	4.43
7456-46	67	3.8	82	3.98	2.56	5.13	3.89
7456-10	67	3.8	82	4.20	3.22	4.56	3.99
7456-21	64	4.4	81	4.80	3.15	4.72	4.22
7456-33	67	3.2	82	4.25	3.27	5.15	4.22
LSD_{05}	16.4	1.08	6.6	1.21	1.30	1.16	1.26

Table 2

Yield components of spring barley DH lines, 1998-2000

DH line	Spike length, cm		Grains per spike		Grain weight per spike, g		1000 kernel weight, g		Volume weight, g l^{-1}	
	min	max	min	max	min	max	min	max	min	max
Ūla- st.	6.4	7.0	18.1	21.8	1.00	1.24	51.8	56.5	684	704
7533-26	6.1	6.7	16.3	21.4	0.60	0.81	39.5	45.5	651	669
7533-32	6.8	7.9	17.8	23.5	0.80	0.98	42.2	44.5	621	669
7533-24	6.4	9.3	17.5	26.2	0.80	1.31	44.8	47.5	675	685
7533-66	6.6	7.5	18.1	23.0	0.60	1.11	42.8	47.0	650	693
7533-34	5.5	8.5	14.9	25.5	0.60	1.29	42.8	46.8	650	675
7456-39	6.7	8.7	18.4	24.9	0.8	1.39	47.2	52.5	623	683
7456-46	8.2	9.9	19.5	26.3	1.00	1.41	48.2	49.0	656	695
7456-10	7.7	8.4	19.5	22.8	1.00	1.27	48.0	52.5	665	695
7456-21	7.5	9.3	17.7	23.3	0.80	1.24	48.2	49.8	665	683
7456-33	7.4	9.2	19.1	24.3	0.80	1.40	48.0	52.2	664	701

depending on the year and line. The longest maturity time was in 1998 (77-92 days). In the dry year of 1999, DH lines of spring barley matured very early (72-74 days) (Table 3). All DH lines matured later than the control variety 'Ūla' (77 days). A higher variation, according to average maturity time, was among the DH lines from genotype No. 7533 (80-83 days), compared with genotype No. 7456 (81-82 days) (Table 1).

Evaluation of individual yield components showed that yield differences were caused by variations in spike productivity (spike length, grain per spike, grain weight per spike), 1000 kernel weight and plant number per plot (Flasarova and Onderka, 1997; Nadziak et al., 1996; Prakash and Sastry, 1997). Weather conditions in 1999 (dry) and 2000 (wet) influenced the plant growth and development, and associated processes of the formation and reduction of yield components.

Number of grains per spike is an important component of high productivity. It ranged between 14.9 and 26.3 depending on the year (Table 2). The highest grain number was distinguished in DH line 7456-46 (23.8). This line significantly surpassed control variety. Figure 1 shows average data of yield components of spring barley DH lines.

Spike length ranged between 5.5 and 9.9 cm depending on the year (Table 2). DH lines 7456-46, 7456-21, 7456-33 significantly surpassed control variety. The DH line with longest spike – 7456-46 (9.3 cm) – was also characterized with the highest grain number per spike (Fig. 1).

Grain weight per spike ranged between 0.6 and 1.41 g depending on particular years (Table 2). DH lines 7456-46 and 7456-10 were the best (1.14-1.24 g) (Fig. 1).

1000 kernel weight ranged between 39.5 and 56.5 g depending on the year and line (Table 2). Analyses of 1000 kernel weight showed that all the spring barley DH lines had smaller grains than control variety 'Ūla'. But DH lines, produced from spring barley genotype No. 7456, were characterized by a higher 1000 kernel weight (47.2-52.5 g) than produced from No. 7533 (39.5-47.5). Volume weight ranged from 621 to 704 g l^{-1} depending on the year, however DH lines did not surpass control variety 'Ūla'.

Investigation showed, that the key grain yield components of the spring barley DH lines were the number of grains per spike and 1000 kernel weight. After three-year evaluation, 4 DH lines – 7533-26, 7456-39, 7456-33, 7456-46, superior by agronomically valuable traits, were selected for breeding purposes. Selected DH lines were passed on to long-term seed storage in the Lithuanian Genebank as valuable genetic material.

Variability of examined traits in spring barley DH lines was established on the basis of analysis of averages of lines and years. Variability of traits was characterized by the coefficient of variation (V %). Medium and low variability was established for the grain yield and its main components of the spring barley DH lines. Medium variability was found for the grain weight per spike (coefficient of variation 15.0-19.4%) and spike length (coefficient of variation 11.4-13.1 %). Low variability was found for the grain yield (coefficient of variation 8.4-11.4 %) and plant height (coefficient of variation 8.6-11.2 %). The lowest variability was found for the time of maturity (coefficient of variation 1.1-4.8 %), and volume weight (coefficient of variation 2.2-3.6 %) (Table 3). Variability of volume weight in spring barley varieties and breeding lines was recorded as rather low in other investigations as well (Mašauskienė et al., 2001). The variation of grain yield and its main components depended on meteorological conditions of the year and genetical background. Assessment by reliable interval of minimal and maximal

Table 3

The variation of agronomic traits of spring barley DH lines, 1998-2000

Year	Mean result, x	Standard error of the mean, Sx	Means of data		Means of data at 05 level of probability		Standard deviation, S	Coefficient of variation, V %
			min	max	min	max		
Grain yield, t ha^{-1}								
1998	4.27	0.11	3.70	4.80	4.03	4.51	0,36	8,4
1999	2.89	0.10	2.49	3.37	2.67	3.11	0,32	11,2
2000	5.11	0.18	4.39	6.16	4.72	5.50	0,58	11,4
X	4.09		3.65	4.77	3.88	4.30		
Plant height, cm								
1998	71.0	2.40	55	78	65.6	76.4	7.97	11.2
1999	45.4	1.18	38	53	42.7	48.0	3.91	8.6
2000	73.8	2.44	57	82	68.4	79.3	8.10	11.0
X	63.4		50	68	59.6	67.3		
Time of maturity, days								
1998	89.7	1.31	77	92	86.8	92.6	4.34	4.8
1999	73.4	0.24	72	74	72.8	73.9	0.81	1.1
2000	80.2	0.75	76	84	78.5	81.8	2.43	3.1
X	81.2		77	83	80.0	82.3		
Volume weight, g l^{-1}								
1998	664	5.61	623	694	651.5	676.5	18.62	2.8
1999	682	4.42	656	704	673.0	692.7	14.68	2.2
2000	670	7.17	621	695	654.3	686.3	23.79	3.6
X	672		646	694	663.0	681.7		
1000 kernel weight, g								
1998	48.3	1.36	39.5	54.2	45.3	51.3	4.50	9.3
1999	47.3	0.63	44.5	51.8	45.9	48.7	2.10	4.4
2000	47.6	1.50	40.0	56.5	44.2	50.9	4.98	10.5
X	47.7		41.7	54.2	45.3	50.2		
Spike length, cm								
1998	8.2	0.33	6.4	9.8	7.5	8.9	1.08	13.1
1999	6.8	0.24	5.5	8.2	6.3	7.4	0.78	11.4
2000	8.0	0.28	6.7	9.9	7.4	8.6	0.92	11.5
X	7.7		6.4	9.3	7.2	8.2		
Grain number per spike								
1998	23.6	0.62	20.0	26.3	22.2	25.0	2.06	8.74
1999	17.9	0.41	14.9	19.5	17.0	18.8	1.37	7.63
2000	22.8	0.40	21.0	25.7	21.9	23.7	1.33	5.83
X	21.4		19.7	23.8	20.7	22.2		
Grain weight per spike, g								
1998	1.2	0.06	0.8	1.4	1.1	1.3	0.20	16.2
1999	0.8	0.05	0.6	1.0	0.7	0.9	0.15	19.4
2000	1.1	0.05	0.8	1.3	1.0	1.2	0.16	15.0
X	1.0		0.7	1.2	0.9	1.1		

data, when the differences arisen from diversity of lines are larger than year differences, showed a greater influence of genetical background of the line, compared with meteorological conditions. The trait, which was mostly influenced by the genetical background, was the 1000 kernel weight. Equally influenced by genetical background and meteorological conditions was volume weight. The impact of meteorological conditions on variability of plant height, time of maturity and grain yield was of greater importance compared with the influence of genetical background.

Conclusions

1. After three year evaluation, 4 DH lines superior by agronomically valuable traits, were selected for breeding purposes: spring barley DH line 7533-26 was distinguished by a short straw, satisfactory tillering,

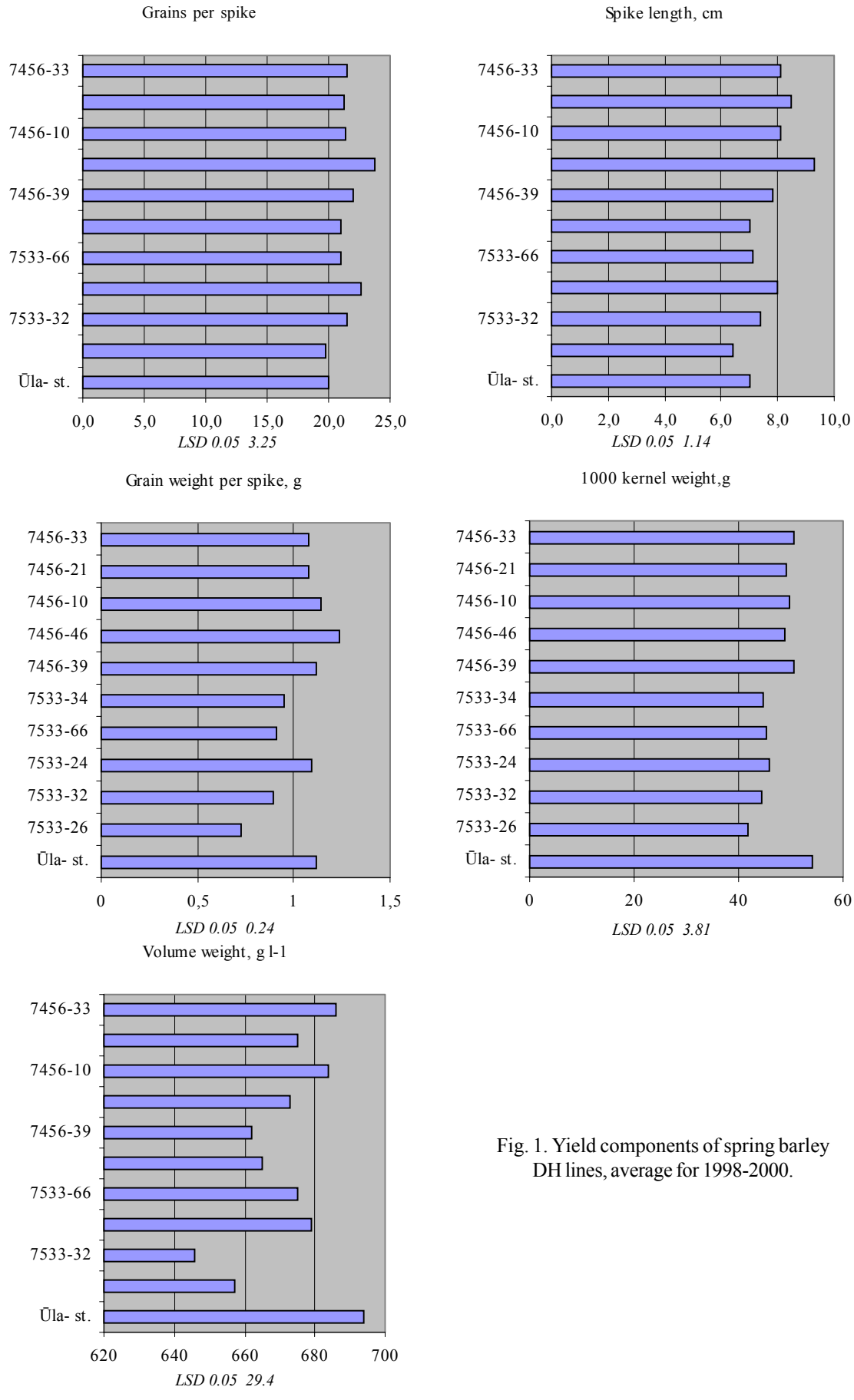


Fig. 1. Yield components of spring barley DH lines, average for 1998-2000.

and good lodging resistance; DH line 7456-39 was distinguished by a high yield, 1000 kernel weight, and lodging resistance; DH line 7456-33 was distinguished by spike length, high 1000 kernel weight, resistance to lodging; DH line 7456-46 was distinguished by spike length, high grain number per spike, and high grain weight per spike.

2. DH lines 7533-26, 7456-39, 7456-33, 7456-46 were passed on to long-term seed storage in the Lithuanian Genebank as valuable genetic material.

3. The variability of traits was characterized by the coefficient of variation. Medium variability was found for the grain weight per spike (coefficient of variation 15.0-19.4 %). The lowest variability was found for the time of maturity (coefficient of variation 1.1-4.8 %), and volume weight (coefficient of variation 2.2-3.6 %).

4. The results showed that impact of meteorological conditions on variability of plant height, time of maturity and grain yield of spring barley DH lines was of greater importance compared with the influence of genetical background.

Acknowledgement

This study was supported by the Lithuanian State Science Program 'Genefund'. Authors are grateful to the International Atomic Energy Agency (IAEA, Vienna) and to prof. Iwona Szarejko (Silesian University) for their support.

References

1. Begum, S., Khatun, F. (1997) Genetic parameters and character association in exotic genotypes of two rowed barley. *Bangladesh Journal of Botany*, Vol. 26, Iss 2, pp. 121-126.

2. Bhojavani, S. S., Razdan, M. K. (1983) Plant tissue culture: theory and practice. *Developments in crop science.* Elsevier Amsterdam, pp. 20-35.

3. Devaux, P. (1992) Haploidy in barley and wheat improvement. *Reproductive biology and plant breeding: XIII th EUCARPIA congress,* July 06-11th, Angers-France, Springer-Verlag, pp. 139-151.

4. Flasarova, M., Onderka, M. (1997) Formation and compensation of yield components in chosen spring barley genotypes. *Rostlina Vyroba,* Vol. 43, Iss 9, pp. 449-454.

5. Iyamabo, O. E., Hayes, P. M. (1995) Effects of selection and opportunities for recombination in doubled-haploid populations of barley (*Hordeum vulgare L.*). *Plant Breeding,* Vol. 144, pp. 131-136.

6. Mannienen, O. (1997) Optimizing anther culture for barley breeding. *Agriculture & Food Science in Finland,* Vol. 6, N.5/6, pp. 389-398.

7. Mašauskienė, A., Paplauskienė, V., Leistrumaitė, A. (2001) Veislės įtaka vasarinių miežių grūdų kokybės ir derlingumo variacijai bei šių rodiklių tarpusavio priklausomumui. *Žemdirbystė: mokslo darbai*, N 73, pp. 194-209.

8. Morrison, R. A., Evans, D. A. (1988) Haploid plants from tissue culture: new plant varieties in a shortened time frame. *Bio/Technology,* N. 6, pp. 684-690.

9. Nadziak, J., Malysa, M., Kudla, M. (1996) Ocena odmian jeczmenia ozimego zgromadzonych w Banku Genow. *Biuletyn Instytutu Hodowli i Aklimatyzacji Roslin,* N 197, pp. 97-111.

10. Olsen, F. L. (1987) Induction of microspore embriogenesis in cultured anthers of *Hordeum vulgare*. The effects of ammonium nitrate, glutamine and asparagine as nitrogen sources. *Carlsberg Research Communications*, No. 52, pp. 393-404.

11. Prakash, V., Sastry, E. V. D. (1997) Genetics of yield and its components in barley (*Hordeum vulgare L.*). *Annals of Arid Zone,* Vol. 36, pp. 43-46.

12. Szarejko, I., Kasha, K. J. (1991) Induction of anther culture derived doubled haploids in barley. *Cereal Research Communications,* 19, pp. 219-237.

13. Tarakanovas, P. (1999) *Statistinių duomenų apdorojomo programos paketas ''Selekcija''*. Akademija, 57 pp.

14. Доспехов, Б. А. (1985) *Методика полевого опыта.* М.: Агропромиздат, 315 с.

15. Лукьянова, М. В., Трофимовская, А. Я., Гудкова, Г. Н., Терентьева, И. А., Ярош, Н. П. (eds.) (1990) *Культурная флора СССР*, т. II , ч. 2, Ячмень. Л.: Агропромиздат, Ленингр. отд-ние, 421 с.

Anotācija

Lai palielinātu vasaras miežu (Hordeum vulgare) selekcijas efektivitāti, tiek izmantotas dažādas biotehnoloģijas metodes. Kopš 1996. g. Lietuvas Zemkopības institūtā tiek lietota putekšņu kultūru metode, lai radītu dihaploīdās (DH) miežu līnijas, izmantojot Lietuvas izcelsmes genotipus. No 1998. līdz 2000. g. novērtētas šo līniju ražas un citas agronomiskās īpašības. Pēc trīsgadīgiem datiem, tālakajam selekcijas darbam ar vērtīgām agronomiskajām īpašībām atlasītas 4 DH līnijas: 7533 – 26, 7456 – 39, 7456 – 33, 7456 – 46. Tām raksturīgi īsi stiebri, apmierinoša cerošana, laba veldres izturība, raža, 1000 graudu masa un labs vārpas garums, augsts graudu skaits un svars no vārpas. Līnijas bija iekļautas konkursa šķirņu salīdzinājumā un vasaras miežu selekcijas programmā. Dihaploīdās līnijas tiks nodotas ilgtermiņa sēklu glabāšanai Lietuvas gēnu bankā. Novērtējot DH līniju īpašibas, konstatēts, ka meteoroloģisko apstākļu ietekme uz auga garuma, nogatavošanās laika, 1000 graudu masas un ražas mainību ir nozīmīgāka nekā genotipa ietekme.

Kviešu maizes ar auzu un griķu miltu piedevu sensorā novērtēšana
Sensory Evaluation of Wheat Bread with Oat and Buckwheat Addition

Dace Kļava, Envija Strautniece, Daina Kārkliņa
LLU Pārtikas Tehnoloģijas fakultāte, e-pasts: dore@cs.llu.lv
Faculty of Food Technology, LLU, e-mail: dore@cs.llu.lv

Abstract. One of the possibilities to make healthier bread is to substitute part of wheat flour by oat flour. However, addition of the oat or buckwheat flour produces changes in the bread sensory properties. The purpose of this study was to evaluate the main sensory properties (color, flavor, aroma, structure, porosity) of wheat bread with oat or buckwheat flour addition. Five samples of bread were evaluated by sensory methods (hedonic scale and line scale). The results of hedonic scaling indicated that there was no difference in the degree of liking among pure wheat bread and bread with oat or buckwheat flour. The line scale was used to evaluate the intensity of sensory properties of bread samples. The results demonstrated that the difference in color was among pure wheat bread and wheat bread with 10% and 15% of buckwheat. No difference in color, flavor, aroma, structure and porosity was observed among wheat bread samples with 10% and 20% of oat flour.
Key words: wheat bread, oat bread, buckwheat bread, sensory evaluation.

Ievads

Aizvien vairāk cilvēku pievērš uzmanību veselīgam jeb funkcionālam uzturam, kurā viens no pamatprincipiem ir līdzsvara ievērošana starp enerģiju, kuru cilvēks patērē dzīves norises procesos, un enerģiju, kuru uzņem ar uzturvielām. Pašlaik tik plaši lietojamais termins "funkcionāla pārtika" radies 20. gs. astoņdesmitajos gados Japānā. Pārtikas produktu ražotāji tā nosaukuši produktus, kuriem pievienotas sastāvdaļas, lai paaugstinātu pārtikas produktu nozīmi veselības uzlabošanā (Hilliam,1998).

Maize ir ļoti nozīmīgs graudaugu produkts cilvēka uzturā. Lietojot uzturā pārsvarā kviešu maizi no smalki maltiem miltiem, cilvēks nepietiekami uzņem vitamīnus, minerālvielas un šķiedrvielas. Tradicionālie paņēmieni, lai palielinātu kviešu maizes uzturvērtību un piešķirtu tai funkcionālas īpašības, ir mīklai pievienot galvenokārt kviešu klijas vai rupji maltus graudus. Kā alternatīva varētu būt auzu vai griķu miltu pievienošana kviešu miltiem, tādējādi paaugstinot maizes funkcionālo vērtību. Tomēr literatūrā sastopami dati par sensoro īpašību izmaiņām, kviešu maizei pievienojot auzu vai kādu citu šķiedrvielām bagātu produktu.

Izvēloties un lietojot uzturā maizes izstrādājumus, patērētājam vissvarīgākās ir produkta sensorās īpašības, kuras kompleksi uztver cilvēka maņu orgāni. Tāpēc jaunos maizes izstrādājumos nepieciešams novērtēt to sensorās īpašības un noskaidrot patērētāju attieksmi.

Pētījuma mērķis bija jaunajiem kviešu maizes izstrādājumiem ar 10%, 20% auzu vai 10%, 15% griķu miltu piedevu veikt sensorās analīzes, izmantojot emocionālās un raksturojošās metodes.

Materiāli un metodes

Kviešu maizei ar 10%, 20% auzu un 10%, 15% griķu miltiem tika veikts kontrolcepiens, izmantojot a/s "Rīgas Dzirnavnieks" a/l kviešu miltus (lipeklis 28%, mitrums 13.5%, pelnvielu saturs 0.55%), griķu miltus (mitrums 14%, pelnvielu daudzums 2.54%) un auzu miltus (mitrums 14.2%, pelnvielas 1.55%), un papildizejvielas: presētais maizes raugs, cukurs, sāls un ūdens. Izmantotās receptūras apkopotas 1. tabulā.

Sensorajai novērtēšanai tika iesniegti 5 maizes paraugi:

A – kontrole 100% kviešu milti,
B – 90% kviešu milti + 10% auzu milti,
C – 80% kviešu milti + 20% auzu milti,
D – 90% kviešu milti + 10% griķu milti,
E – 85% kviešu milti + 15% griķu milti.

Maizes sensorās īpašības (krāsu, aromātu, smaržu+garšu, struktūru, porainību) novērtēja ar raksturojošo metožu līnijskalu, bet maizes patikšanas pakāpi ar emocionālo metožu hēdonisko skalu (Poste, Mackie, 1991).

Hēdoniskajā vērtēšanā katram paraugam izmanto atsevišķu 9 punktu skalu:

____ ārkārtīgi patīk;
____ ļoti patīk;
____ vidēji patīk;
____ mazliet patīk;
____ ne patīk, ne nepatīk;
____ mazliet nepatīk;
____ vidēji nepatīk;
____ ļoti nepatīk;
____ ārkārtīgi nepatīk.

1. tabula/Table 1

Kontrolcepiena receptūras
Recipies of samples for baking test

Paraugi Samples	Sastāvdaļas Composition						
	Kviešu milti/ Wheat flour, g	Auzu milti/ Oat flour, g	Griķu milti/ Buckwheat flour g	Raugs/ Yeast g	Sāls/ Salt, g	Cukurs/ Sugar, g	Ūdens/ Water, ml
Kontrole/ Control	2000	–	–	40	40	40	1176
Kviešu m.+auzu m.10%/ Wheat + oat 10%	1800	200	–	40	40	40	1261
Kviešu m.+auzu m.20%/ Wheat + oat 20%	1600	400	–	40	40	40	1158
Kviešu m.+griķu m.10%/ Wheat + buckwheat 10%	1800	–	200	40	40	40	1290
Kviešu m.+griķu m 15%/ Wheat + buckwheat 15%	1700	–	300	40	40	40	1360

1. att. Līnijskalas.
Fig. 1. Line scales.

Lai novērtētu maizes sensoro īpašību intensitāti, izmanto līnijskalu (1. attēls), kas sastāv no 15 cm garas horizontālas taisnes, uz kuras iezīmēti divi punkti, katrs 1.5 cm attālumā no abiem taisnes galiem.

Iezīmētos punktus apzīmē ar izteicienu (nav izteikta, ļoti intensīva). Katras sensorās īpašības vērtēšanai izmanto atsevišķu skalu. Vērtētāji atzīmē savu vērtējumu, iezīmējot vertikālu līniju šķērsām horizontālajai līnijai tajā punktā, kas labāk atspoguļo vērtētāja uztverto sensorās īpašības lielumu. Pēc tam, kad vērtēšana pabeigta, izmēra attālumu no kreisā galapunkta līdz atzīmei, ko izdarījis vērtētājs (Poste, Mackie, 1991). Sensorā vērtēšana notika LLU Pārtikas Tehnoloģijas fakultātes Pārtikas produktu sensorajā laboratorijā, un tajā piedalījās 29 speciāli vērtētāji (5 vīrieši un 24 sievietes; vidējais vecums 22 gadi). Katram vērtētājam vienlaicīgi izsniedza piecus pilnīgi vienādi noformētus, šifrētus maizes paraugus. Sensorās novērtēšanas rezultātus izvērtē ar statistiskajām metodēm: vienfaktoru dispersijas analīzi un Tjūkija testu (Arhipova, Ramute, Paura, 1998).

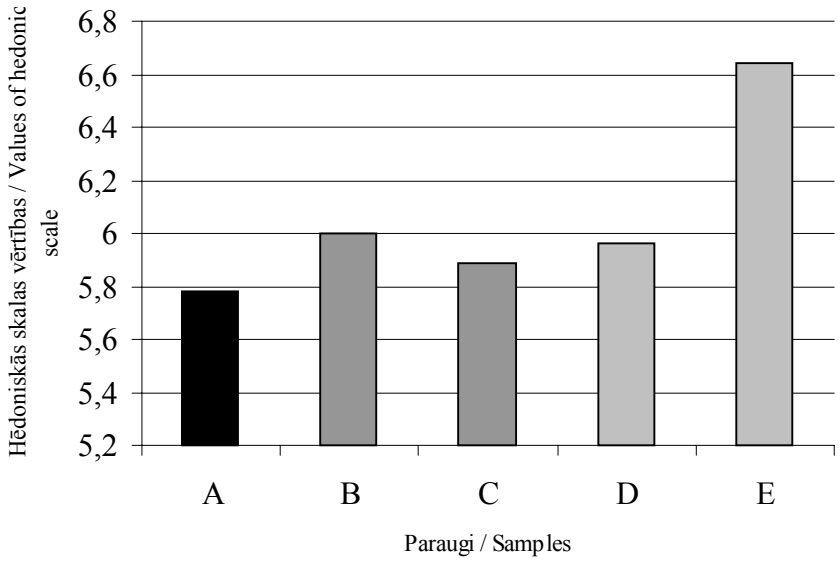
Rezultāti un diskusija

Hēdoniskās vērtēšanas rezultāti, kas norāda maizes patikšanas pakāpi, atspoguļoti 2. attēlā.

Izmantojot hēdonisko skalu, tika iegūti rezultāti, kas norāda produkta patikšanas pakāpi jaunajiem maizes paraugiem.

Iegūtie rezultāti rāda, ka hēdoniskais novērtējums ir robežās no 5.8±0.3 (ne patīk, ne nepatīk) līdz 6.6±0.3 (vidēji patīk).

Izvērtējot sensoros vērtēšanas rezultātus ar disper-



2. att. Maizes paraugu hēdoniskās novērtēšanas rezultāti: A – kontrole 100% kviešu milti; B – 90% kviešu milti + 10% auzu milti; C – 80% kviešu milti + 20% auzu milti; D – 90% kviešu milti + 10% griķu milti; E – 85% kviešu milti + 15% griķu milti.
Fig. 2. Hedonic scores for the five bread samples: A – control 100% wheat flour; B – 90% wheat flour + 10% oat flour; C – 80% wheat flour + 20% oat flour; D – 90% wheat flour + 10% buckwheat flour; E – 85% wheat flour + 15% buckwheat flour.

2. tabula/Table 2

Maizes paraugu hēdoniskā vērtējuma dispersijas analīzes rezultāti
Results of analysis of variance of bread samples using hedonic scale

Dispersijas avots/Source of variation	Brīvības pakāpe/ Degree of freedom, df	Kvadrāta summas/ Sum of squares, SS	Vidējās vērtības kvadrāts/ Mean square, MS	Fišera kritērijs/ Variance ratio, F
Maizes veidi/ Treatments	4	12.75	3.18	1.45
Kļūda/ Error	135	296.78	2.19	
Kopā/ Total	139	309.54		

$\alpha \leq 0.05$

sijas analīzi, tika noskaidrots, vai pastāv būtiska atšķirība patikšanas ziņā, starp eksperimentālajiem maizes paraugiem. Iegūtie rezultāti apkopoti 2. tabulā.

Iegūto rezultātu dispersijas analīze parādīja, ka F=1.45 nepārsniedz $F_{krit.}$=2.43 (n_1=4, n_2=135), tāpēc nepastāv būtiskas atšķirības starp maizes paraugiem patikšanas ziņā. Tas nozīmē, ka vērtētāji nav devuši priekšroku nevienam no pieciem maizes paraugiem.

Izmantojot līnijskalu, maizes paraugiem tika vērtētas galvenās sensorās īpašības: krāsa, aromāts, garša-smarža, struktūra, porainība, kas papildus atļauj salīdzināt jauno maizes izstrādājumu sensorās īpašības ar kontroles parauga īpašībām.

Maizes paraugu krāsas novērtējuma dispersijas analīzes dati atspoguļoti 3. tabulā.

Dispersijas analīzes rezultāti rāda, ka F =2.58 ir lielāks par $F_{krit.}$=2.54 (n_1=4, n_2=135), tādēļ var secināt, ka starp pieciem maizes paraugiem krāsas intensitātes ziņā ir būtiskas atšķirības. Jauno maizes paraugu krāsas intensitāti iespaido pievienotie auzu un griķu milti. Izmantojot Tjūkija testu, tika noskaidrots, ka būtiskākā atšķirība ir starp kontroli (A) un paraugu ar 10% griķu miltu piedevu (D) un maizes paraugu ar 15% griķu miltu piedevu (E). Atšķirība pastāv arī starp paraugu ar 10% auzu miltu piedevu (B) un 15% griķu miltu piedevu (E). Pievienojot kviešu miltiem griķu miltus, kas ir tumšāki, maizes mīkstums iegūst pelēcīgu, griķu miltiem raksturīgu nokrāsu. Tā kā auzu milti ir pelēcīgi balti, tad, pievienojot tos kviešu miltiem, maizes mīkstuma krāsas intensitāte būtiski nemainās.

3. tabula/Table 3

Krāsas novērtējuma dispersijas analīzes rezultāti
Results of analysis of variance of colour

Dispersijas avots/Source of variation	Brīvības pakāpe/ Degree of freedom, df	Kvadrāta summas/ Sum of squares, SS	Vidējās vērtības kvadrāts/ Mean square, MS	Fišera kritērijs/ Variance ratio, F
Maizes veidi/ Treatments	4	60.29	15.07	2.58
Kļūda/ Error	135	786.84	5.82	
Kopā/ Total	139	847.13		

$\alpha \leq 0.05$

4. tabula/Table 4

Aromāta novērtējuma dispersijas analīzes rezultāti
Results of analysis of variance of aroma

Dispersijas avots/Source of variation	Brīvības pakāpe/ Degree of freedom, df	Kvadrāta summas/ Sum of squares, SS	Vidējās vērtības kvadrāts/ Mean square, MS	Fišera kritērijs/ Variance ratio, F
Maizes veidi/ Treatments	4	17.58	4.39	0.83
Kļūda/ Error	135	711.84	5.27	
Kopā/ Total	139	729.42		

$\alpha \leq 0.05$

5. tabula / Table 5

Garšas+smaržas novērtējuma dispersijas analīzes rezultāti
Results of analysis of variance of flavour

Dispersijas avots/Source of variation	Brīvības pakāpe/ Degree of freedom, df	Kvadrāta summas/ Sum of squares, SS	Vidējās vērtības kvadrāts/ Mean square, MS	Fišera kritērijs/ Variance ratio, F
Maizes veidi/ Treatments	4	43.39	10.85	2.13
Kļūda/ Error	135	687.45	5.09	
Kopā/ Total	139	730.84		

$\alpha \leq 0.05$

Sensori novērtētie maizes paraugi pēc krāsas intensitātes sakārtojami šādi:

A_A	B_{AB}	C_{AB}	D_B	E_B
7.2	6.6	6.4	5.8	5.3

Ar vienādu burtu apzīmētie vērtējumi nav būtiski atšķirīgi.

Apskatot hēdoniskās skalas rezultātus (2. attēls), var secināt, ka maizes mīkstuma tumšākā krāsa neietekmē patērētāju vērtējumu maizes izstrādājumiem ar griķu miltiem.

Auzu un griķu miltu specifisko aromātu dēļ, pievienojot tos kviešu miltiem, varētu izmainīties maizes izstrādājumu aromāts, tādēļ bija nepieciešams veikt aromāta intensitātes sensoro novērtējumu. Iegūtie rezultāti apkopoti 4. tabulā.

Sensoro datu izvērtējums ar dispersijas analīzi parāda, ka aromātā būtiskas atšķirības starp kontroli un jaunajiem maizes izstrādājumiem nepastāv, jo F=0.83 ir mazāks par $F_{krit.}$=2.54 (n_1=4, n_2=135).

Izvērtējot kompleksās īpašības garša+smarža

6. tabula/Table 6

Struktūras novērtējuma dispersijas analīzes rezultāti
Results of analysis of variance of structure

Dispersijas avots/Source of variation	Brīvības pakāpe/ Degree of freedom, df	Kvadrāta summas/ Sum of squares, SS	Vidējās vērtības kvadrāts/ Mean square, MS	Fišera kritērijs/ Variance ratio, F
Maizes veidi/ Treatments	4	21.27	5.31	1.16
Kļūda/ Error	135	614.94	4.55	
Kopā/ Total	139	636.21		

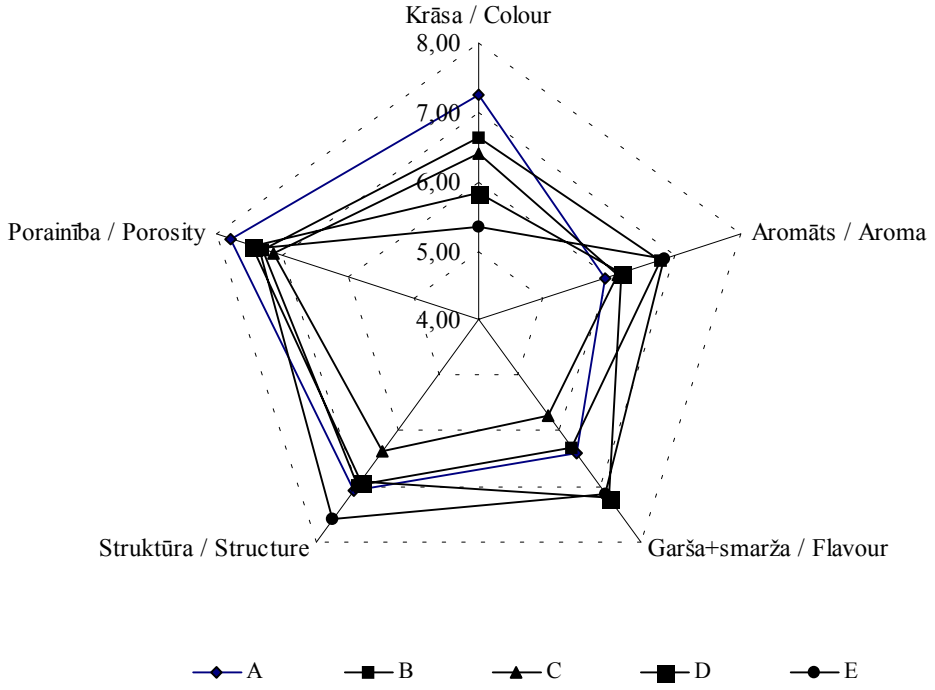
$\alpha \leq 0.05$

7. tabula/Table 7

Porainības novērtējuma dispersijas analīze
Results of analysis of variance of porosity

Dispersijas avots/Source of variation	Brīvības pakāpe/ Degree of freedom, df	Kvadrāta summas/ Sum of squares, SS	Vidējās vērtības kvadrāts/ Mean square, MS	Fišera kritērijs/ Variance ratio, F
Maizes veidi/ Treatments	4	6.45	1.61	0.35
Kļūda/ Error	135	616.32	4.56	
Kopā/ Total	139	622.77		

$\alpha \leq 0.05$



3. att. Maizes paraugu sensoro īpašību lielumu staru diagramma: A – kontrole 100% kviešu milti; B – 90% kviešu milti + 10% auzu milti; C – 80% kviešu milti + 20% auzu milti; D – 90% kviešu milti + 10% griķu milti; E – 85% kviešu milti + 15% griķu milti.

Fig. 3. Star diagram of sensory attributes intensity for bread: A – control 100% wheat flour; B – 90% wheat flour + 10% oat flour; C – 80% wheat flour + 20% oat flour; D – 90% wheat flour + 10% buckwheat flour; E – 85% wheat flour + 15% buckwheat flour.

dispersijas analīzes rezultātus (5. tabula), redzams, ka F=2.13 ir mazāks par $F_{krit.}$=2.54 (n_1=4, n_2=135), tātad garšā+smaržā vērtētiem kontroles un eksperimentālajiem paraugiem būtiskas atšķirības nepastāv.

Pievienojot auzu vai griķu miltus kviešu miltiem, var mainīties maizes struktūra un porainība. Tādēļ ar sensoro analīžu palīdzību tika noskaidrots, kā šīs izmaiņas ietekmē jauno maizes izstrādājumu struktūru un porainību. Iegūtie rezultāti apkopoti 6. un 7. tabulā.

Struktūras novērtējuma dispersijas analīzes rezultāti parāda, ka F=1.16, tas ir mazāks par $F_{krit.}$=2.54 (n_1=4, n_2=135), līdz ar to var secināt, ka lai arī sastāva izmaiņas jaunajos maizes paraugos pastāv, struktūras ziņā nav būtisku atšķirību, salīdzinot ar kontroles paraugu no kviešu miltiem.

Izvērtējot porainības intensitātes dispersijas analīzes rezultātus, ir redzams, ka F=0.35 ir mazāks par $F_{krit.}$=2.54 (n_1=4, n_2=135). No tā var secināt, ka pievienotā 10%, 20% auzu vai 10%, 15% griķu miltu piedeva neietekmē jauno izstrādājumu porainību, salīdzinot ar kontroles paraugu.

Maizes paraugu sensoro īpašību lielumi attēloti staru diagrammās 3. attēlā.

Maizes kvalitātes sensorais novērtējums parāda, ka nepastāv būtiskas atšķirības patikšanas ziņā starp kviešu maizi un jaunajiem maizes izstrādājumiem ar auzu un griķu miltiem. Rezultāti rāda, ka nav būtiskas izmaiņas sensoro īpašību (aromāta, garšas+smaržas, struktūras porainības) intensitātē starp kontroles paraugu un maizes izstrādājumiem ar auzu vai griķu miltiem. Krāsas ziņā pastāv atšķirība starp kontroles paraugu un paraugiem ar griķu miltiem.

Secinājumi

1. Maizes kvalitātes sensorais novērtējums ļauj secināt, ka nepastāv būtiskas atšķirības patikšanas ziņā starp kviešu maizi un maizes izstrādājumiem ar 10%, 20% auzu vai 10%, 15% griķu miltiem, jo dispersijas analīzes rezultātā F=1.45 un nepārsniedz $F_{krit.}$=2.43.

2. Secināts, ka atšķirība krāsas ziņā ir starp kontroles paraugu un maizi ar 10% griķu miltiem un 15% griķu miltiem, kas izskaidrojams ar griķu miltu specifisko tumšo nokrāsu.

3. Novērtējot sensorās īpašības, secināts, ka aromāta, garšas+smaržas, struktūras un porainības intensitāte nav būtiski mainījusies, kviešu miltiem pievienojot 10%, 20% auzu vai 10%, 15% griķu miltus.

Literatūra

1. Arhipova, I., Ramute, L., Paura, L. (1998) *Datu statistiskā apstrāde ar MS Excel.* Jelgava, 159 lpp.

2. Hilliam, M. (1998) The market for Functional Foods. *Int. Dairy Journal*, 8, pp. 349-353.

3. International standart ISO 5492: 1992. (1992) Sensory analysis – Vocabulary.

4. Poste, L. M., Mackie, D. A. et al. (1991) *Laboratory Methods for Sensory Analysis of Food.* Agriculture Canada, Ottawa, 90 pp.

Procesu kontroles un ražošanas monitoringa sistēmas pārtikas uzņēmumos
Process Control and Monitoring of Production in the Food Industry

Juris Vanags
A/S Biotehniskais Centrs, http: //www.innovation.lv/btc
S/C Biotechnical Center
Uldis Viesturs
LV Koksnes ķīmijas institūts, e-pasts: koks@edi.lv
Latvian State Institute of Wood Chemistry, e-mail: koks@edi.lv
Ēvalds Putniņš
A/S Limbažu Piens
S/C Limbazu Piens

Abstract. The application of process control in the food industry is demonstrated, exemplified by the milk pasteurization process. The application task of this automated system was to optimize the production process according to the HACCP principles. Automation is based on the BASIC programmable process controller and the process visualization program "DATU CENTRS".
Key words: process control, food industry, milk pasteurization, controllers.

Ievads

Viens no galvenajiem nosacījumiem, lai produkti iegūtu pircēju pieprasījumu, ir to pieņemama un nemainīga kvalitāte. Sevišķi aktuāli tas ir valstīs, kur vēl nav pilnīgi pabeigta tirgus formēšanās. Tātad arī Latvijā ražotājam šiem jautājumiem ir jāpievērš īpaša uzmanība. Mēdz būt gadījumi, kad labs produkts neiekaro stabilas pozīcijas tirgū, jo epizodiski pārdošanā tas parādās ar kvalitātes novirzēm. Samērā bieži kā viens no šādu noviržu iemesliem ir nepietiekama ražošanas procesu stadiju kontrole un vadība. Teorētiski cilvēks var nodrošināt rutīnu procesa vairāk atkārtojošu operāciju izpildi, taču viņš var kļūdīties un šī kļūda (arī vienreizēja) var radīt produkta partiju ar kvalitātes novirzēm. Tāpēc svarīgi ir nodrošināt nepārtrauktu ražošanas procesu kontroli un datu arhivēšanu, jo tādā gadījumā, ja arī parādīsies kļūda, tad tā tiks uzskaitīta, un tādā gadījumā ir iespējas šo produktu, piemēram, pakļaut atkārtotai pārstrādei. Svarīgi ir nodrošināt ražošanas procesa nepārtrauktu monitoringu. Ja tehnoloģija ir atbilstoša, produkta kvalitāte tiek nodrošināta. Veicot ražošanas procesa monitoringu, ir vieglāk noteikt ražošanas procesa "vājās" vietas. Tiek pieņemts lēmums par procesa stadijas pilnveidošanu, produkta kvalitātes garantijas palielināšanai. Katrā ražotnē realizācija var būt atšķirīga, bet mērķis (t.i., procesa nemainīga kvalitāte) kopējs.

Balstoties uz Koksnes Ķīmijas institūtā veiktajiem pētījumiem (Vanags, Viesturs, 2001a; Vanags, Viesturs, 2001c), a/s "Biotehniskais centrs" ir izstrādājis un ieviesis ražošanas montoringa un/vai procesa kontroles vadības sistēmas vairākos pārtikas pārstrādes uzņēmumos: a/s "Latvijas Balzams", SIA "Spilva", a/s "Cēsu Alus", a/s "Rīgas Raugs", SIA "Velte Eko", a/s "Rīgas Dzirnavnieks", a/s "Limbažu Piens", a/s "Rīgas Piensaimnieks", a/s "Laima" (Vanags, Viesturs, 2001b; Vanags, 2002).

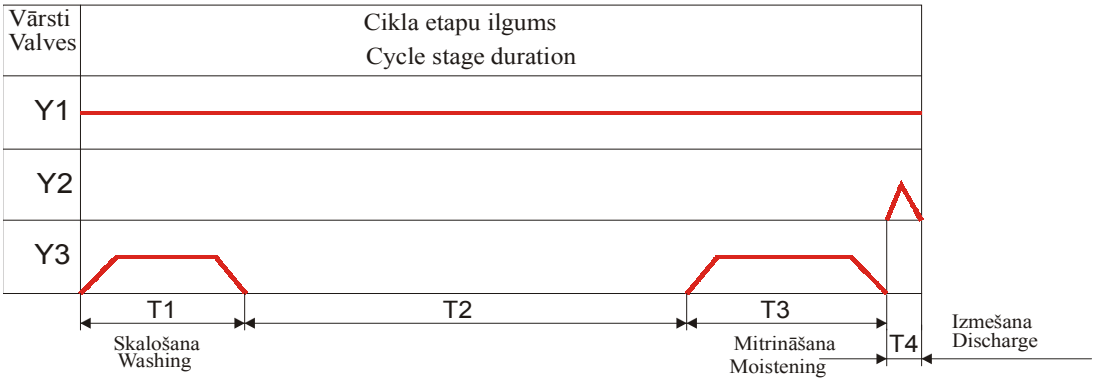
Šajā rakstā kā piemērs apskatīta procesa automatizācijas modifikācija piena pasterizācijā a/s "Limbažu Piens". Apskatītajā gadījumā automatizācijas sistēma tika izstrādāta ražošanas procesa pilnveidošanai saskaņā ar HACCP principiem (Blija et al., 1999; 2002; Kārklīte, Blija, 1999), izmantojot vispārējās piena pārstrādes tehnoloģijas (Hui, 1993; Varnam, Sutherland, 1994; Dairy Processing Handbook, 1995; Spreer, 1995; Walstra et al., 1999), tanī skaitā LLU PTF izstrādnes (Ozola, Ciproviča, 2002). Visiem pasterizācijas procesu HACCP kartes kritiskajiem punktiem tika izveidota īpaša kontrole, kas arī bija šī darba galvenais uzdevums.

Materiāli un metodes

Piena pasterizācijas līnijas automatizācijas kontroliera apraksts

Piena pasterizācijas līnijas kontrolieris ietver šādas iespējas:

1) separēšanas režīma cikla automātisku izpildi;
2) mazgāšanas režīma cikla automātisku izpildi;
3) temperatūras režīmu automātisku kontroli atkarībā no ražojamā produkta;
4) avārijas situāciju automātisku kontroli;
5) procesa kontroli un vadību ar operatora paneļa palīdzību;
6) datu apmaiņas iespējas ar PC, kurš nodrošina



1. att. Separēšanas un mazgāšanas ciklu grafiki.
Fig. 1. Plots of separation and washing cycles.

procesa vizualizāciju un arhivēšanu.

Piena pasterizācijas līnijas automātiskajā kontrolē tiek izmantoti šādi piena pasterizācijas līnijas elementi:

1) piena separators;
2) 3 ūdens padeves vārsti separatora vadībai (Y1,Y2,Y3);
3) piena sūknis no starptvertnes uz plāksni;
4) cirkulācijas vārsts;
5) karstā ūdens sūknis pasterizācijai;
6) tvaika vārsts pasterizācijai;
7) karstā ūdens sūknis siera piena uzsildīšanai;
8) tvaika vārsts siera piena uzsildīšanai;
9) līmenis starptvertnē;
10) četri temperatūras devēji.

Kontrolieris veidots uz BASIC TIGER (ražotājs "Wilke Technology GmbH" (Vom Berg, 1999)) tipa procesora bāzes un ietver sevī interfeisa paneli piena pasterizācijas līnijas tehnisko līdzekļu pieslēgšanai un operatora paneli, kas nodrošina dialogu ar operatoru procesa kontrolei un vadībai. Šāda procesora izvēle ir saistīta ar iespēju elastīgi mainīt programmas parametrus un tekstu. Kontrolieris nodrošina sakaru līniju ar PC.

Laika intervālus T1, T2, T3, T4 iespējams ieregulēt un izmainīt no operatoru paneļa.

Uzņēmumā piena pasterizācijas kvalitātes kontrolei tiek lietota HACCP karte, saskaņā ar kuru pasterizācijas kritiskie punkti (parametri) ir pasterizācijas temperatūra, pasterizācijas un separācijas procesa tehnoloģisko ciklu laiki. Visiem šiem kritiskajiem punktiem tika pievērsta papildus uzmanība, izmantojot augšminētos devējus un kontroles sistēmu.

Rezultāti

Procesa vadības vispārējā shēma

Atkarībā no izvēlētā produkta – piena, kefīra vai siera – piena kontrolierim jānodrošina pasterizācijas temperatūras uzturēšana noteiktajās robežās ar uzdoto precizitāti. Siera piena gatavošanas laikā kontrolieris nodrošina arī dzesēšanas temperatūras uzturēšanu noteiktajās robežās ar uzdoto precizitāti.

Regulējamo temperatūru atsevišķiem produkcijas veidiem paredzēts ieregulēt un izmainīt no operatoru paneļa.

Kontrolieris nepārtraukti seko iespējamajām avārijas situācijām. To gadījumā kontrolieris izdod skaņas signālu un attiecīgu paziņojumu uz operatoru paneļa displeja, kā arī reaģē uz avārijas situācijām atbilstoši saskaņotajam tehniskajam uzdevumam.

Operatoru panelis nodrošina operatora dialogu ar kontrolieri, ļauj vadīt procesu, palaižot vai apturot dažādus darbības režīmus, regulēt atsevišķus sistēmas parametrus.

Operatoru paneļa displejs informē par procesa darba režīmiem, sistēmas parametriemun avārijas paziņojumiem.

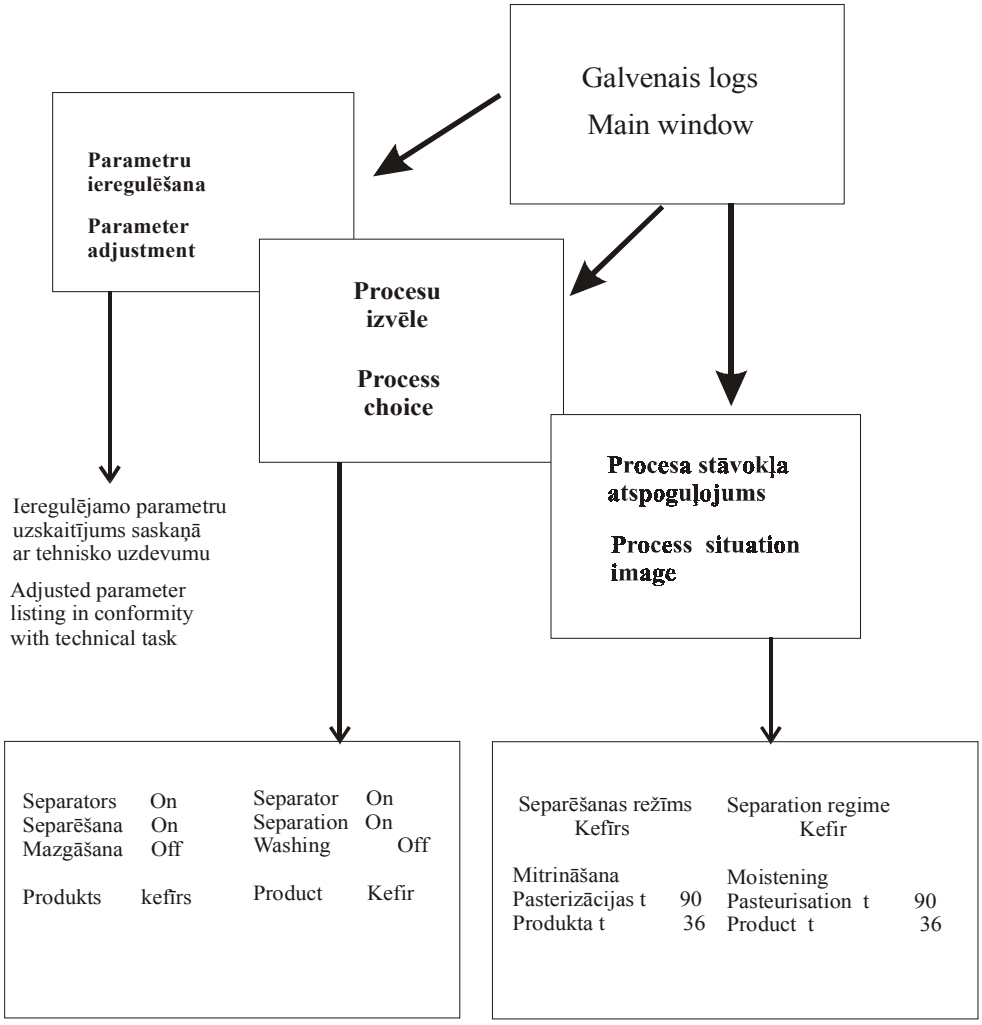
Dialogs ar operatoru tiek veidots logu formā (2. att.). Ar vadības taustiņu palīdzību operators izvēlas vajadzīgo logu un, atrodoties tajā, vai nu saņem informāciju par procesu, vai arī uz to iedarbojas (palaiž procesu, iestāda parametrus utt.) atbilstoši loga paziņojumiem. Pieeju atsevišķiem logiem iespējams aizsargāt ar paroli. Logu saturu un funkcijas iespējams mainīt.

Kontrolieri paredzēts pieslēgt datoram, nodrošinot datu apmaiņu. Tādejādi iespējams veidot automatizācijas sistēmas, izmantojot datoru kā instrumentu procesu vizualizācijai un datu arhivēšanai.

Datu vizualizācijas programma DATU CENTRS

Programmas struktūrshēma attēlota 3. attēlā.

Procesa dati no kontroliera caur RS485 maģistrāli un RS485-RS232 pārveidotāju nonāk uz datora virknes porta. Programma "Datu vācējs" nodrošina to saņemšanu, pārbaudi un saglabāšanu datu bāzē. Programma veido divu veidu datu bāzes katram procesam – procesu saraksta datu bāze, kurā ir uzskaitīti visi notikušie procesi, un katra procesa datu bāze, kurā ir dati par procesa norisi. Procesa datu bāzē tiek fiksēti visi notikumi (ventiļu stāvokļi, temperatūras, utt.).



2. att. Kontrolieru displeja logi.
Fig. 2. Controller display windows

Ieraksti datu bāzē ir kodēti, t.i., katram notikumam ir savs kods. Programma "Datu centrs" atšifrē šos ierakstus, analizē tos un izvada informāciju uz ekrāna vajadzīgā veidā, piem., grafikos, ikonās, jeb tekstā. Lai nodrošinātu elastīgas atskaites, tiek izmantota atskaišu izstrādes programma "Crystal Reports 7 PRO", kas nodrošina ne tikai augsti kvalitatīvas, pēc "WYSIWYG" principa veidotas atskaites ar priekš-apskates iespējām, bet arī iespēju lietotājam pašam mainīt atskaites izskatu.

Galvenie programmas logi parādīti 4. attēlā.

Tajos tiek attēlota procesa shēma (ventiļi, motori, devēji, caurules, utt.). Šī shēma ir "aktīva", t.i., darba gaitā mainoties kāda shēmas elementa stāvoklim, izmaiņa redzama arī uz ekrāna, piemēram, motoram ieslēdzoties, mainās tā stāvoklis uz ekrāna. Papildus šīm vizualizācijas iespējām programma analizē ventiļu un motoru stāvokļus un saskaņā ar fizikas likumiem iezīmē šķidruma kustību, iekrāsojot tās caurules, pa kurām saskaņā ar pieslēgto ventiļu un motoru stāvokļiem ir jāplūst šķidrumam, tādā veidā padarot procesa analīzi uzskatamāku un vienkāršāku. Procesa gaita tiek reģistrēta speciālā "procesu kokā", kura zari satur informāciju par visa procesa soļiem un avārijām. Papildus procesa avārijas var redzēt saraksta veidā avāriju logā.

Temperatūru svārstības var novērot mini grafikā, kurā tiek izvērsta pēdējā ½ stunda. Nospiežot detalizētā skata pogu tiek izsaukts temperatūru grafiku logs (5. att.).

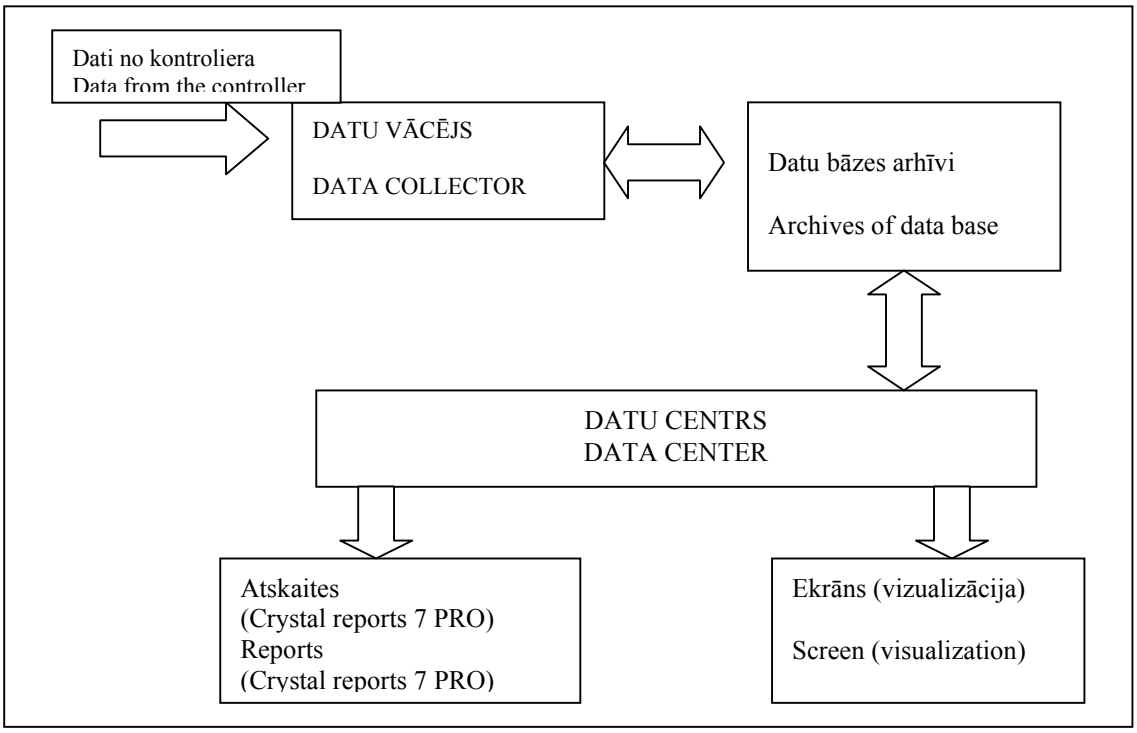
Tajā var redzēt lielāku grafiku, kuru lietotājs var mērogot un izvērst. Loga augšējā daļā atrodas:

– automātiskās grafika izvērses pogas, kas izvērš grafika asis dažādos režīmos, piemēram, pēdējās stundas garumā, dienas garumā, utt.;

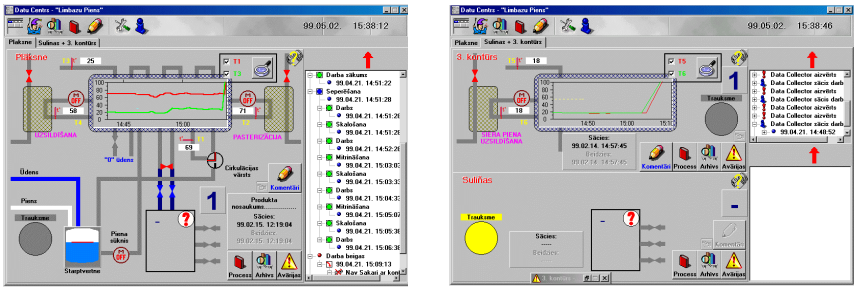
– pogas, ar kurām var ieslēgt/izslēgt grafika "restes";

– grafika izdrukas poga.

Novietojot peles kursoru uz kāda grafika punkta un nospiežot peles kreiso pogu, loga labajā pusē var redzēt izvēlētā punkta laiku un temperatūras šajā laika punktā.



3. att. Programmas DATU CENTRS struktūra.
Fig. 3. Structure of the DATA CENTER program.



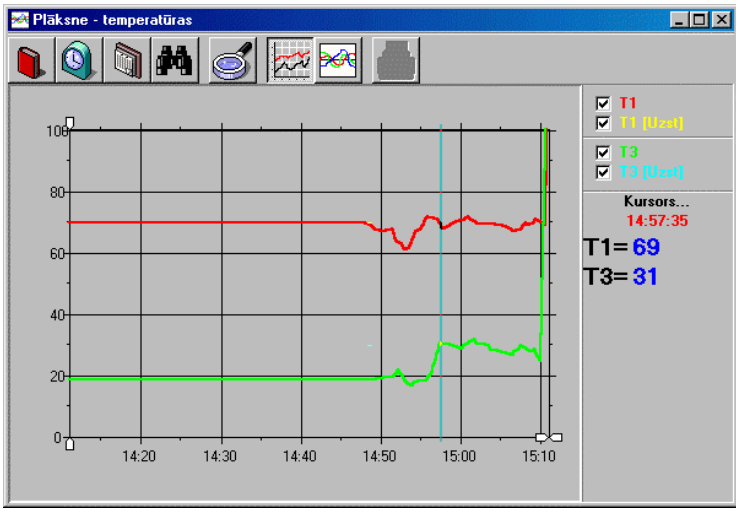
4. att. Galvenie programmas logi:"plāksnei" (pa kreisi) un "3. kontūrs un suliņas".
Fig. 4. The program's main windows: "for the plate" (left) and "circuit 3 and whey".

Analizējot uzkrātos arhīva datus pēdējā gada laikā (viens piemērs attēlots 5. att.), redzams, ka temperatūras kontroles sistēmas kopējā inerce ir mainīgs lielums, tā pamatā ir atkarīga no siltummaiņa un citām ar ārējo un tehnoloģisko vidi saistītām virsmām, kā arī no plūsmu cirkulācijas intensitātes. Mūsu izveidotajai sistēmai tā svārstās 8-10 min. robežās, bet mērīšanas sistēmas kopējā inerce ir ap 30 sekundēm. Tā kā mērīšanas sistēmas inerce ir būtiski mazāka par sistēmas pašinerci, tad mērīšanas sistēmas pielietojums ir korekts. Turklāt lielāko daļu no mērīšanas sistēmas inerces veido integrēšanas laiks, kas programmā ir maināms. Relatīvi liels integrācijas laiks tika izvēlēts, lai novērstu fluktuējošu faktoru nevēlamu iedarbību uz sistēmas regulāciju.

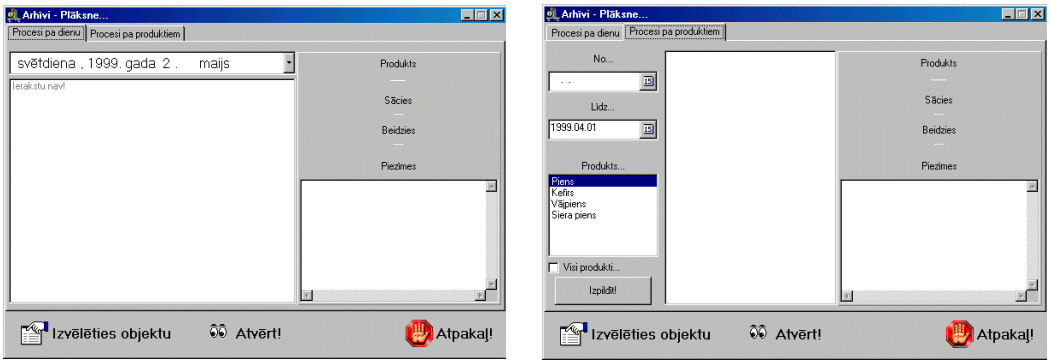
Arhīvi

Visi procesa gaitas dati tiek saglabāti un var tikt izsaukti pēc lietotāja vēlēšanās jebkurā laikā. Arhīvu var izvēlēties divos logos (6. att.)

Kreisajā logā, izvēloties kādu konkrētu dienu, var redzēt visus šajā dienā notikušos procesus. Labajā logā tiek ievadīts meklēšanas periods un norādīts produkts. Kad vajadzīgais process atrasts, to var atvērt. Atverot lietotājs redz visu procesu, ieskaitot temperatūru grafikus, procesa gaitu un avārijas. Vajadzības gadījumā lietotājs var izdrukāt vajadzīgās atskaites.



5. att. Temperatūru grafiku logs.
Fig. 5. Temperature plot window.



6. att. Arhīvu izvēles logi: procesi pa dienu (pa kreisi) un procesi pa produktiem.
Fig. 6. Archives choice windows: processes within a day and processes in products.

Procesa optimizācijas iespējas saskaņā ar HACCP prasībām, izmantojot izstrādāto procesa automatizācijas sistēmu

Pasterizācijas iekārtas automatizācija ar tā procesa norises uzskaiti nodrošina riska un kritisko punktu īpašu kontroli un kļūdu novēršanu saskaņā ar HACCP karti. Īsumā atgādinām galvenos HACCP principus, lai novērtētu riska pakāpi un izveidotu kontroles sistēmu, kas koncentrējas uz mērījumiem kritiskajos punktos, nevis paļaujas vienīgi uz gatavā produkta analīzēm. Tie ir šādi:

– riska identifikācija un riska bīstamības analīze;
– kritisko punktu kontroles identifikācija;
– kritisko robežu izveidošana;
– reģistrācijas darbības;
– korektīvās darbības;
– ierakstu glabāšana;
– pārbaudes operācijas.

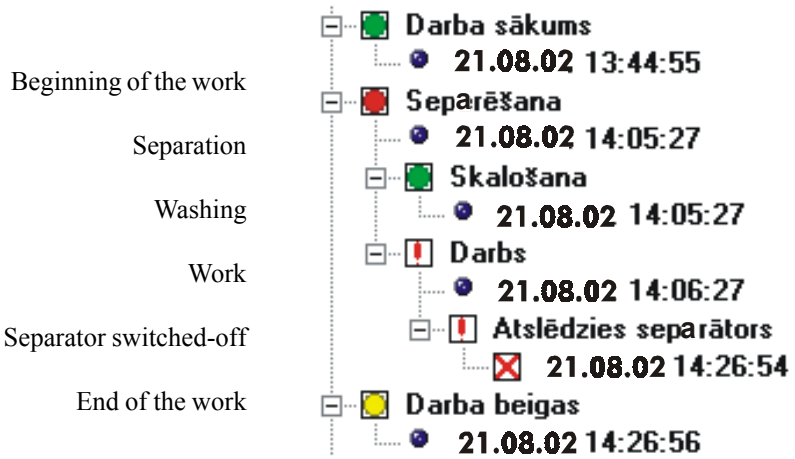
Mūsu izstrādne ir ne tikai mērījumi kritiskajos punktos, bet arī īpaša kontroles sistēma, lai novērstu iespējamās parametru novirzes.

Šeit jāpiezīmē, ka šajā gadījumā HACCP principu ievērošana pagaidām attiecas tikai uz pasterizācijas procesu, kas uzņēmumā ir visriskantākais. Ja uzņēmumā vienā ražošanas stadijā šie principi ir ieviesti, tad tos ieviest citās stadijās būs jau vieglāk, jo personāls būs ieguvis pielietošanas pieredzi.

Dotā automatizētā sistēma fiksē un kontrolē ne tikai pasterizācijas temperatūru, bet arī citas temperatūras (pasterizācijas, karstā ūdens uzsildīšanas u.c.), no kurām ir atkarīga sistēmas darbība. Turklāt vēl datu uzskaites un vizualizācijas programma fiksē katra procesa un notikuma laikus, t.i., izpildmehānismu ieslēgšanos/izslēgšanos, procesu sākumus un beigas, avārijas u.c. (7. att.) Vēl kā būtiska dotās automatizētās sistēmas priekšrocība minama iespēja elastīgi mainīt sistēmas regulācijas parametrus. Rezultātā sistēma dod iespēju konstatēt kritiskās vietas savlaicīgi, pirms tās vēl nopietni ietekmējušas izejas produkta kvalitāti.

Apskatīsim dažas situācijas, kādas var izveidoties.

1. Energonesēju (tvaiks, ūdens, elektrība) piegādes traucējumi.



7. att. Pasterizācijas procesa protokolēšana.
Fig. 7. Pasteurization process trace.

Tvaika un ūdens padeves pārtraukuma gadījumā netiek nodrošināta kāda no primārajām temperatūrām, tiek izdots trauksmes signāls, un iekārtas izpildmehānismi tiek ieslēgti atkarībā no procesa stadijas tādā stāvoklī, kas nodrošina produkta saglabāšanos.

Elektrības pārtraukuma gadījumā īslaicīga kontroliera darbība tiek uzturēta ar nepārtrauktā barošanas bloka UPS palīdzību. Ja elektrības padeves pārtraukums ir īss (līdz 10-15 sekundēm), tad sistēma turpina darboties tālāk bez izmaiņām. Ja elektrības pārtraukums ir lielāks, tad sistēma tiek ieslēgta noteiktā stāvoklī, tādā veidā izvairoties no avārijas un mazinot produkta sabojāšanas iespēju.

Vēl kā tipisks gadījums minama tvaika ieejas spiediena maiņa, kā rezultātā pasterizācijas temperatūra vairs nav pietiekami stabila, t.i., notiek tās svārstības, jo proporcionāli regulējošais tvaika ventilis nespēj izsekot šīm izmaiņām. Tam par cēloni var būt tvaika noplūde vai arī cita tvaika patērētāja nesabalansēta ietekme. Informācija par doto ietekmi atspoguļojas nepārtrauktā monitoringa grafikos. Informācija norāda uz nepieciešamību sakārtot tvaika pievada mezglus pasterizācijas iekārtai.

2. Kvalitātes novirzes cēloņu noskaidrošana.

Secinot, piemēram, ka pirms trim dienām ražotai produkcijai ir novirzes no kvalitātes, jāieiet programmā DATU CENTRS un arhīvā (kas izveidots kalendāra formā) un jāaplūko procesa norise šais dienās. No šīs informācijas var redzēt, vai temperatūru režīmi bijuši pareizi izvēlēti un nodrošināti, kā arī dažādu operāciju un iekārtu ieslēgšanas/izslēgšanas laikus. Tātad ar šādu datu analīzi var noskaidrot kļūdas, ko pieļāvis iekārtas apkalpotājs (piemēram, nepareizi regulēti temperatūras režīmi) vai kas radušās citu iemeslu dēļ (piemēram, nestabili darbojas kāda iekārta).

Šeit jāpiezīmē, ka dotajā sistēmā ir paredzēta pietiekami nepasterizēta piena atgriešana atpakaļ sistēmā, kas var notikt, ja kādu iemeslu dēļ nav izdevies sasniegt nepieciešamo pasterizācijas temperatūru sistēmas izejā. Tādā veidā tiek novērsta nepasterizēta piena izdošana. Šāda situācija var izveidoties, ja radusies problēma tvaika vai ūdens piegādē vai arī bojājums proporcionālajā tvaika padeves ventilī.

3. Sistēmas darbības novirzes savlaicīga konstatēšana.

Kā piemēru var minēt siltā ūdens padeves caurules sienas apaugšanas konstatēšanu. Šādā gadījumā temperatūras diference starp uzsildītā ūdens temperatūru un pasterizācijas temperatūru palielinās. Tas saistīts ar to, ka, apaugot siltā ūdens padeves caurules sienām, samazinās caurules siltumpārneses koeficients un caurules efektīvais šķērsgriezums, tāpēc netiek nodrošināta pietiekami efektīva siltumpārnese no caurules uz siltummaiņa plāksni. Maksimāli pieļaujamā starpība starp pasterizācijas temperatūru un siltā ūdens padeves temperatūru ir 10˚C. Pēc DATU CENTRA programmas sniegtās informācijas būs redzams, kad ir sācies caurules apaugšanas process (tas ir pakāpenisks), – pēc starpības $t_3 - t_4$ izmaiņas dinamikas. Kad, aplūkojot datorprogrammas pierakstus, kļūst redzams, ka šai starpībai ir tendence palielināties, tas nozīmēs, ka nepieciešams savlaicīgi cauruli tīrīt. Tā rezultātā savlaicīgi tiks konstatēta kritiskā vieta un novērsts sistēmas darbības traucējums.

Kā citu piemēru var minēt regulācijas parametru maiņu, ja mainās sistēmas īpašības. Datu nepārtrauktā uzskaite dod iespēju konstatēt gan ieturēto temperatūru lielumus, gan arī temperatūru fluktuāciju lielumu. Ja sistēmā nav optimāli piemeklēti procesa vadības parametri, tad regulācija notiek ar vairāk vai mazāk izteiktām fluktuācijām. Jebkura sistēma nolietojas, un tāpēc arī mainās izpildmehānismu un sistēmas līnijas elementu īpašības, kā rezultātā, pastāvot iepriekš uzstādītajiem regulācijas PID parametriem, pasterizācijas līnijas darbība nebūs optimāla, t.i., sāks palielināties temperatūras svārstību amplitūda. DATU CENTRA

monitoringa programma jau savlaicīgi "brīdinās" par nepieciešamību piekoriģēt PID regulācijas parametrus.

Paaugstinātas temperatūras svārstības (jau virs ±2˚C) atstāj nevēlamu iespaidu uz izejas piena kvalitāti. No vienas puses, temperatūras paaugstinājumi piena svārstību augšējās amplitūdas iedarbības rezultātā samazina piena recināšanas kvalitāti, kas savukārt ietekmē ražojamā siera kvalitāti. No otras puses, temperatūras svārstību apakšējās amplitūdas iedarbības rezultātā netiek nodrošināta pilnīga baktēriju iznīcināšana. Šāds piens nebūs lietojams turpmākai apstrādei un būs atkārtoti jāpasterizē, kas savukārt, deformējot pienā esošā kazeīna kvalitāti, ietekmēs siera kvalitāti.

Diskusija

Kā jau minēts, dotajai sistēmai ir iespēja ērti un uzskatāmi mainīt ieregulētos parametrus. Tos svarīgi koriģēt, mainoties gatavās produkcijas veidam un piena kvalitātei. Pasterizācijas parametrus izvēlas atkarībā no piena analīzes rezultātiem, sezonas un laika apstākļiem.

Datorizēta uzskaites sistēma padziļina saiti starp ieejas (piena kvalitāte, sezona, laika apstākļi) un pasterizācijas parametriem. Šīs saites padziļināšana izpaužas tādā veidā, ka personāls precīzi fiksē ieejas parametrus, bet datorprogramma arhivē pasterizācijas procesa norisi un, saistot to ar izejas piena produkta kvalitāti, personāls iegūst iemaņas pēc iespējas precīzāku pasterizācijas parametru izvēlē atkarībā no ieejas rādītājiem.

Šāda elastīga parametru maiņa atkarībā no pienākošā piena īpašībām ir svarīga mūsu apstākļos, jo saimniecības ir samērā nelielas un līdz ar to piegādātāju skaits ir liels. Tā rezultātā pienākošā piena tauku saturs un citi rādītāji dažādās piena partijās var atšķirties būtiski. Uz šo faktoru ārzemju piena pasterizācijas iekārtu ražotāji lielu vērību nevērš, jo šāda situācija nav tipiska piena pārstrādes uzņēmumos pasaulē.

Dotās sistēmas ieviešana veicināja noviržu konstatēšanu ražošanas procesā, kā rezultātā savlaicīgi tika veiktas operācijas to novēršanai. Atkarībā no pienākošā piena parametriem ar lietotājam ērtu interfeisu tika pieskaņoti procesa parametri. Tas palīdzēja nodrošināt stabilu kavalitāti dažādām piena partijām.

Dotās izstrādnes ekonomiskais efekts ir neapšaubāms, kaut gan grūti kvantitatīvi novērtējams, jo tas ir saistīts ar ražošanas kvalitātes stabilitātes uzlabošanos, personāla kvalifikācijas pilnveidošanu un uzskaites sistematizēšanu. Bez tam sistēmas ieviešanas rezultātā samazinās iekārtu apkalpotāju – operatoru – darba apjoms, kā rezultātā viena operatora pienākumu apjomu maiņā varēja palielināt. Kā integrālu kvantitatīvu rezultātu varētu minēt vidējo brāķa procenta samazināšanos no 4% uz 1.5%.

Slēdziens

Dotais piemērs liecina, ka procesu kontroles metožu un iekārtu pielietošana var veicināt ražošanas procesa pilnveidošanu. Pielietojot procesa kontroles sistēmu ražošanā ar HACCP principiem, tiek izvērtētas un īpaši kontrolētas procesu norises "vājās vietas". Šajās "vājajās vietās" izstrādāta un apgūta īpaša kontroles sistēma, arī rekomendācijas organizatoriskām pārmaiņām ražošanas procesā. Kā minēts ievadā, pamatojoties uz līdzīgiem principiem, ir izstrādātas un darbojas procesu kontroles un vadības sistēmas vairākos citos uzņēmumos (Vanags, 2002).

Pateicība

Šis darbs tika finansēts no LZP (Proj. 369), IZM (TOP 27-01), a/s "Limbažu Piens" un a/s "Biotehniskais Centrs" līdzekļiem. Paldies as. prof. I. Ciprovičai par konsultācijām.

Literatūra

1. Berg, vom, B., Groppe, P. (1999) Pack den Tiger in die Schaltung. In: *Messen, Steuern und Pegeln mit dem BASIC – TIGER SYSTEM*. Franzis Verlag GmbH, pp. 121-128.

2. Blija, A., Skore, D., Karklite, A., Galoburda, R. (1999) Food quality management in the public catering. In: *Materials of the 10th Biennial Congress of ARAHE*. Yokohama, Japan, 16-19 August, 1999. Topic 6-29.

3. Blija, A., Skore, D., Karklite, A. (2002) Changes of food quality management systems in the public catering. In: *Changes at the Other End of the Chain*. Butijn, C.A.A. et al. (ed.). Shaker Publishing, the Netherlands, pp. 43-48.

4. *Dairy Processing Handbook* (1995) Tetra Pak Processing Systems AB, Lund, 436 pp.

5. Hui, Y. H. (ed.) (1993) *Dairy Science and Technology*. VCH, New York, etc., vol. 1, 2, 3.

6. Kārklīte, A., Blija, A. (1999) HACCP sistēmas ieviešana praksē. *Zinātniski praktiskā konference "Jaunais gadsimts un pārtika". Referāti*. Jelgava, LLU, 181.-185. lpp.

7. Ozola, L., Ciproviča, I. (2002) *Piena pārstrādes tehnoloģija*. Jelgava, LLU, 248 lpp.

8. Spreer, E. (1995) *Technologie der Milchverarbeitung*. 7. Aufl., neubearb. und aktualisierte. Behr's, Hamburg, 571 S.

9. Vanags, J. (2002) Biotehniskais Centrs – perfekti automatizācijas risinājumi. *Enerģētika & Automatizācija,* Nr. 12, 58.-59. lpp.

10. Vanags, J., Viesturs, U. (2001a) Flexible process control application based on local mixing intensity measurements. In: *Novel Processes and Control Technologies in Food Industry*. Bozoglu, F., Deak, T., Bibek, R. (eds.), IOS Press, Amsterdam-Berlin-Oxford-Tokyo-Washington, DS, pp. 24-36.

11. Vanags, J., Viesturs, U. (2001b) Elastīga

ražošanas procesu kontrole pārtikas rūpniecībā. *Konferences "Pārtikas un uztura attīstības virzieni nākotnē" materiāli*. Jelgava, 205.-211. lpp.

12. Vanags, J., Viesturs, U. (2001c) Local mixing intensity measurements for the food industry and biotechnology. *Food technol. Biotechnol*., 39 (1), pp. 59- 65.

13. Varnam, A. H., Sutherland, J. R. (1994) *Milk and Milk Products: Technology, Chemistry and Microbiology*. Chapmann & Hall, London, 451 pp.

14. Walstra, P., Geurts, T. J., Noomen, A. et al. (1999) *Dairy Technology: Principles of Milk Properties and Processes.* Marcel Dekker, New York-Basel, XV, 727 pp.

Reflections on an Ethic Development for Rural Areas
Lauku ētikas veidošanās atspoguļojums

Carmelo Cannarella
National Research Council of Italy (CNR), e-mail: carmelo.cannarella@virgilio.it
Itālijas Nacionālā Zinātnes padome, e-pasts: carmelo.cannarella@virgilio.it

Abstract. This article provides some considerations and analytical tools about the issues related to the problems of definition, measurement and policy analysis on development in rural areas. The mutual relations between man, space and time create a dynamic framework in which human development process plays a fundamental role. The identification of a human centered approach in development highlights the presence of a plurality of human needs which should be analyzed, quantified and formalized as determinants of a problematic complex essential in the definition of political and economic choices for rural development. In this perspective, development is thus based on a "global interdependence" between economic results and the value of rights, dignity and freedom which has to be incorporated in the evaluation of the resulting situations. The achievement of material and not material resources can be the result of the respect of social rules (duty, loyalty, good will) deriving from an ethic consciousness in which competition and utility as well as rights and freedom can be quantified and qualified through identified parameters of intrinsic value.
Key words: development, rural areas, ethics, human resources.

Introduction

The present evolution of agricultural policies in Europe pushes to pay more and more attention to rural development whose conceptualization should represent the core of all rural studies. A large number of meanings and concepts, placed in several different but interrelated analytical levels (locality, land use, spatial classifications, socio-economic variables – producers, laborers, consumers – historical variables, environment and agricultural issues, policy making processes, etc.) are critically involved towards a) the definition of what should be considered "rural" and b) the interpretation of the dynamics of "development".

A wide theoretical debate, particularly focused on regional economic growth theories (Camagni, 1992, 1995a, 1995b), is at the base of different approaches to rurality. Three main approaches can be very synthetically identified in the classification of these economic theories according to an idea of "rural space" which respectively refers to a spatial, a territorial and a constructivist approach. Spatial approach is based on a strong interweave of rural with agriculture and the urban-rural dichotomy (Blanc, 1997; Halfacree, 1993; Pratt, 1996); territorial approach emphasizes the economic diversification of rural areas and it is referred to a local economic approach (Saraceno, 1994; Keating, 1998) while according to constructivist approach rural space appears as a social representation and a mental construct (Hoggart et al., 1995; Halfacree, 1993; Pratt, 1996).

From these analyses, rurality appears as a very dynamic concept, being influenced by continuing evolving geographical, historical and socio-economic variables which can be embodied in many expressions of the "human factor": traditions, mentality, power balances among different social groups, ethnicity, religions, languages, etc. Rurality therefore cannot be separated from an idea of "evolution" and the related identification of those elements at the base of the "processes of change" in rural areas. The mutual relations between man, space and time create a dynamic framework in which human development process plays a fundamental role. In this perspective, local resources, peculiarities and contexts (Blanc, 1997; Halfacree, 1993; Moseley, 1996) are influenced by a complex interplay between a socio-economic and a socio-cultural dimension which however constitute development as *one* process. These dimensions can be measured and evaluated on the one side through the potential acquiring or consuming of material goods and, on the other side, by potential fulfillment of mental, cultural, psychological and social values (justice, tolerance, human rights, unarbitrary and lawful wealth, etc.). It is important to underline again that these two dimensions deeply interact being components of the same whole process. The availability of an adequate quantity and quality of certain tangible goods is an essential precondition to the fulfillment of intangible resources and *vice versa*. The combination of these two dimensions is at the base of the identification of basic needs for human development: they cannot be considered two different (and opposite) *interpretations* of development. Nevertheless conventional economic analyses tend to be focused essentially on the material

facet of development, which can be quantified, while its immaterial side (and the related influences on the material side) is usually neglected. Many economic discussions about development in rural areas are thus deprived of critical factors which deeply determine individual and social behavior and choices.

The same limit of conventional economic analyses can be found while evaluating and quantifying development: being focused only on one aspect of development, these analyses can provide a partial quantification of its material elements. The possibilities to consider and evaluate "development" in its global reality unavoidably imply a concrete paradigm shift from the assumption *GNP increases=progress* to *global development+quality of life=progress* perspective (Henderson, 1999) capable to assess development in a more holistic way encompassing fields as diverse as children's services, arts, culture, infrastructure, etc. all concerned with maintaining and improving quality of life of people involved. The inclusion in the definition of development of elements such as human values, person's nature, well-being, income and power distribution, etc. drives to make some necessary considerations not only about efficiency in economic, social and public decisions but also about the effectiveness of these actions within an ethic environment.[1] The idea of an efficient and effective development involves some crucial considerations about equity, social justice as well as those market's limits to provide adequate answers to these questions. An analysis on the relations between market and development opens in fact the discussion about mechanisms and possibilities to generate a widespread well-being, on environmental and social sustainable bases, involving those categories (social groups but also regions, areas and economic activities) defined "weak" by conventional economics for their incapability to nourish their own development.

An efficient and effective development is thus related to its capabilities to provide some concrete remedies to the unavoidable market political, social and economic distortions. The possibilities to define this development path should be based on an analytical perspective capable to calculate social and public costs, promoting and elevating social welfare in order to find a balance between economic efficiency and social effectiveness. Justice, solidarity, creativity and adequate life standard levels are for this reason essential concepts to complete and integrate any analysis on development**:** competition and efficiency are in fact partial elements which have to be accompanied by other basic parameters of development

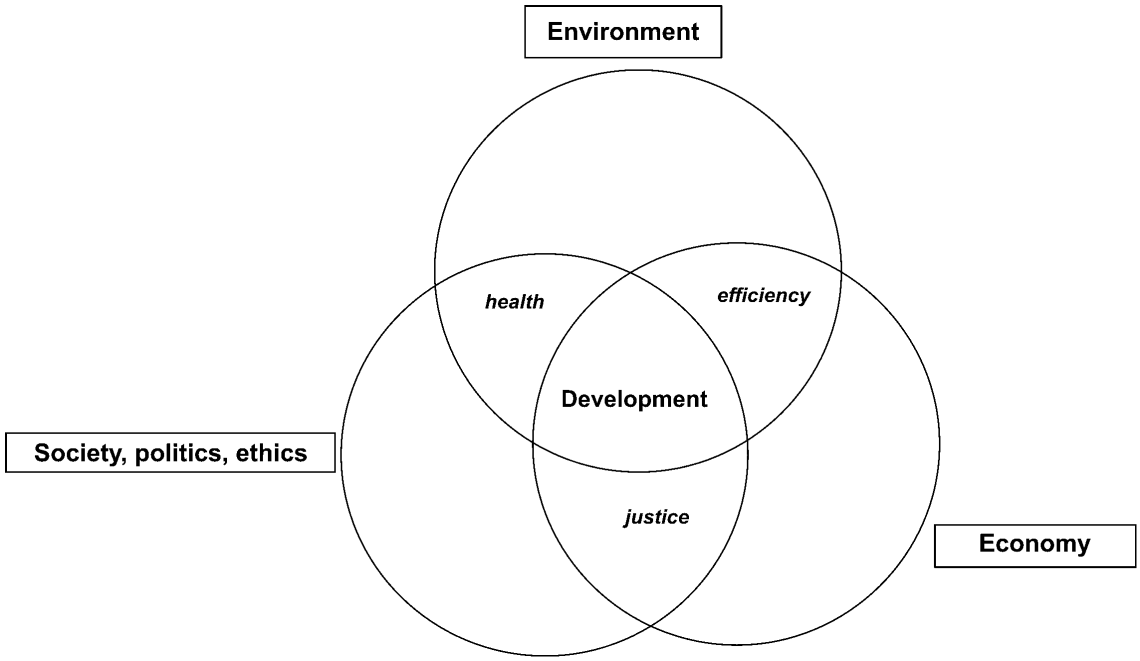


Fig. 1. Systems and interrelations of global development.

[1] In this discussion it is not possible to provide a detailed analysis about the issue of public choices. For these topics see for example Arrow (1963), Davidson et al. (1957), Elster and Hylland (1986), Feldman (1980), Fishburn (1973), Gottinger and Leinfellner (1978), Green and Laffont (1979), Hammond (1986), Heller et al. (1986), Mueller (1979).

(Fig. 1). This is the reason why Gross National Product (GDP) calculations cannot be used to measure development because they completely ignore the informal and unpaid economy of caring, volunteering and mutual aid (mainly provided by women). These activities often represent a "social glue" and a substantial share of society in particular (but not exclusively) in developing countries and in regions hit by dramatic economic and political crises (Sen, 1997a; Henderson, 1999).

What is development?

The inclusion of ethic and emotional considerations in the definition of a dimension placed beyond the idea of "utility" can represent an important step in understanding eventual divergences between economic and social welfare: GNP increases not necessarily drive in fact to parallel increases in social well-being. The interactions among political, social, economic and cultural dimensions are critical factors towards the identifications of the elements which, influencing human behavior, can support development and make, in the same time, economics more efficient and effective. Economic policies for rural areas are in fact always accompanied by definite ethic patterns which are usually referred to modernization and rationalization strategies but the definition of "modernization" or "modern" is an extremely complex issue: "traditional" is not synonym of "lack of modernity". In addition, a "rural community" is only *one* human interrelation system among an extremely huge number of relations in which individuals can be simultaneously classified (or in which individuals classify themselves). The definition of these concepts implies complex analyses about the dynamic mechanisms of social, economic and political change from which development *can* spring (Hettne, 1996; Eisenstadt, 1974; Martinelli, 1998; Sen, 1975, 2000; Germani, 1971): it means identification and interpretation of specific historical problems connected to nature and succeeding of socio-economic systems and the mechanisms of their inner development and interaction which influence the differentiation among social groups, the transformation of a society or the eventual failure of this transformation.

Yet, the discussions about development cannot avoid the problem of the value-judgements which can be given to different kind of society and to development itself: is there an objective possibility to classify and order societies within a hierarchic scale according to an idea of developed, developing and under-developed society based on their presumed superiority in economic or social evolution? Is there a unique pattern and a "right" direction in development according to which under-development could be solved?

Possible answers to these questions are related to the above mentioned socio-economic and the socio-cultural dimensions in development which refer to two corresponding approaches: an engineering and an ethic approach. On the one side, the idea of progress is related to changes in production resources (for example in technologies) and in social relations towards more efficiency; on the other side, progress is linked to a concept of a *positive social result*. A direction to social change can arise only from the involvement of both sides thus determining development as oriented change. It is evident that this double faced problematic nature of development can create some analytical problems: the engineering side of development, being mainly related to economic factors, can be measured and evaluated through quantifiable data (incomes, savings, prices, inflation, trade flows, employment, etc.). What to do with the ethic side which incorporates many non-quantifiable and intangible values for which there is no monetary measurement at present? How to quantify the non-quantifiable? And finally: how it can

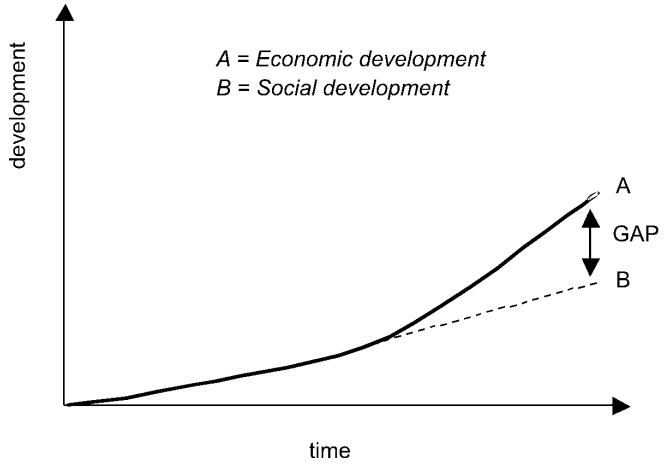


Fig. 2. Economic and social development.

be possible to re-connect these two facets within a whole process?

In recent years many indicators of social well-being have been developed at the community, national and international levels which can be adopted "to monitor the social system, helping to identify changes and to guide intervention to alter the course of social change" (Land, 1999). These quality of life indicators concretely contribute to increase interests about the dynamics of social conditions providing useful tools in the effort to re-connect economic and social progress.[2] These indicators often confirm in fact how economic growth rarely corresponds to a sustainable human development both in more advanced and in less advanced economies.

This condition frequently arises when ethic, human and environmental issues are not adequately incorporated into public choices and decisions thus creating a gap (Fig. 2) measured in terms of a divergence between economic indicators (income, savings, productivity, employment) and human and environmental indicators (justice, equity, environment protection, education and social services' quality, health, housing, etc.). In addition, the eventual presence of political and administrative corruption contributes to widen this gap: corruption, diverting resources from their efficient use, make the social tissue unable to translate a potential growth in private income into widespread well-being through quantity and quality increases in public services' provision[3].

If the ethic side of development is neglected, the possibilities to fill the gap showed in Figure 2 are unavoidably linked to the capabilities of the social tissue involved to quickly adapt to the modified scenario in order to solve the consequent contradictions. This creates the bases for destabilizing conditions, crises and tensions whose depth and dynamics depend on the instruments at disposal of the social tissue to manage these changes and on the variability of this adaptation behavior which can greatly vary in time and space and also according to different social, age and gender groups. Changes are in fact socially and individually lived in different ways because dimension and complexity of these groups can vary in different historical periods and in different development stages.

The inclusion of ethic considerations can concretely contribute to provide more complete answers for a so-called 5W1H question scheme (Who, Where, When, Why, What, How) in re-thinking development: it is clear enough that finding answers for these apparently plain questions can be often a rather difficult task because this step involves a deep analysis about a great number of material and immaterial variables linked to economic, technical, political, historical and cultural dimensions. These variables frequently act as "causes" concretely influencing the social, political and economic tissue which, in this perspective, thus becomes a sort of "final effect" resulting by the interaction of these variables within a historical process. Even each variable represents a final result of similar interactions; for this reason complex feedback chains are produced among variables and factors involved. These linkages can be represented in a "relation diagram" (Fig. 3a), a graphic representation and an exemplification of this cause-effect network. Many answers to the above mentioned questions can be found within this relation network to be considered as problematic systems even if a quantification of the interrelation degree among components (being many "human" elements not immediately expressed by numbers for example cultures, traditions, memories, opinions, etc.) still remains a very difficult task. These diagrams, however, can provide some interpretative keys identifying events and factors which can be focused on a relation system through coherent interrelations among causes and effects.

At a theoretical level, these diagrams can contribute to highlight a crucial paradigm of an ethic development: a right action can be judged as such only if analyzed as a whole through the rightness of its consequences (Fig. 3.b)[4]. Taking into consideration the effects which could arise from the adoption of development actions could be considered a rather obvious assumption but it becomes less obvious if these impacts are analyzed and evaluated through a perspective diverse from an economic one (in a conventional sense) which is traditionally based on the idea of *maximization of personal utility*. This paradigm shift implies the incorporation (and the related value or dis-value assessment) to relations different to the utility ones. Many relevant economic relations operate thanks to a wide versatility in behavior and values: rights and freedom for example could be seen not only as legal or deontological principles but also as entities having an

[2] About this kind of "system of social accounts", an important work has been done during these decades with a great number of publications and research activities. See for example Henderson (1974), Land (1999), Sen (1993), Sen (1997b), Peterson and Naresh (1997), Cummins (1997), Booysen (2002), Johansson (2002), Noll (2002), Hudler and Richter (2002).

[3] Italy provides a typical example of this condition in which, due to political and bureaucratic corruption, even high private incomes are accompanied by administrative inefficiency and an extremely poor provision of low quality public goods and services. See for example Vannucci (1997), Benassi and Sganga (1994).

[4] This analysis on impacts and consequences implies relevant considerations about the presence of different opinions in the evaluation of a concrete situation. For these topics see for example Scheffler (1982), Slote (1985).

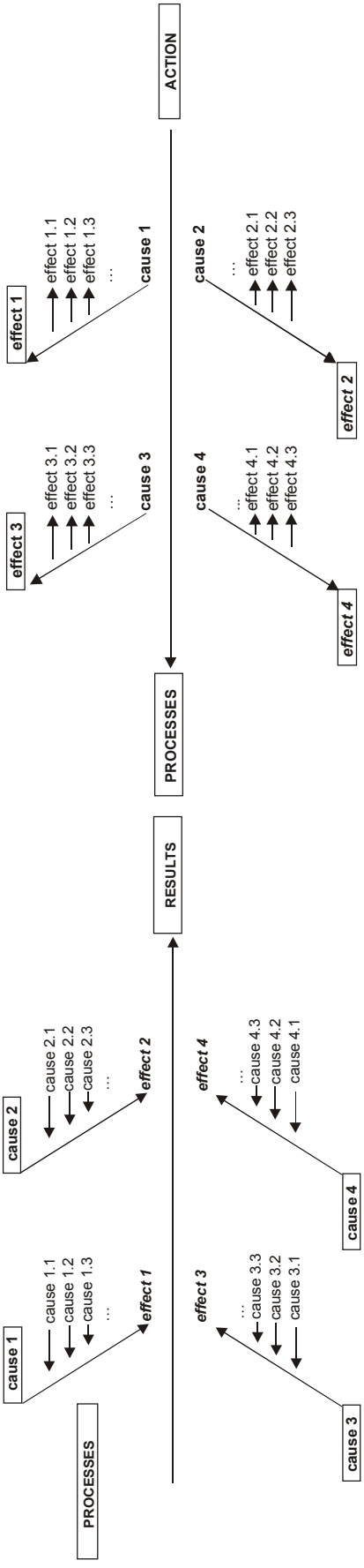


Fig. 3.a A relation diagram for results.

Fig. 3.a A relation diagram for actions.

Fig. 3. A relation diagram.

intrinsically autonomous value (Guest and Milne, 1985; Sen, 1992). In this scenario, the systematic deviance from a behavior based on personal utility towards a behavior based on rules (duty, loyalty, good will) could concretely contribute to achieve also economic efficiency both at individual and at group level (Morishima, 1982; Sen, 1985b).

The inclusion in this relation network of elements which could elevate the concept of "rationality" in human behavior, influencing and enhancing the potential options for the definition of interests and possible choices, can drive to a rethinking in some principles of fundamental mechanisms of conventional development towards the definition of an "ethic" development such as:

a) individual and community well-being do not depend exclusively on "consumption" or "production" factors;

b) individual tasks and goals are not focused exclusively on maximization of personal well-being, but they can be based also on the value assignment to group and others' well-being;

c) individual choices are not driven exclusively by the achievement of personal interests but also by the acknowledgement of a reciprocal interdependence of "personal successes".

These principles are substantially independent representing crucial elements in the definition of an ethic development essentially based on social well-being: of course, it is always necessary to admit the existence of an instrumental value in the acceptance of rules or social interests towards the achievement of personal goals. This idea of development doesn't exclude in fact the presence of personal interests, but it tends to stimulate the convergence of interests within a community (with the related actions of loyalty towards this community) which can drive to a more efficient achievement of these personal goals. An ethic development is thus connected to the respect of social responsibilities as fundamental individual duty. Ethic development could be therefore defined as a human and environmental process directed to the achievement of material and not material resources through the respect of social rules (duty, loyalty, good will) related to an ethic consciousness in which competition and utility as well as rights and freedom are quantified and qualified through identified parameters of intrinsic value.

Needs and choices in development

The presence of different perspectives in the identification of individual goals is a crucial step towards a definition of needs both at individual and at community level overcoming the conventional notion of "demand". These needs can be expressed in different forms and can show diverse motivations and different (continuing evolving) possible relationships with endogenous and exogenous sources of development. For this reason diverse types of actions have to be considered useful to ethic development in rural areas by distinguishing between the types of development actions that can meet these needs. A summary diagram can highlight the different links that are possible in a rural area, in particular between: a) **the actions needed** for an area's development; b) **the activities required to meet these needs** (for example exogenous/endogenous development through recovery/development with local actions and resources, acquisition of development through external actions and resources, specific actions, etc.); c) **various types of development provision and sources of development**; d) the **basis of provision** for each of these sources of development. This summary diagram can be drawn through a Quality Function Deployment (QFD) type chart (Fig. 4): it describes the general framework within which the

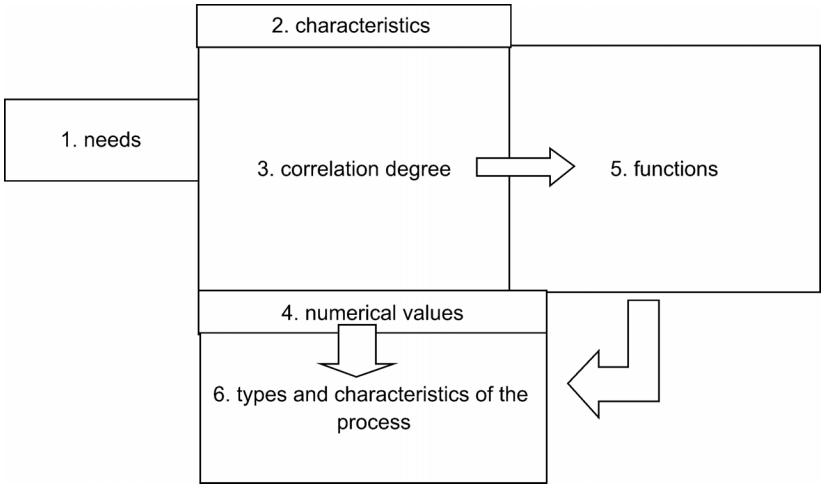


Fig. 4. A QFD type chart.

actions needed for rural development and the different means for satisfying those needs are expressed defining characteristics and possible impacts of the processes and methods *during a planning phase*. The Quality Function Deployment (QFD) is in fact a managerial method created for quality assurance in new products during the planning and development phases (Akao, 1989). The main benefits of this method, which can achieve a very detailed level, are linked to the promotion of a *preventive development* rather than a *reactive one*. It can be expected that the benefits obtained thanks to this method in production of goods and services could be achieved by its adoption, as operative approach, also in the definition of intervention action to support social development. A QFD could be synthetically defined a method to translate needs of the final users into corresponding characteristics of the required measures through the following steps:

1. identification of needs;
2. definition of planning methods;
3. characteristics of single elements and factors of the process;
4. implementation;
5. standardization of the processes.

This approach should contribute: a) to understand the needs of the final users reducing the risk of wrong approaches; b) to reduce time losses; c) to reduce costs (in particular those related to correction actions); d) to improve the final users' satisfactions; e) to increase success margins.

In this way the identification and fulfillment of a need become essential elements which should underlie any process from the sources of intervention useful in developing rural areas contributing to modify many present approaches to development issues. In theory, the range of intervention sources in rural development can be extremely wide but practical experience can easily confirm how many organizations tend to be aimed at developing measures of direct relevance to "conventional" rural issues. This includes all sector organizations, especially in the farming and agri-food field, in rural tourism, craftworking, etc. Often the vocation of these institutions leads administrators to focus on a particular objective and to confine themselves to it, which results in the introduction of ever-greater specialization, as well as a certain compartmentalization between institutions. The main limit of these organizations is that (unfortunately) in many cases they operate according to their own rules (often political), without a useful and effective connection with the outside, being more committed to mediate interests. Even in research, which provides crucial contributions in this field, this departmentalization can be found: the rural issue is highly segmented: studies on environment, land use, agriculture, urban/rural relations, rural economics, rural sociology, etc.

Apart from the above mentioned political inefficiency deriving from corruption, these QFD diagrams should contribute to solve some inadequacies between the needs' side and the intervention provision side. These inadequacies often are biased on the following problematic issues:

a) **inadequacies deriving from the nature of institutions responsible for development**: they can include:

– inadequacies in terms of **distance** – this means a physical distance between institutions and rural areas. Added to physical distance is the psychological distance deriving from the fact that often administrators and bureaucrats know little about rural environment. Many aspects of rural development are not immediately evident and considered low profile issues: politicians tend to be not interested in them;

– inadequacies in terms of **time** – Institutions and Agencies have their own "time"; in many cases procedures last several years, whereas needs for development can be generally short-term;

– inadequacies in **interests and in defining the intervention objective** – for many bureaucrats, the intervention objective may be divorced from a global vision of the area: frequently the objective is too circumscribed, limited and partial, rather than a part of an overall territorial strategy;

– inadequacies in terms of **approach** – politicians often ignore those very institutional or other contextual aspects that prove so essential to rural development or to instigating change in an area;

– inadequacies in terms of **communication**: political institutions and agencies tend to use two different languages. The former language is mainly based on juridical and legal terms while the latter is tailored for specific intervention areas (agriculture, health, environment, scientific research, etc.). The result of this coexistence of languages is frequently translated into very complex documents which create severe communication problems between institutions and individuals and among institutions. This condition can also be the consequence of an unclear language frequently adopted in State law and regulations to which local offices have to refer. These documents are rarely written paying attention to the final users being created to be mainly coherent to bureaucratic languages;

b) **inadequacies in terms of practices**: the lack of adequate knowledge on rural development mechanisms results in actions that sometimes conflict with rural development needs and territorial approaches;

c) **inadequacies associated with financial problems**: in general, very few financial resources are earmarked actions directed to aid rural development. Many intervention measures that may be useful to rural areas

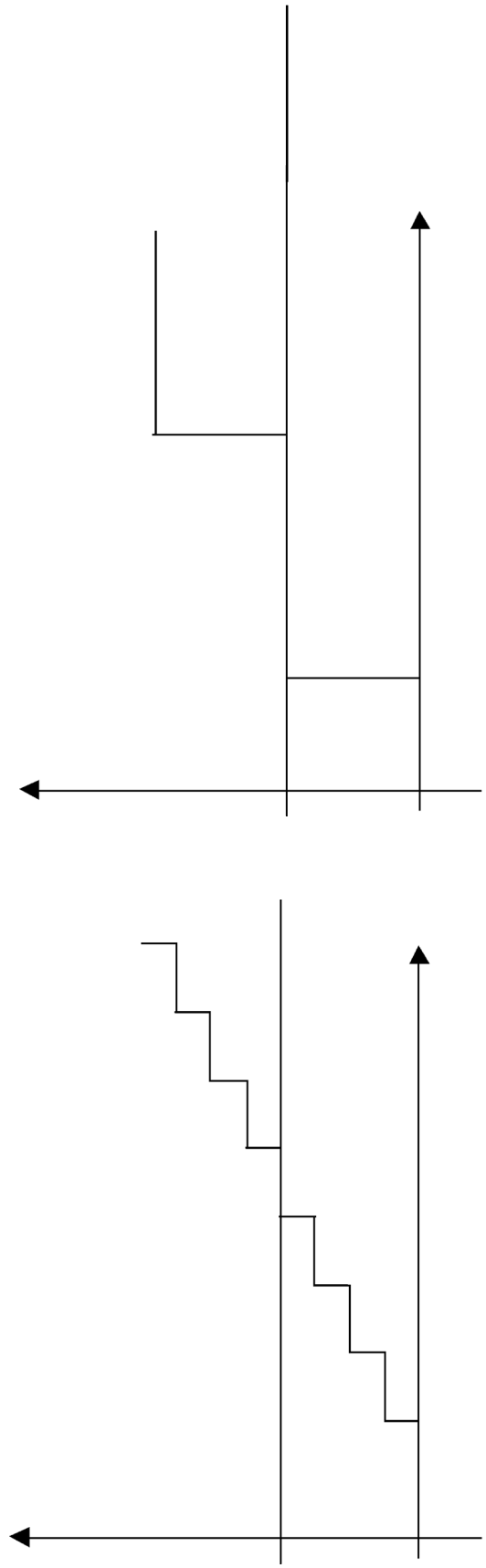


Fig. 5. Leni gradu and pleno gradu approaches.

are often the product of actions directed for other purposes, for example, sector actions, especially in agriculture, energy, environment, etc.

It is clear enough that many of these inefficiencies result because needs are not adequately identified, quantified and graded. Considering needs as standpoint for any analysis on ethic development, having their identification a chronological precedence over the means to satisfy them, it is possible to synthetically distinguish two different approaches in development which could be named, in Latin words, *pleno gradu* (with few big steps) or *leni gradu* (with many small steps) (Fig. 5). *Pleno gradu* is the conventional approach to development generally based on great breakthroughs: it usually implies high costs and risks with the involvement of a great amount of national and foreign investments, high-skilled human resources as well as advanced financial services. The implementation of this strategy requires, for this reason, subsidies and concrete incentives to stimulate a convergence of investments in rural areas which can become a difficult task if rural areas show critical conditions (because a larger part of these investments are based on urban population savings). The introduction of development actions through a *pleno gradu* strategy is generally led by an elite of specialists, focused on new technologies, sudden implementation of new approaches and methods, and fast demolition of previously adopted methods and processes. The *leni gradu* approach in development is based on a slow and gradual change with the involvement of large groups of human capital because it tends to improve the existing resources and the conventional know-how. For this reason, this strategy requires less investments and shows less evident immediate results than the *pleno gradu* approach because it is mainly focused on human resources, processes and personal commitment while the other one is mainly technology and profit based. Differences between *pleno* and *leni gradu* approaches are resumed in Table 1.

As previously mentioned, development is based on complex processes: for this reason the implementation of a *leni gradu* strategy has to be linked to small improvements in all the processes involved. In the same time, in order to make this strategy "stable", it is extremely important to introduce simple methods easily accessible to a large number of potential users. Little improvements within the introduction of innovations are stable when based on a standardization of processes thanks to the implementation of a maintenance, correction and improvement phases. When these three phases are incorporated in commonly shared usual procedures, then it will be possible to move to the next step with the introduction of little further innovations.

Concluding comments

A society is a complex system articulated in an extremely wide variety of sub-systems. This means that the understanding of the characteristics of a society (or segments of a society) interested by development processes plays a crucial role: historical circumstances always modify characteristics and needs of specific social groups within the dynamic process of social change which nourishes development. For this reason, there isn't a unique way to development but approaches and methods should be adapted to these specific contexts and historical circumstances.

Development can show its own efficiency and effectiveness: these goals can be achieved through a simultaneously just, healthy and efficient process according to some tangible (technical, physical, mathematical parameters) and not tangible patterns (ethic, psychological, philosophical, juridical parameters): both sides are essential to the achievement of an adequate individual and social well-being.

This approach is thus based on a "global interdependence" perspective in which economic results and the value, for example, of rights' respect (or environment protection or personal commitment) or the dis-value of rights' violation (or environment degradation or political corruption), are incorporated in the evaluation of the resulting situations (Sen, 1982, 1985a). The evaluation of these interdependences is an essential step in the analysis of possible choices within a development process because any activity, having an instrumental role, produces consequences; even economically efficient activities can determine unexpected social consequences. In order to achieve a global evaluation of these activities it is thus not sufficient to evaluate their value in ethical terms, but also their instrumental role and their potential positive

Table 1

***Leni* and *Pleno Gradu* approaches**

	Leni Gradu	Pleno Gradu	
Investments required degree	Low	High	
Efforts required degree	High	Low	
Human resources involvement	High	Low	
Priorities	Commitment and efforts	Results and profits	
Focus	Culture and mentality	Technology	

or negative effects on other spheres. In this perspective, a choice could be defined "right" when also its impacts are just, healthy and efficient.

In conclusion, it is essential to recognize that development, under-development and poverty are primary political phenomena and only secondly economic issues: politics have to play a critical role in the discussions on development. An ethic development is not directly based on the provision of an adequate quantity of material and immaterial resources to support well-being because the point is linked to the understanding the mechanisms which facilitate or hamper the effective or potential availability of these resources. The main focus is not only how to create well-being but also how to make it available for all through the creation of those conditions essential of its circulation, achievement and self-nourishment. Hence the main obstacle to development should be identified in *exclusion*: poverty should be rather considered as an effect of the exclusion from material and/or immaterial resources.

All this unavoidably implies critical considerations which involve role and nature of politics both at internal (for example about nature of modern democracy itself) and international level (for example nature of international relations, action of super-national subjects, etc.). In both cases, *responsibility* (and its reverse side *political apathy*) represents the focal point of the issue: in brief, no ethic development can be carried out if mediated by political forces inspired by the concept of "renounce to responsibility" or "renounce to consciousness".

References

1. Akao Yoji (1989) *Quality Function Deployment for product development*. Union of Japanese Engineers and Scientists, Tokyo, 387 pp.

2. Arrow, K. J. (1963) *Social Choice and Individual Values*. Wiley, New York, 131 pp. (Italian translation, Etas Libri, 1977.)

3. Benassi, L., Sganga, S. (1994) Sviluppo, criminalitą e corruzione (Development, crime and corruption). In: *Qualeimpresa*, n. 4, pp. 40-54. (In Italian.)

4. Blanc, M. (1997) Rurality: concepts and approaches. Paper presented at the 48th Seminar *Rural restructuring within developed economies of the European Association of Agricultural Economists*, Dijion, 20-21 March.

5. Booysen, F. (2002) An Overview and Evaluation of Composite Indices of Development in: *Social Indicators Research,* Vol. 59(2), pp. 115-151.

6. Camagni, R. P. (1992) *Final report of the research project on development prospects of the Community's lagging regions and the socio-economic consequences of the completion of the internal market. An approach in terms of local 'milieux' and innovation networks.* GREMI, Milan, 126 pp.

7. Camagni, R. P. (1995a) Global network and local milieu: towards a theory of economic space. In: Conti S. Malecki E. J., and Oinas P. (eds.) *The industrial enterprise and its environment: spatial perspectives.* Avebury, Aldershot, pp. 195-214.

8. Camagni R. P. (1995b) The concept of innovative milieu and its relevance for public policies in European lagging regions. In: *Papers of the Regional Science Association*, (74)4, pp. 317-340.

9. Cummins, R. A. (1997) *Comprehensive Quality of Life Scale-Adult*. School of Psychology, Deakin University, Australia, 64 pp.

10. Davidson, D., Suppes, P., Siegel, S. (1957) *Decision Making: an experimental approach*. University Press, Stanford, 121 pp.

11. Eisenstadt, S. N. (1974) *Mutamento sociale e tradizione nei processi innovativi (Social change and tradition in innovative processes).* Liguori, Napoli, 544 pp. (In Italian.)

12. Elster, J., Hylland, A. (eds) (1986) *Foundations of Social Choice Theory.* Cambridge University Press, Cambridge, 256 pp.

13. Feldman, A. (1980) *Welfare economics and social choice theory*. Martinus Nijhoff, Boston, 256 pp.

14. Fishburn, P. C. (1973) *The theory of social choice*. University Press, Princeton, 264 pp.

15. Germani, G. (1971) *Sociologia della modernizzazione (Sociology of modernization)*. Laterza, Bari, 304 pp. (In Italian.)

16. Gottinger, H. W., Leinfellner, W. (eds) (1978) *Decision theory and social ethics.* Reidel, Dordrecht, 351 pp.

17. Green, J., Laffont, J. J. (1979) Incentives in public decision making. In: *Studies in Public Economics*, vol.1. North-Holland, Amsterdam, pp. 65-78.

18. Guest, S., Milne, A. (eds.) (1985) *Equality and discrimination: essays in freedom and Justice.* Franz Steiner, Stuttgart, 105 pp.

19. Halfacree, K. H. (1993) Locality and social representation: space, discourse and alternative definitions of the rural. In: *Journal of Rural Studies*, (9)1, pp. 23-37.

20. Hammond, P. J. (1986) Consequentialist social norms for public decision. In: Heller W., Starr D. and Starret R. (eds) *Social choice and public decision making: essays in honor of K. J. Arrow*, vol. I. Cambridge University Press, Cambridge, 239 pp.

21. Heller, W., Starr, D., Starret, R. (eds) (1986) *Social choice and public decision making: essays in honor of K. J. Arrow*, vol. I. Cambridge University Press, Cambridge, 239 pp.

22. Henderson, H. (1999) *Beyond Globalization: shaping a sustainable global economy.* New

Economics Foundation, Kumarion Press, 89 pp.

23. Henderson, D. W. (1974) *Social Indicators: A Rationale and Research Framework.* Ottawa: Economic Council of Canada, 90 pp.

24. Hettne, B. (1996) *Le teorie dello sviluppo (Theories on Development).* Harmattan-Italia, Torino, 319 pp. (In Italian.)

25. Hoggart, K., Buller, H., Black, R. (1995) *Rural Europe: identity and change.* Arnold, London, 316 pp.

26. Hudler, M., Richter, R. (2002) Cross-national Comparison of the Quality of Life in Europe: Inventory of Surveys and Methods. In: *Social Indicators Research,* Vol. 58(1-3), pp. 217-228.

27. Johansson, S. (2002) Conceptualizing and Measuring Quality of Life for National Policy. In: *Social Indicators Research,* Vol. 58(1-3), pp. 13-32.

28. Keating, M. (1998) *The new regionalism in Western Europe: territorial restructuring and political change.* Edward Elger, Cheltenham and Northhampton, 242 pp.

29. Land, K. (1999) Social Indicators. In: Edgar F. Borgatta and Rhonda V. Montgomery (eds.) *Encyclopedia of Sociology,* Vol. IV. New York: MacMillan, pp. 1776-2012.

30. Martinelli, A. (1998) *La modernizzazione (Modernization).* Laterza, Bari, 160 pp. (In Italian.)

31. Morishima, M. (1982) *Why has Japan succeeded? Western technology Japanese ethos*. Cambridge University Press, Cambridge, 220 pp.

32. Moseley, M. J. (1996) Baseline studies for local rural development programmes: towards a methodology. In: *Planning Practice and Research*, n. 11, pp. 19-36.

33. Mueller, D. C. (1979) *Public choice.* University Press, Cambridge, 312 pp. (3rd ed. – 778 pp.).

34. Noll, H. H. (2002) Towards a European System of Social Indicators: Theoretical Framework and System Architecture. In: *Social Indicators Research,* Vol. 58(1-3), pp. 47-87.

35. Peterson, M., Naresh, K. M. (1997) Comparative Marketing Measures of Societal Quality of Life: Substantive Dimensions in 186 Countries. *Journal of Macromarketing,* 17 (Spring), pp. 25-38.

36. Pratt, A. C. (1996) Discourses of rurality: loose talk or social struggle. In: *Journal of Rural Studies,* (12)3, pp. 69-78.

37. Saraceno, E. (1994) Alternative readings of spatial differentiation: the rural versus the local economy approach in Italy. In: *European Review of Agricultural Economics,* (21)3/4, pp. 451-474.

38. Scheffler, S. (1982) *The rejection of Consequentialism*. Clarendon Press, Oxford, 300 pp.

39. Sen, A. (1975) *Employment, Technology and Development.* Oxford, Claredon Press, 304 pp.

40. Sen, A. (1982) Rights and Agency. In: *Philosophy and Public Affairs,* n. 11, pp. 3-39.

41. Sen, A. (1985a) Rights and Goals, Austin Lecture 1984. In: Guest S. and Milne A. (eds.) *Equality and discrimination: essays in freedom and Justice.* Franz Steiner, Stuttgart, pp. 14-19.

42. Sen, A. (1985b) Women, technology and sexual division. In: *Trade and Development*, no. 6.

43. Sen, A. (1992) *Resources. Values and Development*. Bollati Boringhieri, 547 pp. (Italian translation.)

44. Sen, A. (1993) *The Standard of Living* (edited by G. Hawthorne). Marsilio, 144 pp. (Italian translation.)

45. Sen, A. (1997a) *Povertv and Famines: An Essay on Entitlement and Deprivation.* Mondadori, 416 pp. (Italian translation.)

46. Sen, A. (1997b) *The Quality of Life (*edited with Martha Nussbaum). Feltrinelli, 328 pp. (Italian translation.)

47. Sen, A. (2000) *Lo sviluppo č libertą (Development is freedom).* Mondadori, Milano, 384 pp. (In Italian.)

48. Slote, M. (1985) *Commo–sense Morality and Consequentialism.* Routledge, London, 157 pp.

49. Vannucci, A. (1997) *Il mercato della corruzione. I meccanismi dello scambio occulto in Italia (Corruption's market: mechanisms of shadow exchange in Italy).* Societą Aperta Edizioni, Milan, 214 pp. (In Italian.)

Anotācija

Raksts atspoguļo autora pētījumu rezultātus, pielietotās metodes un dažus apsvērumus par Itālijas lauku attīstības politiku sociāli ekonomiskos aspektos. Noskaidrotas savstarpējās attiecības starp cilvēku, sociālekonomisko telpu un laiku, kas kopā rada dinamisku struktūru, kurā lauku cilvēka attīstības process spēlē būtisku lomu. Pētījumi koncentrēti uz cilvēku vajadzību daudzveidību un mainību, kas rada galveno problēmu kompleksu, veidojot lauku politiku un ekonomisko vidi. Secināts arī, ka lauku perspektīvā attīstībā ir jābāzējas uz globālo savstarpējo ietekmi un saistību starp ekonomiskiem rezultātiem un tiesību, cieņas un brīvības vērtībām. Materiālie un intelektuālie sasniegumi var būt sociālo likumu (pienākums, lojalitāte, labklājība) ievērošanas rezultāts, kas izriet no etniskās apziņas.

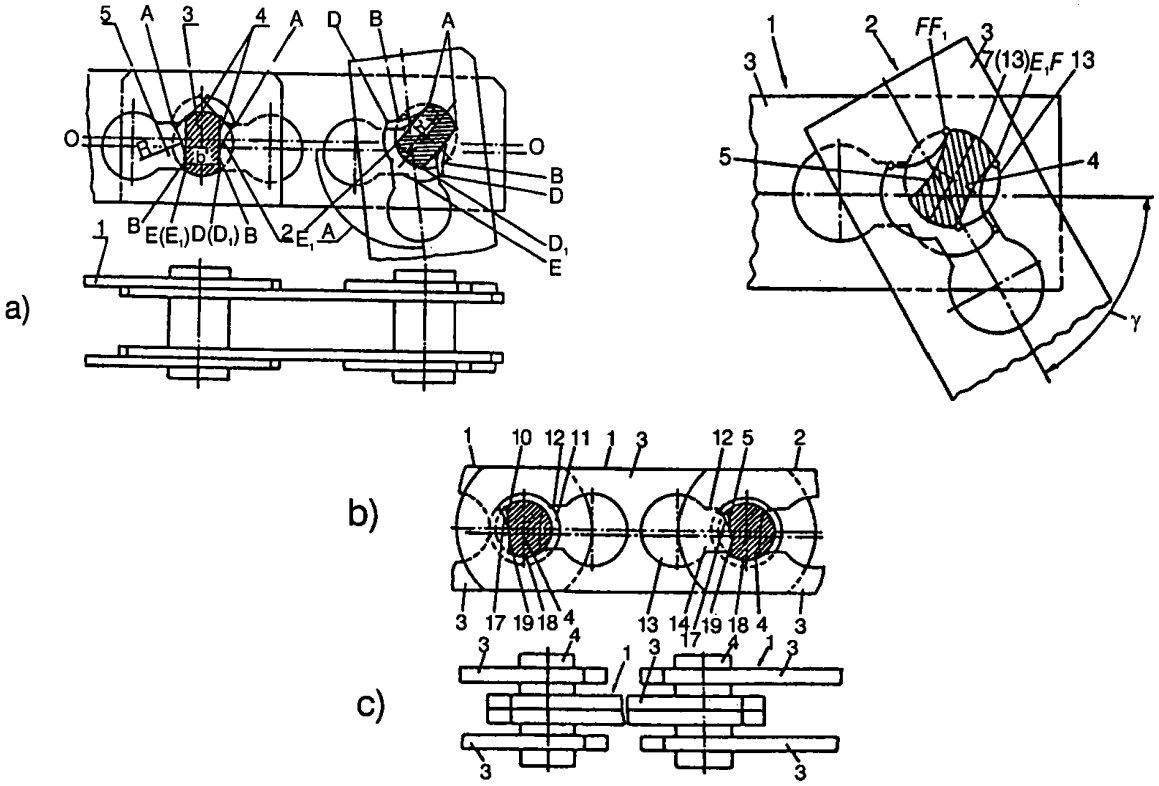
Konveijera ķēdes iekārtas darbības pētījumi
Investigations into the Operation of Conveyor Chain Equipment

Guntars Uzkliņģis
LLU Mehānikas institūts, e-pasts: eriks@inka.cs.llu.lv
Institute of Mechanics, LLU, e-mail: eriks@cs.llu.lv

Abstract. The conveyor chain equipment consists of a rolling friction hinge chain and multistroke sprockets. The article presents investigations into the chain and sprocket mesh and rolling hinge operation. Peculiarities of mesh are related to the formation of rolling friction in the chain hinges. Kinematic properties of mutual coercion of chain axles, plates and sprockets, the forces in hinges and the axle–plate anti-slide ensurance are analyzed. The change of forces in the rolling hinge is analyzed for the case when the contact line of the plate operation surface and axle centre trajectory functions $x_1 = f(\gamma)$ and $x_o = \mu(\gamma)$ change lineary. In the result of theoretical research, correlations for determination of the forces in the chain hinge have been obtained. It has been proved that friction forces in the hinge ensure rolling of the operation surfaces.
Key words: rolling friction hinge chain, chain sprocket, mesh, forces in the hinge, part anti-slide ensurance.

Ievads

Ķēdes iekārtas (konveijera darba orgāns – ķēde ar rausējiem kopā ar zvaigznītēm) darbmūžu būtiski ietekmē zvaigznītes zoba ģeometriskā forma, materiāls, termiskā apstrāde, izgatavošanas tehnoloģija, precizitāte un montāžas kvalitāte [1., 2., 3.]. Pēc gājienu skaita izšķir viengājiena un daudzgājienu zvaigznītes [2.]. Agrāk lietotajās standartizētajās zvaigznītēs zobu augstums tika noteikts kļūdaini [2.]. Tas neļāva pilnīgi izmantot konveijera ķēdes iespējamo darba resursu. Zvaigznītes darbmūžu var palielināt, nemainot tās materiālu un termisko apstrādi,



1. att. Rites berzes šarnīru ķēžu konstruktīvās īpatnības pēc autorapliecībām: a – Nº 582697 [7.]; b – Nº 1270072 [8.]; c – Nº 1416776 [9.].
Fig. 1. Rolling hinge chain constructive peculiarities according to patents: a – Nº582697 [7.]; b – Nº1270072 [8.]; c – Nº 1416776 [9.].

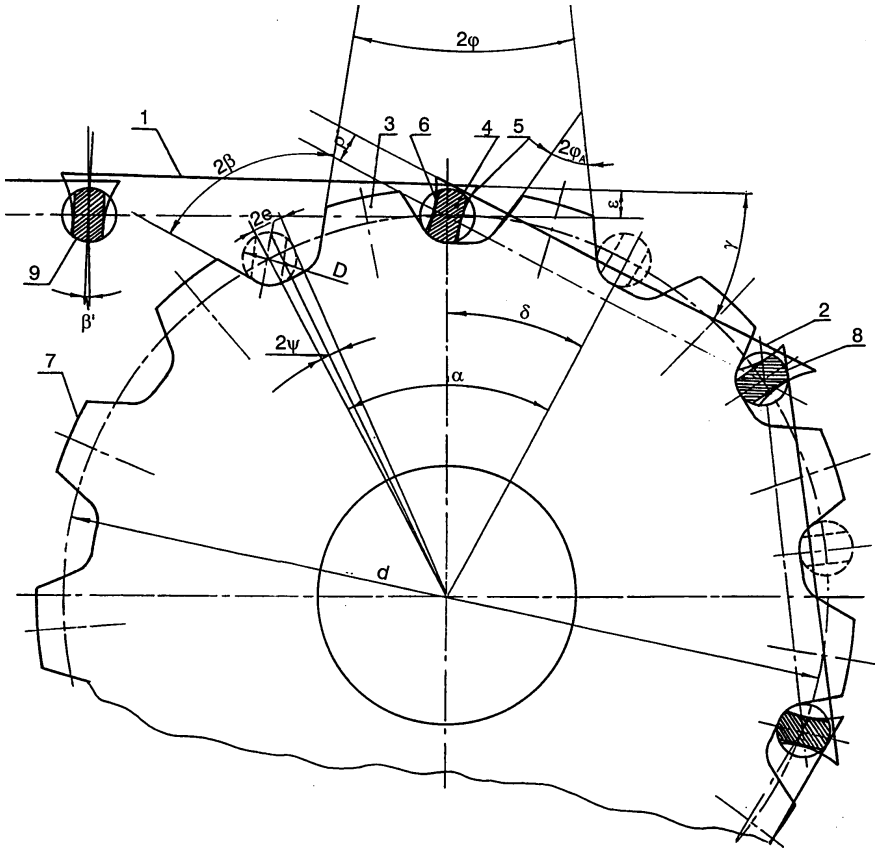
bet gan izveidojot racionālāku zobu konstrukciju. Saglabājot pietiekamu zobu stiprību, var samazināt to izmērus un izveidot daudzgājienu zvaigznīti [3., 4.].

Būtisks ķēdes iekārtas darbmūža kāpinājums panākts, lietojot konveijera ķēdi ar rites berzes šarnīriem (1. att.) [5.]. Lai izveidotu ķēdi ar rites berzes šarnīriem, vajadzēja teorētiski izpētīt jautājumu par ķēdes soļa izmaiņas ierobežošanu ķēdes sazobes procesā ar zvaigznīti [5., 6.].

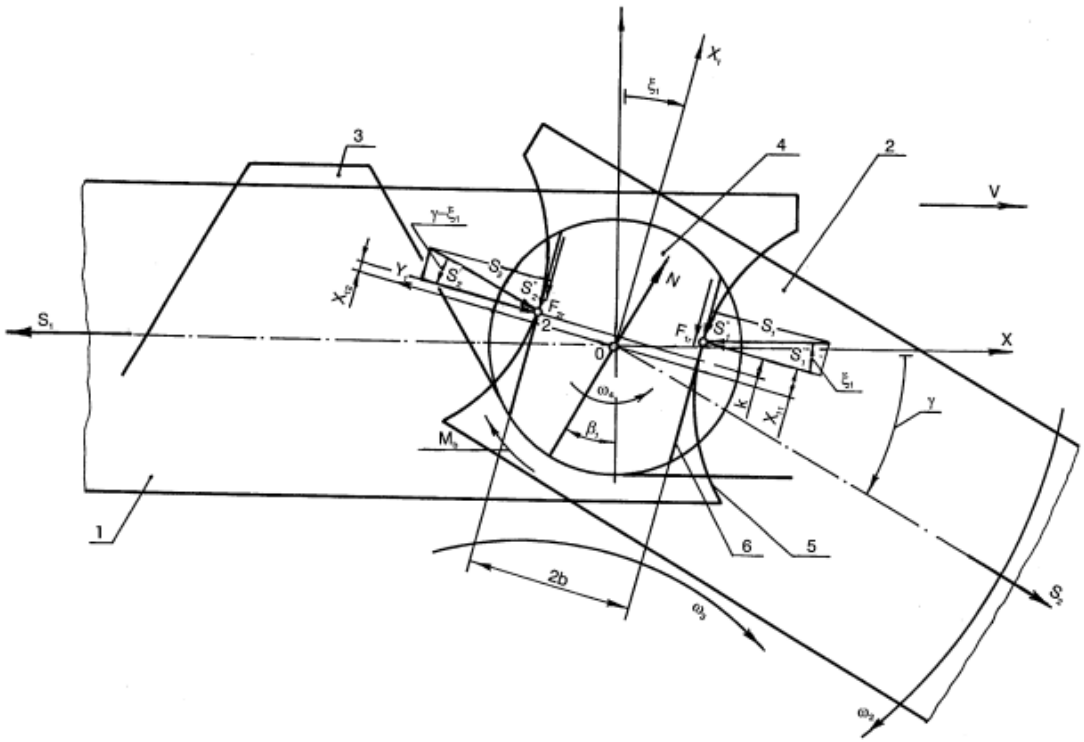
Rakstā izklāstīti rites berzes šarnīru ķēdes un divgājienu zvaigznītes sazobes un rites pētījumi ķēdes šarnīrā.

Metodes

Konveijera ķēdes iekārtas darbība pētīta teorētiski. 2. attēlā parādīts ķēdes posma 1 ieejas process sazobē ar divgājienu dzenošo zvaigznīti. Ķēdes iekšējo un ārējo posmu darba apstākļi uz zvaigznītes ir vienādi, jo ķēde nesatur rullīšus un buksītes. Posms 2 kopā ar zvaigznīti un asītēm 4 un 8 sazobes procesā pagriežas par leņķi $\gamma_\Sigma = 360^o\ m \times z^{-1}$ (šeit m – zvaigznītes gājienu skaits; z – zobu skaits). Posms 1 būs iegājis sazobē tad, kad asīte 9 saskarsies ar zobu 7. Posms 2 jau atrodas sazobē. Uz asīti 4 darbojas spēki S_1 un S_2, zoba 3 reakcija N, kā arī rites berzes pretestības spēki F_{1r} un F_{2r} (3. att.). Zvaigznītei rotējot, spēku S_2 un N virziens un lielums nepārtraukti mainās attiecībā pret nemainīgo spēka S_1 virzienu un skaitlisko lielumu. Ķēdes posmam 2 kopā ar zvaigznīti, pagriežoties par leņķi $0 \leqslant \gamma \leqslant \gamma_\Sigma$ attiecībā pret posmu 1, ķēdes posma 1 plāksnīšu liektās darbīgās virsmas 5 veļas pa asītes 4 plakanajām darba virsmām 6, t.i., plāksnīšu 1 priekšējie gali pārvietojas radiāli uz augšu. Ķēdes šarnīra kontakta punkts 1 pārvietojas augšup, un starp spēku S_1 un S_2 darbības līnijām izveidojas plecs k. Tad, kad moments k $S_1^{/}$ būs lielāks par asītes un zoba berzes momentu M_b un rites berzes momenta pretestību šarnīrā, asīte 4 pagriezīsies attiecībā pret zobu 3 pretēji zvaigznītes rotācijas virzienam. Posmam 1 nonākot sazobē ar zvaigznīti



2. att. Rites berzes šarnīru ķēdes un divgājienu zvaigznītes sazobes shēma:
1 un 2 – ķēdes plāksnītes; 3 un 7 – zvaigznītes zobi; 4, 8 un 9 – ķēdes asītes;
5 – plāksnītes cauruma liektā darba virsma; 6 – asītes plakanā darba virsma.
Fig. 2. Rolling friction hinge chain and double-stroke sprocket mesh scheme:
1 and 2 – chain plates; 3 and 7 – sprocket teeth; 4, 8 and 9 – chain axles;
5 – plate opening convex operation surface; 6 – axle flat operation surface.



3. att. Spēku shēma ķēdes rites šarnīrā:
1 un 2 – ķēdes plāksnītes; 3 – zvaigznītes zobs; 4 – ķēdes asīte;
5 – plāksnītes cauruma liektā darba virsma; 6 – asītes plakanā darba virsma.
Fig. 3. Scheme of forces in the rolling friction hinge:
1 and 2 – chain plates; 3 – sprocket tooth; 4 – chain axle;
5 – plate opening convex operation surface; 6 – axle flat operation surface.

($\gamma = \gamma_\Sigma$), asīte pagriežas par leņķi $\gamma_o = 0.5\ \gamma_\Sigma$. Ķēdes šarnīrā veidojas rites berze, bet starp asīti un zobu – slīdes berze. Asītes un plāksnīšu kontakta zona noslogota ne tikai ar normāliem spēkiem $S_2^{/}$ un $S_1^{/}$, bet arī ar tangenciāliem spēkiem F_{1r}, F_{2r}, $S_1^{//}$ un $S_2^{//}$. Lai nodrošinātu riti bez slīdes, spēku summa $F_{1r} + S_1^{//}$ un $F_{2r} + S_2^{//}$ nedrīkst pārsniegt tangenciālos slīdes berzes spēkus starp asītes un plāksnītes aktīvajām darba virsmām. Ja plecs k pieaug, bet asīte 4 nepagriežas (to notur berzes moments M_b), tad plāksnītes 1 un 2 gali var noslīdēt lejup pa asītes plakni virzienā pret zvaigznīti. Šajā gadījumā tiek traucēts asītes un plāksnītes pareizs savstarpējs novietojums, kas var radīt šarnīra ieķīlēšanos, deformācijas un riti ar slīdi. Nosakot šarnīra parametrus, jāpanāk netraucēta rite neatkarīgi no detaļu darbīgo virsmu stāvokļa un ķēdes darba apstākļiem.

Rezultāti

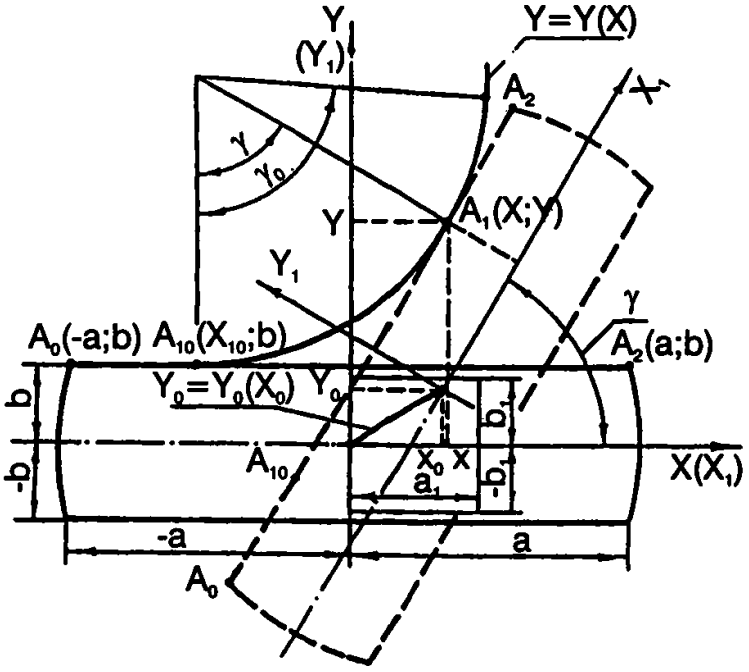
Ķēdes asītes līdzsvara nosacījums (3. att.):

$$S_2 \cos\gamma + N \sin\beta_1 - F_{1r} \sin\xi_1 - F_{2r} \sin\xi_1 - S_1 = 0; \quad (1)$$

$$S_2 \cos\gamma + N \cos\beta_1 - F_{1r} \cos\xi_1 - F_{2r} \cos\xi_1 = 0;$$

$$S_2\, b \sin(\gamma - \xi_1) - S_2\, x_{12} \cos(\gamma - \xi_1) - M_b + S_1\, x_{11} \cos\xi_1 - S_1\, b \sin\xi_1 - F_{1r}\, b + F_{2r}\, b = 0,$$

kur S_1 un S_2 – ķēdes posmu 1 un 2 stiepes spēki, N;
N – normālā reakcija, N;
F_{1r} un F_{2r} – rites berzes spēki;
γ – ķēdes posmu savstarpējais pagrieziena leņķis;
β_1 – normālās reakcijas leņķis;
ξ_1 – lokālās koordinātu sistēmas $x_1 oy_1$ orientācijas leņķis;
x_{11} un x_{12} – plāksnītes un asītes kontakta punktu koordinātas.



4. att. Rites berzes šarnīra kinematiskā shēma.
Fig. 4. Rolling friction hinge kinematic scheme.

Posma 1 pagrieziena leņķis

$$\gamma = \arcsin\left[\frac{R}{t}\,(1 - \cos\omega t)\right], \tag{2}$$

kur R – zvaigznītes dalījuma aploces rādiuss, mm;
t – ķēdes solis, mm;
ω – zvaigznītes griešanās frekvence, s^{-1}.

Leņķis γ mainās robežās $0 \leq \gamma \leq \gamma_{\Sigma}$. Ja kontakta punkta 1 pārvietojuma funkcija $x_1 = f(\gamma)$ un asītes centra 0 kustības funkcija $x_o = \mu(\gamma)$ mainās lineāri (4. att.) [5.], tad:

$$x_{11} = x_{10} + \frac{a - x_{10}}{\gamma_o}\,\xi_1\,; \tag{3}$$

$$x_{12} = x_{10} + \frac{a - x_{10}}{\gamma_o}\,(\gamma - \xi_1)\,; \tag{4}$$

$$\dot{x}_{11} = \frac{a - x_{10}}{\gamma_o}\,\dot{\xi}_1\,; \tag{5}$$

$$\dot{x}_{12} = \frac{a - x_{10}}{\gamma_o}\,(\omega - \dot{\xi}_1)\,, \tag{6}$$

kur x_{10} – attālums no y ass līdz punktam A_{10}, kas sadala plāksnītes kontaktlīniju taisnajā un liektajā daļā (ķēdei ar posmu vienpusīgu pagriezienu, 1.a att.);
a – asītes "kakliņa" (taisnstūra garākās malas) izmēra puse;
γ_o – asītes maksimālais pagrieziena leņķis.
$\dot{x}_{11}$ un $\dot{x}_{12}$ - rites ātrums, mm × s^{-1}.

Rites pretestības spēks [10.]:

$$F_{1r} = \frac{\mu \dot{x}_{11}}{K} \cdot \frac{S_1 \cos \xi_1}{\rho_{11}} ; \quad (7)$$

$$F_{2r} = \frac{\mu \dot{x}_{12}}{K} \cdot \frac{S_2 (\cos \gamma - \xi_1)}{\rho_{12}} , \quad (8)$$

kur μ – ķēdes detaļu materiāla viskozitātes (iekšējās berzes) koeficients, N × s/mm^3 ;
K – detaļu materiāla kontakta virsmu stingums, N × mm^{-3} ;
ρ_{11} un ρ_{12} – ķēdes iekšējā un ārējā posma plāksnītes darbīgās virsmas (kontakta līnijas) liekuma rādiuss, mm.

Ja kontakta līnija uzdota ar parametrisku vienādojumu, tad liekuma rādiusu izsaka šādi [11.]:

$$\rho_{11} = \frac{\left(\dot{u}_{11}^2 + \dot{v}_{11}^2\right)^{\frac{3}{2}}}{\left|\dot{u}_{11} \ddot{v}_{11} - \dot{v}_{11} \ddot{u}_{11}\right|} ; \quad (9)$$

$$\rho_{12} = \frac{\left(\dot{u}_{12}^2 + \dot{v}_{12}^2\right)^{3/2}}{\left|\dot{u}_{12} \ddot{v}_{12} - \dot{v}_{12} \ddot{u}_{12}\right|} ; \quad (10)$$

kur [5.]:

$$u_{11} = x_{01} + x_{11} \cos \xi_1 - b \sin \xi_1 ; \quad (11)$$

$$v_{11} = y_{01} + x_{11} \sin \xi_1 + b \cos \xi_1 ; \quad (12)$$

$$x_{01} = \frac{a_1}{\gamma_o} \xi_1 ; \quad (13)$$

$$y_{01} = \frac{a_1}{6 \gamma_o} \xi_1^2 - \frac{a - x_{10} - \frac{2}{3} a_1}{\gamma_o} \ln \left| \frac{2}{2 - \xi_1^2} \right| - \frac{x_{10}}{\sqrt{2}} \ln \left| \frac{\sqrt{2 + \xi_1}}{\sqrt{2 - \xi_1}} \right| ; \quad (14)$$

$$u_{12} = x_{02} + x_{12} \cos (\gamma - \xi_1) - b \sin (\gamma - \xi_1) ; \quad (15)$$

$$v_{12} = y_{02} + x_{12} \sin (\gamma - \xi_1) + b \cos (\gamma - \xi_1) ; \quad (16)$$

$$x_{02} = \frac{a_1}{\gamma_o} (\gamma - \xi_1) ; \quad (17)$$

$$y_{02} = \frac{a_1}{6\gamma_o}(\gamma - \xi_1)^2 - \frac{a - x_{10} - \frac{2}{3}a_1}{\gamma_o}\ln\left|\frac{2}{2 - (\gamma - \xi_1)^2}\right| - \quad (18)$$

$$- \frac{x_{10}}{\sqrt{2}}\ln\left|\frac{\sqrt{2} + (\gamma - \xi_1)}{\sqrt{2} - (\gamma - \xi_1)}\right|,$$

kur u_{11}, u_{12}, v_{11} un v_{12} – plāksnītes kontaktlīnijas koordinātas;
x_{01}, x_{02}, y_{01} un y_{02} – asītes centra kustības trajektorijas koordinātas;
x_{11} un x_{12} – asītes un plāksnītes kontakta punkta koordinātas koordinātu sistēmā $x_1 oy_1$;
b – asītes „kakliņa“ (taisnstūra īsākās malas) platuma izmēra puse;
a_1 – asītes centra 0 pārvietojuma (ķēdes soļa izmaiņas virzienā) robežizmērs.

Asītes berzes moments pret zvaigznītes zobu

$$M_b = 0{,}5\, D\, f' N, \quad (19)$$

kur D – asītes diametrs;
f' – asītes un zoba reducētais berzes koeficients; $f' = \Psi f$ (šeit $\Psi > 1$, kas ievēro normālās reakcijas N nevienmērīgu sadalījumu pa asītes un plāksnītes darbīgo kontaktvirsmu; f – berzes koeficients asītei pa zobu).

Atrisinot vienādojumu sistēmu (1), ievērojot (2) ... (19) noteikta spēku S_2, N, F_{1r} un F_{2r}, kā arī leņķa ξ_1 izmaiņas likumsakarības, ja $0 \le \gamma \le \gamma_\Sigma$.

Pētījumi veikti, pie šādiem sākuma datiem: $\gamma_\Sigma = 55.38^o$; $\gamma_o = 28^o$; $S_1 = 29.4$ kN; D = 18 mm; b = 5 mm; $\mu K^{-1} = 0.0045$ s; f = 0.235; $a_1 = 2$ mm; $x_{10} = -3$ mm; $\beta_1 = 23^o20'$; a = 7.5 mm; R = 134.5 mm; n = 14 min^{-1}. Šie dati atbilst reālai konveijera ķēdei ar soli t = 125 mm.

Skaitliskā analīze parādīja, ka spēks S_1 samazinās no 29.4 līdz 12.7 kN, bet reakcija N palielinās no nulles līdz 46 kN. Rites berzes spēki nepārsniedz 0.05 kN, un leņķis $\xi_1 \le 0.5\,\gamma_\Sigma$.

Plāksnītes slīde pa asītes plakni nenotiek, jo

$$F_{1r} + S_1 \sin\xi_1 \le f S_1 \cos\xi_1; \quad (20)$$

$$F_{2r} + S_2 \sin(\gamma - \xi_1) \le f S_2 \cos(\gamma - \xi_1). \quad (21)$$

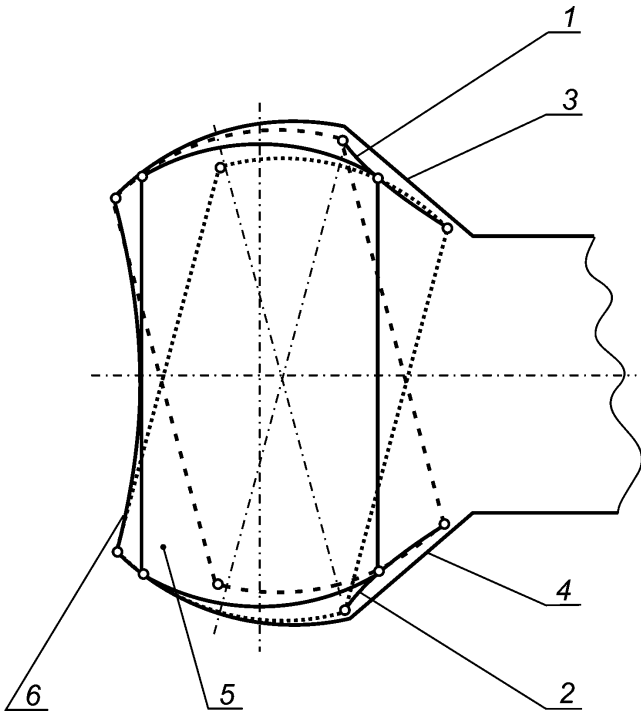
Diskusija

Rites principa ieviešana ir progresīva metode ātri dilstošu salāgojumu konstruēšanā. Lai plāksnītes liektā darbīgā virsma varētu netraucēti ritēt pa asītes darbīgo plakni, šarnīrā jābūt spraugām starp plāksnītes fasoncaurumu un asīti. Ķēdes taisnvirziena kustībā jāsakrīt asītes un plāksnīšu horizontālajām simetrijas asīm. Jāievēro, ka ekspluatācijā var mainīties ķēdes noslogojums, kā arī iespējama transportējamā materiāla ietekme. Ķēdes šarnīrs būs darbspējīgs tikai tad, kad ķēdes detaļu novietojums būs saskaņots visos ķēdes iekārtas darba režīmos. Ķēdes detaļu pareizu fiksāciju nodrošina ne tikai berzes spēki, bet arī plāksnītes fasonveida cauruma ģeometriskā forma. Pašbremzēšanās spēja rodas no berzes spēkiem starp asīti un plāksnīti. Tomēr šo īpašību var izmantot tikai tad, ja ir pietiekams ķēdes sastiepuma spēks. Ir iespējams tāds ķēdes iekārtas darba režīms, kad ķēde būs niecīgi noslogota un berzes spēki nenodrošinās ķēdes detaļu pareizu savstarpējo orientāciju. Šajā gadījumā ķēdes detaļu fiksāciju nodrošina plāksnītes fasoncauruma forma, kas nepieļauj detaļu slīdi. Lai to realizētu, konstruē asītes raksturīgo punktu trajektorijas 1 un 2 (5. att.) un tām atbilstoši nosaka fasoncauruma elementu 3 un 4 formu (veidojas it kā vadīklas, kas nepieļauj detaļu noslīdi).

Teorētiskajos pētījumos ir iegūti vienādojumi jebkura asītes punkta kustības trajektorijas noteikšanai [6.].

Slēdziens

1. Teorētiskajos pētijumos iegūti vienādojumi spēku noteikšanai ķēdes rites berzes šarnīrā. Spēki noderīgi ķēdes detaļu stiprības aprēķiniem,. kā arī sazobes kvalitātes analīzei un uzlabošanai.



5. att. Plāksnītes fasoncauruma elementu formas noteikšanas shēma:
1 un 2 – asītes raksturīgo punktu kustības trajektorijas; 3 un 4 – plāksnītes fasoncauruma "vadīklas" asītei; 5 – asīte; 6 – plāksnītes darbīgā virsma.
Fig. 5. Determination sheme of the plate figure opening element shape:
1 and 2 – axle characteristic point motion trajectories; 3 and 4 – plate figure opening "directing surface" for the axle; 5 – axle; 6 – plate operation surface.

2. Ķēdes asītes un plāksnītes pretizslīdes nodrošinājums reālā ķēdes konstrukcijā tiek garantēts ne tikai ar berzes spēkiem šarnīrā, bet arī ar plāksnītes īpašu fasoncauruma ģeometrisko formu. Abu paņēmienu kombinācija nodrošina šarnīra detaļu pareizu darbību.

Literatūra

1. Готовцев, А. А., Столбин, Г. В., Котенок, И. П. (1973) *Проектирование цепных передач*. М.: Машиностроение, 376 с.

2. Готовцев, А., Узклингис, Г. (1972) Исследование возможностей повышения долговечности звездочек тяговых цепей. *Тр. Латв. СХА*, вып. 49, с. 97-107.

3. Узклингис, Г. А. (1982) Особенности определения основных параметров зубчатых венцов многоходовых звездочек. *Тр. Латв. СХА*, вып. 202, с. 63-66.

4. Узклингис, Г. А., Горенштейн, А. (1978) Эксперементальное исследование влияние формы зубьев звездочек на износ цепи. *Тр. Латв. СХА*, вып. 149, с. 12-20.

5. Узклингис, Г. А., Томашунс, И. А. (1976) Определение основных параметров шарнира трения качения тяговых цепей. *Точность и надежность механических систем,* вып. 3, с. 76-89.

6. Узклингис, Г. А. (1981) *Исследование и усовершенствование цепного устройства навозоуборочного скребкового транспортера. Автореф. дисс. на соис. ученой степени канд. техн. наук (05.06.; 05.02.02).* М., 18 с.

7. *Пластинчатая цепь. Авторское свидетельство СССР No 58269.* Заявл. 25.07.75 (№ 21662334 / 25-27). (Соавторы А. А. Готовцев, И. П. Котенок, В. А. Маркс, А. А. Першин, Г. П. Румковский.)

8. *Пластинчатая цепь. Авторское свидетельство СССР No 1270072*. Заявл. 20.12.84. (№ 3865055 / 27-03). Бюллетень No 42, 15.11.86. (Соавторы И. А. Томашунс, Ю. С. Зельцер, Л. А. Доминиекс, Ю. Я. Чачс.)

9. *Цепная передача. Авторское свидетельство*

СССР No 1416776. Заявл. 31.05.85 (№ 3906249 / 30-27). Бюллетень No 30, 15. 08.88. (Соавторы И. Томашунс, Ю. Чачс, Я. Ишканс, Я. Киршс.)

10. Ишлинский, А. Ю. (1940) Теория сопротивления перекатыванию (трения качения) и смежных явлений. *Сб. докл. Всесоюзн. конф. по трению и износу в машинах*, Т. 2. М.–Л., Изд-во АН СССР, с. 255-264.

11. Выгодский, М. Я. (1962) *Справочник по высшей математике*. Изд. 6-е доп. и испр. М.: Изд-во физ.-мат. лит., 872 с.

LLU Raksti Nr. 10 (305)
Atbildīgais redaktors Valdis Klāsens
Parakstīts iespiešanai 10.02.2004.
Iespiests Jelgavas tipogrāfijā
Jelgavā, Raiņa ielā 27

AUTORU IEVĒRĪBAI

Latvijas Lauksaimniecības universitātes Raksti ievieto publikācijas par nozīmīgiem, oriģināliem, teorētiskiem un eksperimentāliem pētījumiem, kas interesē zinātnieku un nozares speciālistu auditoriju. Publicē arī nozares zinātnes pārskatus un hronikas rakstura materiālus.

Manuskriptus autori iesniedz tehniskajam redaktoram latviešu, angļu, krievu valodā. Personas, kas iesniedz manuskriptu, to paraksta un pilnībā atbild par iesniegtā manuskripta īpašuma tiesībām un zinātnisko līmeni. Redkolēģijai ir tiesības pakļaut manuskriptus tālākai izvērtēšanai un izņēmuma gadījumos arī noraidīt, ja tie neatbilst vispārējiem publikācijas kritērijiem vai tiek uzskatīti kā nepiemēroti LLU Rakstiem. Iesniedzot manuskriptus publicēšanai, autors(i) apliecina, ka darbs nav iepriekš publicēts, nav paredzēts publicēšanai citos izdevumos, un to izlasījuši un atzinuši par labu visi autori. Autori piešķir ekskluzīvas tiesības Latvijas Lauksaimniecības universitātei iesniegtā raksta publicēšanai.

Vēlamā rakstu struktūra: **virsraksts** (raksta valodā un angļu valodā); **autors** vai autori – pilni vārdi un uzvārdi, darba vietas nosaukums (raksta valodā un angļu valodā), pilna pasta adrese, tālruņa numurs, fakss, e-pasta adrese; ***abstract*** – kopsavilkums angļu valodā līdz 250 vārdiem vienā rindkopā izsmeļoši informē par rakstā iekļauto datu būtību; ***key words*** – ne vairāk kā 5 (angļu valodā); krievu un angļu valodā iesniegtiem rakstiem **kopsavilkums** – latviešu valodā vienā rindkopā; **ievads** – situācija un hipotēze; **materiāli un metodes** – pētījuma objekts, metodes un metodika, lai ikviens gūtu priekšstatu par pētījumu gaitu; **rezultāti** – teksta, tabulu, attēlu veidā ar atbilstošu datu ticamības novērtējumu un rezultātu analīzi; **diskusija** – pētījumu rezultātu interpretācija, salīdzinājums ar citu autoru līdzīgiem pētījumiem, jaunākajām zinātnes atziņām; **secinājumi; literatūras saraksts**. Manuskriptu apjomam nevajadzētu pārsniegt 15 lappuses – oriģinālrakstam, 20 lappuses – apskata rakstam un 6 īsiem ziņojumiem. Manuskriptā jānumurē lappuses, attēli, tabulas un formulas.

Teksts

Darbs jānoformē datorsalikumā programmā *MS Word* uz A4 formāta lapām, lietojot *Unicode* fontu *Times New Roman* ar izmēru 12. Pamatteksts sastāv no rindkopām. Sarežģītu un optiski grūti uztveramu burtu veidu lietošana pamattekstā nav pieļaujama. Teksta laukuma attālums no lapas malām – 25 mm. Rindstarpu attālums – 1.5. Skaitļos kā decimāldalītājs jālieto punkts, nevis komats. Manuskriptā lietojamas SI sistēmas mērvienības un arī attiecīgie saīsinājumi.

Tabulas

Tabulām (visos potenciālo izdevumu manuskriptos) jābūt veidotām programmā *MS Word* vai *Excel*. Tabulu virsraksti, teksts tajās un paskaidrojumi pie tām tulkojami arī angļu valodā. Tabulām jābūt saprotamām arī tad, ja teksts nav lasīts. Tabulu numuri jāraksta ar arābu cipariem labajā pusē virs virsraksta. Tās nedrīkst pārsniegt apdrukai paredzēto lapas laukumu, un tabulu zemteksta piezīmēm jābūt uz tās pašas lapas. Ja tabula turpinās uz vairākām lappusēm, tabulas galva bez virsraksta jāatkārto katrā lapā, virsraksta vietā rakstot «.....tabulas turpinājums» vai «.....tabulas nobeigums». Nav ieteicams veidot tabulas, kurām rindu vai kolonnu skaits mazāks par trīs. Kolonnās skaitļiem jābūt nolīdzinātiem. Daudzzīmju skaitļi jāsadala grupās pa trim. Ja kolonnā uz leju atkārtojas tas pats skaitlis vai teksts, tas jāraksta atkārtoti, nedrīkst likt atkārtojuma simboliku.

Attēli

Diagrammas, zīmējumus un fotogrāfijas uzskata par attēliem. Attēliem jābūt melnbaltā izpildījumā un tie novietojami teksta beigās uz atsevišķām lapām. Skanētos attēlus, digitālās fotogrāfijas un zīmējumus var veidot jebkurā grafiskajā programmā, bet ievietot tos *MS Word* kā attēlus (*Picture*), nevis kā attiecīgās programmas objektus. Diagrammas ieteicams veidot *MS Excel* vai *MS Word*, izmantojot *Microsoft Graph*. Diagrammās vēlams izvairīties no fona tonējuma un ierāmējuma līniju lietošanas; tīklu līniju biezumam jābūt ¼ pt, rakstzīmju izmēram jābūt tādam pašam kā pamattekstā. Attēlos jāizvairās no uzrakstiem uz tiem. Uzrakstu vietā lietojami simboli vai cipari, kas atšifrējami zem attēla. Paraksts zem attēla sākas ar attēla numuru, tad seko nosaukums, kas atklāj vai raksturo attēlā redzamo, un tad attēlā lietoto ciparu, simbolu atšifrējums. Attēla nosaukums un visi paskaidrojumi tajā tulkojami arī angļu valodā.

Formulas

Formulas jāraksta *MS Equation* programmā. Formulas tekstā raksta atsevišķā rindā pa vidu. Formulas numurē, numuru rakstot tajā pašā rindā starp divām apaļajām iekavām lapas labajā pusē. Formulās lietotajam pamatvienību lielumam jābūt tādam pašam kā pamattekstā. Kursīvā rakstāmi pieņemto apzīmējumu simboli. Formulās ietverto lielumu mērvienības raksta aiz to nosaukumiem vai skaitliskajām vērtībām tekstā. Formulu paskaidrojumi rakstāmi aiz formulas, katrs savā rindā. Starp paskaidrojumu un mērvienību liek defisi, bet aiz mērvienības – semikolu, un aiz pēdējās mērvienības paskaidrojuma – punktu.

Citējumi

Atsauces tekstā pieraksta, apaļajās iekavās ierakstot izmantotā izdevuma autoru un izdošanas gadu, piem. (Monod, 1963).

Literatūras saraksts darba beigās jānoformē alfabēta kārtībā, atsevišķus darbus pierakstot šādi: **žurnālu raksti** – Hahey, R., Senseman, S., Krutz, L., Hons, F. (2002) Soil carbon and nitrogen mineralization as affected by atrazine and glyghosate. *Biol. Fertil. Soils*, 35, pp. 35-40; **grāmatas** – *Lauksaimniecības ilgtermiņa investīciju kreditēšanas programma.* (2001) LR Zemkopības ministrija, Rīga, 20 lpp.; **grāmatu nodaļas** – Carrey, E. A. (1989) Peptide mapping. In: *Protein Structure*. Creighton, T. E. (ed.) ILR Press, Oxford, pp. 191-224.; **INTERNET resursu apraksts** – Veselības noteicošie faktori. Vide kā dzīvības un veselības resurss: http.://www.liis.lv/vid_ves/faktori.htm – Resurss aprakstīts 2004. gada 13. Janvārī.

Ja atsauces pieraksta ar skaitli kvadrātiekavās citēšanas secībā, tad arī literatūras sarakstu noformē citēšanas secībā.

Atsaucēm tekstā jāsakrīt ar literatūras sarakstā minētajiem avotiem, un tiem jābūt publiski pieejamiem.

Finmāls

Recenzēto un atticcīgi papildināto manuskripta pēdējo versiju autors(i) elektroniskā veidā kopā ar manuskriptu iesniedz tehniskajam redaktoram.

Tikai precīza visu iepriekš minēto prasību ievērošana sekmēs sagatavoto manuskriptu ātrāku publicēšanu.

Atkāpes no šo noteikumu prasībām pieļaujamas, saskaņojot ar LLU Rakstu redkolēģiju.

LLU Rakstu redkolēģijas adrese:

Lielā iela 2, Jelgava, LV 3001
Telefons: 30 05671; fakss: 30 05685;
e-pasts: skuja@cs.llu.lv

Papildus informācija par LLU Rakstiem:
http://*www.cs.llu.lv/zinatne.htm*