

# LACTOBACILLUS RHAMNOSUS HN001™

*Lactobacillus rhamnosus* HN001 and DR20 refer to the same strain. HN001 has been referred to as HOWARU *Rhamnosus*, HOWARU *L. rhamnosus* and HOWARU *Rhamnosus* DR20.

## In vitro trials

### Probiotic selection, survival, stability, production

1. Tang C, Xie B, Sun Z. 2017. Antibacterial activity and mechanism of B-type oligomeric procyanidins from lotus seedpod on enterotoxigenic *Escherichia coli*. *Functional Foods* 38, 454-463.
2. Mäkeläinen H, Forssten S, Olli K, Granlund L, Rautonen N, Ouwehand AC. 2009. Probiotic lactobacilli in a semi-soft cheese survive in the simulated human gastrointestinal tract. *Int Dairy J.* 19: 675-683.
3. Prasad J, Gill H, Smart J, Gopal PK. 1998. Selection and characterization of *Lactobacillus* and *Bifidobacterium* strains for use as probiotics. *Int Dairy J.* 8: 993-1002.

### Safety

1. Zhou JS, Pillidge CJ, Gopal PK, Gill HS. 2005. Antibiotic susceptibility profiles of new probiotic *Lactobacillus* and *Bifidobacterium* strains. *Int J Food Microbiol.* 98: 211-217.
2. Zhou JS, Rutherfurd KJ, Gill HS. 2005. Inability of probiotic bacterial strains *Lactobacillus rhamnosus* HN001 and *Bifidobacterium lactis* HN019 to induce human platelet aggregation *in vitro*. *J Food Prot.* 68: 2459-2464.
3. Zhou JS, Gopal PK, Gill HS. 2001. Potential probiotic lactic acid bacteria *Lactobacillus rhamnosus* (HN001), *Lactobacillus acidophilus* (HN017) and *Bifidobacterium lactis* (HN019) do not degrade gastric mucin *in vitro*. *Int J Food Microbiol.* 63: 81-90.

### Antipathogenic/antitoxic activity

1. Bertuccini L, Russo R, Iosi F, Superti F. 2017. Effects of *Lactobacillus rhamnosus* and *Lactobacillus acidophilus* on bacterial vaginal pathogens. *Int J Immunopathol Pharmacol.* 30(2): 163-167.
2. Inturri R, Stivala A, Furneri PM, Blandino G. 2016. Growth and adhesion to HT-29 cells inhibition of Gram-negatives by *Bifidobacterium longum* BB536 e *Lactobacillus rhamnosus* HN001 alone and in combination. *Eur Rev Med Pharmacol Sci.* 20(23): 4943-4949.
3. Ephraim E, Schultz RD, Duster M, Warrack S, Spiegel CA, Safdar N. 2012. *In vitro* evaluation of the antagonistic effects of the probiotics *Lactobacillus rhamnosus* HN001 and Florajen 3 against Group B Streptococci. *Int J Prob Preb* 7: 113-120.
4. Gopal PK, Prasad J, Smart J, Gill HS. 2001. *In vitro* adherence properties of *Lactobacillus rhamnosus* DR20 and *Bifidobacterium lactis* DR10 strains and their antagonistic activity against an enterotoxigenic *Escherichia coli*. *Int J Food Microbiol.* 67: 207-216.  
*Also listed under Adherence*

### Prebiotic utilization

1. Sims IM, Ryan JL, Kim SH. 2014. *In vitro* fermentation of prebiotic oligosaccharides by *Bifidobacterium lactis* HN019 and *Lactobacillus* spp. *Anaerobe* 25: 11-17.
2. Mäkeläinen H, Saarinen M, Stowell J, Rautonen N and Ouwehand AC. 2010. Xylo-oligosaccharides and lactitol promote the growth of *Bifidobacterium lactis* and *Lactobacillus* species in pure cultures. *Beneficial Microbes* 1: 139-148.
3. Mäkeläinen H, Hasselwander O, Rautonen N, Ouwehand AC. 2009. Panose, a new prebiotic candidate. *Lett Appl Microbiol.* 49: 666-672.
4. Gopal PK, Sullivan PA, Smart BJ. 2001. Utilisation of galacto-oligosaccharides as selective substrates for growth by lactic acid bacteria including *Bifidobacterium lactis* DR10 and *Lactobacillus rhamnosus* DR20. *Int Dairy J.* 11: 19-25.

## Adherence

1. Jang SE, Jeong JJ, Choi SY, Kim H, Han MJ, Kim DH. 2017. *Lactobacillus rhamnosus* HN001 and *Lactobacillus acidophilus* La-14 Attenuate Gardnerella vaginalis-Infected Bacterial Vaginosis in Mice. *Nutrients*. 23;9(6). doi: 10.3390/nu9060531. [Erratum in: *Nutrients*. 2017 Jul 07;9(7)]  
*Also listed under Animal trials/Antipathogenic activity and Immune system modulation*
2. Inturri R, Stivala A, Blandino G. 2015. Microbiological characteristics of the probiotic strains *B. longum* BB536 and *L. rhamnosus* HN001 used in combination. *Minerva Gastroenterol Dietol*. 61(4): 191-197.
3. Gopal PK, Prasad J, Smart J, Gill HS. 2001. *In vitro* adherence properties of *Lactobacillus rhamnosus* DR20 and *Bifidobacterium lactis* DR10 strains and their antagonistic activity against an enterotoxigenic *Escherichia coli*. *Int J Food Microbiol*. 67: 207-216.  
*Also listed under Antipathogenic Activity and/or Bacteriocins*

## Intestinal permeability

1. Mokkala K, Laitinen K, R yti  H. 2016. *Bifidobacterium lactis* 420 and fish oil enhance intestinal epithelial integrity in Caco-2 cells. *Nutr Res*. 36: 246-52.
2. Anderson RC, Cookson AL, McNabb WC, Kelly WJ, Roy NC. 2010. *Lactobacillus plantarum* DSM 2648 is a potential probiotic that enhances intestinal barrier function. *FEMS Microbiol Lett*. 309: 184-92.

## Genomics

1. Sisto A, De Bellis P, Visconti A, Morelli L, Lavermicocca P. 2009. Development of a PCR assay for the strain-specific identification of probiotic strain *Lactobacillus parucasei* IMPC2.1. *Int J Food Microbiol*. 136: 59-65.
2. Christensson C, Bratt H, Collins LJ, Coolbear T, Holland R, Lubbers MW, O'Toole PW, Reid JR. 2002. Cloning and expression of an oligopeptidase, PepO, with novel specificity from *Lactobacillus rhamnosus* HN001 (DR20). *Appl Environ Microbiol*. 68: 254-262.
3. Walter J, Hertel C, Tannock GW, Lis CM, Munro K, Hammes WP. 2001. Detection of *Lactobacillus*, *Pediococcus*, *Leuconostoc* and *Weissella* species in human feces by using group-specific PCR primers and denaturing gradient gel electrophoresis. *Appl Environ Microbiol*. 67: 2578-2585.

## Protein identification

1. Gagic D, Wen W, Collett MA, Rakonjac J. 2012. Unique secreted-surface protein complex of *Lactobacillus rhamnosus*, identified by phage display. *Microbiologyopen*. Dec 11. doi: 10.1002/mbo3.53. [Epub ahead of print] PubMed PMID: 23233310.

## Oral health

1. Lin X, Chen X, Chen Y, Jiang W, Chen H. 2014. The effect of five probiotic lactobacilli strains on the growth and biofilm formation of *Streptococcus mutans*. *Oral Dis*. May 7. doi: 10.1111/odi.12257.

## Animal trials

### Safety

1. Zhou JS, Gill HS. 2005. Immunostimulatory probiotic *Lactobacillus rhamnosus* HN001 and *Bifidobacterium lactis* HN019 do not induce pathological inflammation in mouse model of experimental autoimmune thyroiditis. *Int J Food Microbiol*. 103: 97-104.
2. Zhou JS, Shu Q, Rutherford KJ, Prasad J, Birtles MJ, Gopal PK, Gill HS. 2000. Safety assessment of potential probiotic lactic acid bacterial strains *Lactobacillus rhamnosus* HN001, *Lb. acidophilus* HN017 and *Bifidobacterium lactis* HN019 in BALB/c mice. *Int J Food Microbiol*. 56: 87-96.
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### Synbiotic

1. Alves CC, Waitzberg DL, de Andrade LS, dos Santos Aguiar L, Reis MB, Guanabara CC, J nior OA, Ribeiro DA and Sala P. 2017. Prebiotic and Synbiotic Modifications of Beta Oxidation and Lipogenic Gene Expression after Experimental Hypercholesterolemia in Rat Liver. *Front. Microbiol*. 8: 2010. doi: 10.3389/fmicb.2017.02010.

### Immune system modulation/enhancement

1. Jang SE, Jeong JJ, Choi SY, Kim H, Han MJ, Kim DH. 2017. *Lactobacillus rhamnosus* HN001 and *Lactobacillus acidophilus* La-14 Attenuate Gardnerella vaginalis-Infected Bacterial Vaginosis in Mice. *Nutrients*. May 23;9(6).doi: 10.3390/nu9060531. [Erratum in: *Nutrients*. 2017 Jul 07;9(7)]

*Also listed under In vitro/Adherence and animal trials/Antipathogenic activity*

2. Cross ML, Mortensen RR, Kudsk J, Gill HS. 2002. Dietary intake of *Lactobacillus rhamnosus* HN001 enhances production of both TH1 and Th2 cytokines in antigen-primed mice. *Med Microbiol Immunol*. 191: 49-53.

3. Shu Q, Gill HS. 2002. Immune protection mediated by the probiotic *Lactobacillus rhamnosus* HN001 (DR20) against *Escherichia coli* O157:H7 infection in mice. *FEMS Immunol Med Microbiol*. 34: 59-64.

*Also listed under Antipathogenic activity*

4. Gill HS, Rutherfurd KJ. 2001. Immune enhancement conferred by oral delivery of *Lactobacillus rhamnosus* HN001 in different milk-based substrates. *J Dairy Res*. 68: 611-616.

5. Gill HS, Rutherfurd KJ. 2001. Viability and dose-response studies on the effects of the immunoenhancing lactic acid bacterium *Lactobacillus rhamnosus* in mice. *Br J Nutr*. 86: 285-289.

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### Antipathogenic activity

1. Jang SE, Jeong JJ, Choi SY, Kim H, Han MJ, Kim DH. 2017. *Lactobacillus rhamnosus* HN001 and *Lactobacillus acidophilus* La-14 Attenuate Gardnerella vaginalis-Infected Bacterial Vaginosis in Mice. *Nutrients*. 23;9(6). doi: 10.3390/nu9060531. [Erratum in: *Nutrients*. 2017 Jul 07;9(7)]

*Also listed under In vitro/Adherence and animal trials/Immune system modulation*

2. Shu Q, Gill HS. 2002. Immune protection mediated by the probiotic *Lactobacillus rhamnosus* HN001 (DR20) against *Escherichia coli* O157:H7 infection in mice. *FEMS Immunol Med Microbiol*. 34: 59-64.

*Also listed under Immune system modulation/enhancement*

3. Gill HS, Shu Q, Lin H, Rutherfurd KJ, Cross ML. 2001. Protection against translocating *Salmonella typhimurium* infection in mice by feeding the immuno-enhancing probiotic *Lactobacillus rhamnosus* strain HN001. *Medical Microbiology and Immunology*. 190: 97-104.

### Allergy

1. Thomas DJ, Husmann RJ, Villamar M, Winship TR, Buck RH, Zuckermann FA. 2011. *Lactobacillus rhamnosus* HN001 Attenuates Allergy Development in a Pig Model. *PLoS One*. 6: e16577.

### Diabetes

1. Al-Salami H, Butt G, Fawcett JP, Tucker IG, Golocorbin-con S, Mikov M. 2008. Probiotic treatment reduces blood glucose levels and increases systemic absorption of gliclazide in diabetic rats. *Eur J Drug Metab Phama*. 33: 101-106.

2. Al-Salami H, Butt G, Tucker IG, Skrbic R, Golocorbin-Kon S, Mikov M. 2008. Probiotic pre-treatment reduces gliclazide permeation (*ex vivo*) in healthy rats but increases it in diabetic rats to the level seen in untreated healthy rats. *Arch Drug Info*. 1: 35-41.

### Mineral absorption and bone health

1. Kruger MC, Fear A, Chua WH, Plimmer GG, Schollum LM. 2009. The effect of *Lactobacillus rhamnosus* HN001 on mineral absorption and bone health in growing male and ovariectomised female rats. *Dairy Sci Technol* 89: 219-231.

### Host gene expression

1. Tannock GW, Taylor C, Lawley B, Loach D, Gould M, Dunn AC, McLellan AD, Black MA, McNoe L, Dekker J, Gopal P and Collett MA. 2014. Altered transcription of murine genes induced in the small bowel by administration of probiotic strain *Lactobacillus rhamnosus* HN001. *Appl Environ Microbiol*. *Appl Environ Microbiol*. 80(9): 2851-9. [Supplementary material included]

### Necrotizing enterocolitis

1. Good M, Sodhi CP, Ozolek JA, Buck RH, Goehring KC, Thomas DL, Vikram A, Bibby K, Morowitz MJ, Firek B, Lu P, Hackam DJ. 2014. *Lactobacillus rhamnosus* HN001 decreases the severity of necrotizing enterocolitis in neonatal mice and preterm piglets: evidence in mice for a role of TLR9. *Am J Physiol Gastrointest Liver Physiol*. 306(11): G1021-32.

## Human clinical studies

### Safety

1. Warrack S, Panjekar P, Duster M, Safdar N. 2014. Tolerability of a probiotic in subjects with a history of methicillin-resistant *Staphylococcus aureus* colonisation. *Benef Microbes*. 5: 389-95.
2. Dekker JW, Wickens K, Black PN, Stanley TV, Mitchell EA, Fitzharris P, Tannock GW, Purdie G, Crane J. 2009. Safety aspects of probiotic bacterial strains *Lactobacillus rhamnosus* HN001 and *Bifidobacterium animalis* subsp. *lactis* HN019 in human infants aged 0-2 years. *Int Dairy J*. 19: 149-154.

### Immune system enhancement

1. Marlow G, Han DY, Wickens K, Stanley T, Crane J, Mitchell EA, Dekker J, Barthow C, Fitzharris P, Ferguson LR, Morgan AR. 2015. Differential effects of two probiotics on the risks of eczema and atopy associated with single nucleotide polymorphisms to Toll-like receptors. *Pediatr Allergy Immunol*. 26(3): 262-71.
2. Caceres P, Montes S, Vega N, Cruchet S, Brunser O and Gotteland M. 2011. Effects of *Lactobacillus rhamnosus* HN001 on acute respiratory infections and intestinal secretory IgA in children. *J Ped Inf Dis* 5: 353-362.  
*Also listed under Gastrointestinal ecology*
3. Ibrahim F, Ruvio S, Granlund L, Salminen S, Viitanen M, Ouwehand AC. 2010. Probiotics and immunosenescence: cheese as a carrier. *FEMS Immunol Med Microbiol*. 59: 53-9.
4. Prescott SL, Wickens K, Westcott L, Jung W, Currie H, Black PN, Stanley TV, Mitchell EA, Fitzharris P, Siebers R, Wu L, Crane J. 2008. Supplementation with *Lactobacillus rhamnosus* or *Bifidobacterium lactis* probiotics in pregnancy increases cord blood interferon-gamma and breast milk transforming growth factor-beta and immunoglobulin A detection. *Clin Exp Allergy* 38, 1606-1614.
5. Gill HS, Cross ML, Rutherford KJ, Gopal PK. 2001. Dietary probiotic supplementation to enhance cellular immunity in the elderly. *Br J Biomed Sci*. 58: 94-96.

6. Gill HS, Rutherford KJ. 2001. Probiotic supplementation to enhance natural immunity in the elderly: effects of a newly characterized immunostimulatory strain *Lactobacillus rhamnosus* HN001 (DR20) on leucocyte phagocytosis. *Nutr Res*. 21: 183-189.

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8. Sheih YH, Chiang BL, Wang LH, Liao C, Gill HS. 2001. Systemic immunity-enhancing effects in healthy subjects following dietary consumption of the lactic acid bacterium *Lactobacillus rhamnosus* HN001. *J Am Coll Nutr*. 20: 149-156.

### Allergy treatment

1. Barthow C, Wickens K, Stanley T, Mitchell EA, Maude R, Abels P, Purdie G, Murphy R, Stone P, Kang J, Hood F, Rowden J, Barnes P, Fitzharris P, Craig J, Slykerman RF, Crane J. 2016. The probiotics in pregnancy study (PiP study): rationale and design of a double-blind randomized controlled trial to improve maternal health during pregnancy and prevent infant eczema and allergy. *BMC Pregnancy Childbirth*. 16(1): 133.
2. Morgan AR, Han DY, Wickens K, Barthow C, Mitchell EA, Stanley TV, Dekker J, Crane J, Ferguson LR. 2014. Differential modification of genetic susceptibility to childhood eczema by two probiotics. *Clin Exp Allergy*. 2014 Aug 21.
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6. Wickens K, Black PN, Stanley TV, Mitchell E, Fitzharris P, Tannock GW, Purdie G, Crane J; Probiotic Study Group. 2008. A differential effect of 2 probiotics in the prevention of eczema and atopy: A double-blind, randomized, placebo controlled trial. *J Allergy Clin Immunol.* 122: 788-94.

7. Sistek D, Kelly R, Wickens K, Stanley T, Fitzharris P, Crane J. 2006. Is the effect of probiotics on atopic dermatitis confined to food sensitized children? *Clin Exp Allergy* 36: 629-633.

### Gastrointestinal ecology

1. Eggers S, Barker A, Valentine S, Hess T, Duster M, Safdar N. 2016. Impact of Probiotics for Reducing Infections in Veterans (IMPROVE): Study protocol for a double-blind, randomized controlled trial to reduce carriage of *Staphylococcus aureus*. *Contemp Clin Trials.* 9(52): 39-45.

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*Also listed under Gastrointestinal ecology*

3. Lahtinen SJ, Forssten S, Aakko J, Granlund L, Rautonen N, Salminen S, Viitanen M, Ouwehand AC. 2011. Probiotic cheese containing *Lactobacillus rhamnosus* HN001 and *Lactobacillus acidophilus* NCFM modifies subpopulations of fecal lactobacilli and *Clostridium difficile* in the elderly. *Age (Dordr).* 2011 Jan 25.

4. Walter J, Hertel C, Tannock GW, Lis CM, Munro K, Hammes WP. 2001. Detection of *Lactobacillus*, *Pediococcus*, *Leuconostoc* and *Weissella* species in human feces by using group-specific PCR primers and denaturing gradient gel electrophoresis. *Appl Environ Microbiol.* 67: 2578-2585.

5. Tannock GW, Munro K, Harmsen HJM, Welling GW, Smart J, Gopal PK. 2000. Analysis of the fecal microflora of human subjects consuming a probiotic product containing *Lactobacillus rhamnosus* DR20. *Appl Environ Microbiol.* 66: 2578-2588.

### Synbiotic

1. Waitzberg DL, Logullo LC, Bittencourt AF, Torrinhas RS, Shiroma GM, Paulino NP, Teixeira-da-Silva ML. 2013. Effect of synbiotic in constipated adult women – A randomized, double-blind, placebo-controlled study of clinical response. *Clin Nutr.* 32: 27-33.

### Women's health

1. De Alberti D, Russo R, Terruzzi F, Nobile V, Ouwehand AC. 2015. Lactobacilli vaginal colonisation after oral consumption of Respecta® complex: a randomized controlled pilot study. *Arch Gynecol Obstet.* 292(4): 861-7.

### Depression and anxiety

1. Slykerman RF, Hood F, Wickens K, Thompson JMD, Barthow C, Murphy R, Kang J, Rowden J, Stone P, Crane J, Stanley T, Abels P, Purdie G, Maude R, Mitchell EA; Probiotic in Pregnancy Study Group. 2017. Effect of *Lactobacillus rhamnosus* HN001 in Pregnancy on Postpartum Symptoms of Depression and Anxiety: A Randomised Double-blind Placebo-controlled Trial. *EBioMedicine.* 24: 159-165. doi: 10.1016/j.ebiom.2017.09.013.

### Product functionality

1. Tan JSH, Yeo C-R, Popovich DG. 2017. Fermentation of protopanaxadiol type ginsenosides (PD) with probiotic *Bifidobacterium lactis* and *Lactobacillus rhamnosus*. *Applied Microbiology and Biotechnology* 6 May, Pages 1-11.

2. Aljewicz M, Cichosz G. 2017. Influence of probiotic (*Lactobacillus acidophilus* NCFM, *L. paracasei* LPC37 and *L. rhamnosus* HN001) strains on starter cultures and secondary microflora in Swiss- and Dutch-type cheeses. *J Food Process Preserv.* 41: e13253. <https://doi.org/10.1111/jfpp13253>.

3. Sady M, Najgebauer-Lejko D, Domagała J. 2017. The suitability of different probiotic strains for the production of fruit-whey beverages. *Acta Sci Pol Technol Aliment.* Oct-Dec;16(4): 421-429. doi: 10.17306/J.AFS.0515.

4. Toh M, Liu SQ. 2017. Influence of commercial inactivated yeast derivatives on the survival of probiotic bacterium *Lactobacillus rhamnosus* HN001 in an acidic environment. *AMB Express.* Dec;7(1): 156. doi: 10.1186/s13568-017-0456-4.

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9. Lim PL, Toh M, Liu SQ. 2015. *Saccharomyces cerevisiae* EC-1118 enhances the survivability of probiotic *Lactobacillus rhamnosus* HN001 in an acidic environment. *Appl Microbiol Biotechnol.* Apr 7.
10. Aljewicz M, Cichosz G, Nalepa B and Kowalska M. 2014. Influence of the Probiotic *Lactobacillus acidophilus* NCFM and *Lactobacillus rhamnosus* HN001 on Proteolysis Patterns of Edam Cheese. *Food Technol. Biotechnol.* 52 (4) 439-447.
11. Aljewicz M, Siemianowska E, Cichosz G, Tońska E. 2014. The effect of probiotics (*Lactobacillus rhamnosus* HN001, *Lactobacillus paracasei* LPC-37 and *Lactobacillus acidophilus* NCFM) on the availability of minerals from Dutch-type cheese. *J Dairy Sci.* 2014 Jun 6. pii: S0022-0302(14)00403-2.
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16. Shah NP, Ding WK, Fallour MJ, Leyer G. 2010. Improving the stability of probiotic bacteria in model fruit juices using vitamins and antioxidants. *J Food Sci.* 75: M278-82.
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19. Phillips M, Kailasapathy K, Tran L. 2006. Viability of commercial probiotic cultures (*L. acidophilus*, *Bifidobacterium* sp., *L. casei*, *L. paracasei* and *L. rhamnosus*) in cheddar cheese. *Int J Food Microbiol.* 108: 276-280.
20. Prasad J, McJarow P, Gopal R. 2003. Heat and osmotic stress responses of probiotic *Lactobacillus rhamnosus* HN001 (DR20) in relation to viability after drying. *Appl Environ Microbiol.* 69: 917-925.

## Reviews

1. Lehtinen MJ, Henriksson A. 2015. Fortifying with probiotics. *Food Pacific Manufacturing Journal*, June 2015, 16-18.
2. Hao Q, Lu Z, Dong BR, Huang CQ, Wu T. 2011. Probiotics for preventing acute upper respiratory tract infections (Review). [A reprint of a Cochrane review, prepared and maintained by The Cochrane Collaboration and published in The Cochrane Library, 2011, Issue 9]
3. Lahtinen SJ, Kumar R. 2009. Probiotics improve immune system function. *Indian Dairyman* 61: 49-54.
4. Ouwehand AC, Lahtinen S, Nurminen P. 2009. *Lactobacillus rhamnosus* HN001 and *Bifidobacterium lactis* HN019. In *Handbook of probiotics and prebiotics*. Lee YK, Salminen SJ (eds). Wiley & Sons, New Jersey, 2nd edition, pp. 473-477.

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