# Comparison of Vero and MDCK cell lines transfected with human *siat7e* gene for conversion to suspension culture

Mehrbod P, Fotouhi F, Irani Mokhtari G, Mohammadpour A, Farahmand B<sup>\*</sup>

Influenza and Other Respiratory Viruses Department, Pasteur Institute of Iran, Tehran, Iran.

# ABSTRACT

**Introduction:** Inactivated influenza vaccines are traditionally produced in chicken embryonated eggs but its limitations in producing the required doses in pandemic outbreaks quickly enough has made searching for alternative modes of production necessary. The use of cell culture-based vaccine production is one way of overcoming the limitations of the egg-based method and securing a more rapid response. Although Vero cells are suitable for production of influenza vaccine, but their anchorage-dependency limits their production capability. In this study adherent Vero and MDCK cells were transfected with human *siat7e* gene in order to convert anchorage-dependent cells to those capable of growing in suspension. **Methods:** Human *siat7e* gene was amplified with primers containing restriction sites for *Xho* I and *Hind* III and the product was cloned into pEGFP-N1 vector upstream of GFP sequence. The cells were transfected cells which were then evaluated using inverted immunofluorescence microscopy. **Results:** Anchorage-dependent cells exhibited changes in cell-cell adhesion and cell spreading behavior following transfection. Vero cells showed a higher longevity compared to MDCK cells as viability of the latter cells declined after 50 h. **Conclusion:** The data showed that adherent Vero cells can successfully be converted to anchorage- independent cells capable of growing in suspension with human *siat7e* gene.

KEYWORDS: Human Siat7e, influenza virus, transfection, Vero cell, suspension culture.

# INTRODUCTION

Annual influenza epidemics continue to have a considerable impact on health worldwide. In response to rapid antigenic changes in influenza viruses, the most effective approach to reduce associated morbidity and mortality is the use of viral vaccines which are traditionally produced in embryonated chicken eggs [1-2]. However, in the event of a pandemic outbreak, the egg-based production system may not meet the surge in the demand due to the limitations associated with this approach, which include difficulty in securing reliable egg supplies, a shortage of embryonated eggs, prolonged cultivation periods, and burdensome operations [3-6]. These limitations have triggered the search for alternatives methods of production and World Health Organization (WHO) recommends using established mammalian cell culture lines especially MDCK, VERO, and PER.C6 as an alternative to egg-based substrates in the manufacture of influenza vaccine [7-8]. Propagation of influenza viruses in the cell culture is more advantageous because it is more rapid, it does not alter virus antigenicity and

\*Corresponding Author: Behrokh Farahmand, Ph.D Associate Professor, Influenza and Other Respiratory Viruses Department, Pasteur Institute of Iran, Tehran, Iran. Email: b\_farahmand@pasteur.ac.ir Tel/Fax: (+98) 2166953311

generally results in a homogeneous virus preparation with respect to hemagglutinin (HA) compared to the virus propagation in eggs [3-6]. However, one of the limiting aspects in scaling up virus production in these continuous cell lines is the fact that these cells are anchorage-dependent requiring surface adhesion to proliferate [9, 10]. A cell line that can propagate in suspension would greatly facilitate the scale-up process of influenza virus production [11]. Human influenza viruses preferentially bind to the NeuAca2,6Gal receptors [12], thus, enhanced  $\alpha$ -2,6-linked receptor levels should increase the number of interactions between human influenza virions and the cell surface to increase the virus binding avidity [13, 14]. SIAT7e (sialyltransferase ST6GalNac V), a member of the ST6GalNac family of sialyltransferases, is a type II Golgi membrane protein that transfers sialic acid from the donor CMP-Neu5Ac to the GalNac residue on the ganglioside. It is an catalyzes the  $\alpha$ -2,6-sialylation of Nthat enzyme acetyllactosamine moieties of glycoproteins and glycolipids. Indirect involvement of SIAT7e in synthesizing a carbohydrate structure conjugated to proteins on the cell surface has been proposed [15]. The gene *siat7e* was identified as playing a key role in controlling the cell adhesion to the surface. It was shown that higher *siat7e* transcription corresponded to a lower degree of adhesion [16]. Conversion of MDCK cell line to suspension culture by transfection with human *siat7e* gene and its application in influenza virus production has previously been demonstrated [11]. Based on previous reports on successful over-expression of *siat7e* in mammalian cells, we assumed that the *siat7e* over-expression in Vero cells would increase  $\alpha$ -2,6sialylation of N-acetyllactosamine as well. Therefore, we attempted for the first time to transfect WHO candidate cell (Vero cell line) for virus propagation by human *siat7e* gene to produce anchorage-independent *siat7e*-expressing cells capable of growing in suspension. Furthermore, we compared the performance of the two transfected cell lines under well-defined optimized conditions.

#### **MATERIALS and METHODS**

#### **Cell lines**

Vero (CCL-81<sup>TM</sup>) and MDCK (CCL-34<sup>TM</sup>) cells purchased from American Type Culture Collection (ATCC) were grown and passaged in Dulbecco's Modified Eagle's Medium (DMEM) supplemented with 10% Fetal Bovine Serum (FBS),100 U/ml penicillin G and 100 µg/ml streptomycin (Gibco, UK) at 37°C and 5% CO2. The media was changed two to three times per week.

#### **Plasmid construction**

Competent E. coli DH5a was transformed with the construct carrying full length cDNA clone of human siat7e gene (accession No: NM\_030965.1) purchased from GeneCopoeia (USA) and the target gene was amplified by Forward: 5'-AGC TCG AGC CAT GAA GAC CCT GAT-3' and Reverse: 5'-CTA CAA CAC AAG CTT ATT CTC AGG TG-3' primers containing XhoI and Hind III restriction sites, respectively (underlined). The PCR amplification cycles consisted of initial denaturation at 95°C for 10 min, and 35 cycles of denaturation at 95°C for 15s, annealing at 55°C for 30s, and extension at 72°C for 10s with a final extension at 72°C for 10 min. After digestion with XhoI and HindIII and purification the amplicon was cloned in the similarly digested pEGFP-N1 vector (kindly provided by Dr Abbas Jamali, Pasteur Institute of IRAN) upstream of the GFP sequence, schematically presented in Fig.1.



Fig. 1. The schematic presentation of human *siat7e* gene subcloned in EGFP-N1 vector. The new construct was transformed to *E. coli* Top10F" (Invitrogen, USA) and kept at -70 °C till required.

### Cell transfection

The MDCK and Vero cells were grown in 6-well plates (Orange Scientific, Belgium) to 60-80% confluency and transfected with the construct /lipofectamine 2000 (Invitrogen, USA) mixture and incubated for 4 h. Cells were then washed and grown in selective media containing 10% FBS and 0.4 mg/ml G418 antibiotic (Sigma, USA) . The medium was

70

changed after 24 h and the cells were grown for a further 2 weeks with a change of medium every 3 days. The transfected cells were evaluated for viability, phenotypic changes and *siat7e* gene expression, and after confirmation were stored.

## Phenotype and viability

The phenotypic changes of *siat7e*-expressing cells compared to the parental cells were monitored by light microscopy and their viability was measured by Trypan blue staining and the percentage was calculated using the following formula.

No. of viable cells / total cells (viable and dead) x 100 = % viable cells

## Siate7e gene Expression

RNA samples were extracted from parental and the SIAT7eexpressing MDCK and Vero cells using High Pure RNA Isolation kit (Roche, Switzerland). The extracted RNAs were reverse-transcribed using random hexamer primers in accordance to the manufacturer's protocol. Quantitative realtime PCR was carried out with Real Q Plus 2X Master mix Green (Ampliqon, Denmark) and SIAT7e -sense (5'TTA CTC ACA AGATGCTG3') SIAT7e-antisense GCC and (5'GCACCATGCCATAAACATTG3') primers to produce an amplicon of 148 bp covering nucleotides 846 to 994 using Corbett Rotor-Gene Q 6000 (Corbett Research, Australia) in a total volume of 25 µl. A 313 bp amplicon of gapdh gene (position 452 to 765) was the internal control for the reaction with GAPDH-For (5'-AAC ATC ATC CCT GCT TCC AC-3') and GAPDH-Rev (5'-GAC CAC CTG GTC CTC AGT GT-3') primers. The 40 cycles amplification consisted of denaturation at 95°C for 15 s annealing at 65°C for 30 s, and extension at 72°C for 30 s.

## **Fluorescent imaging**

Fluorescent microscopy was used to confirm GFP expression, which was indicative of the *siat7e* gene expression in transfected Vero and MDCK cells.

### Optimization

To optimize the expression of the *siat7e* gene, the effects of cell confluency (30-80%), concentration of construct (800-4800 ng/ $\mu$ l), lipofectamine (6-15 $\mu$ l), G418 antibiotic (0.2-1.4 mg/ml) and media (DMEM and Opti-MEM) were evaluated using fluorescent microscope.

## Statistical analysis

The gene expression data expressed as mean  $\pm$  SD was analyzed using analysis of variance (ANOVA) LSD post-hoc test (SPSS 18.0). Variations with p $\leq$  0.05 were considered statistically significant.

## RESULTS

#### **Construct verification**

The results of PCR amplification of *siat7e* from the original vector and verification of its subcloning in pEGFP-N1 by colony PCR enzymatic digestion with *Hind*III/*Xho*I are shown in Fig 2.

#### **Optimization results**

The efficiency of transfection in both cell lines was evaluated by fluorescent microscopy observation of GFP expression. The highest level of GFP expression was obtained with the cell confluency of 60%, construct concentration of 1600 ng/ $\mu$ l, lipofectamine at twice the construct concentration, G418 at 0.4 mg/ml and DMEM as the transfection medium. Under optimized conditions both cell lines gave similar results.

#### Phenotype and viability evaluation

Expression of the *siat7e* gene in both cell lines resulted in changes in the morphology and cell-cell attachment behavior of the transfected cells compared to the parental cells. Monitoring the cells showed that transfected cells developed a round morphology while maintaining viability (Fig. 3). The viability measurement of the suspended cells was conducted for 200 h by staining samples at different times with trypan blue. The survival rate of Vero and MDCK clones differed significantly. While Vero cells remained viable throughout the period of observation (200 h), cell death in *siat7e*-expressing MDCK clones started nearly 50 h post-transfection and cell viability was near zero at 150 h (Fig. 3). Fluorescent microscopy confirmed the expression of *gfp* gene which was cloned

downstream of *siat7e* gene in both cell lines, but the percentage of cells expressing GFP was significantly higher in Vero cells.

# Gene expression results

Expression of *siat7e* gene in transfected cells was detected by qPCR using specific primers. Parental cells were considered as negative control. GAPDH was amplified consistently in all samples as internal housekeeping control. All data were reported as fold reduction normalized to GAPDH. The results in Fig. 4 show the significant over-expression of the *siat7e* gene in transfected Vero cells compared to the parental cells (p< 0.05), while expression of *siat7e* was similar in both cell lines (p> 0.05).



**Fig 2.** A) The results of PCR amplification with *siat7e* gene specific primers Lane 1- negative control, lane 2-*siat7e* gene PCR product (1000 bp), lane 3-positive control (influenza virus hemagglutinin protein), lane 4- DNA ladder (1 kb). B) gel electrophoresis results of pEGFP-*SIAT7e* colony PCR. Lanes 1-5: colony PCR products, lanes 6 & 7- DNA ladder (1 kb). C) enzymatic digestion of pEGFP-*SIAT7e* with *Hind*III/*XhoI*. Lane 1- undigested construct. Lane 2- digested construct with *Hind*III/*XhoI*. Lanes 3: DNA ladder, (1 kb, Fermentas, Lithuania).





**Fig. 3.** A) The viability percentage of the *siat7e* expressing cells during the period of experiment using Trypan blue staining. Vero cells expressing *siat7e* showed a higher percentage of viability compared to *siat7e*-expressing MDCK cells. B) Fluorescent microscope images MDCK-*siat7e* and Vero-*siat7e* transfected cells at different time intervals. Data are averages of 3 independent repeats.



Fig. 4. Comparison between Vero and MDCK cells in *siat7e* gene expression. Data are averages of 3 independent repeats (mean ± SD).

## DISCUSSION

Cell based vaccine technologies offer distinct advantages over egg-based methods. They are faster and eliminate the need for embryonated chicken eggs, thus reduce the potential for contamination with viable and nonviable particulates thus, have higher initial purity. They eliminate the extensive times for vaccine production and increase the production volume during pandemics [17].

Although immortalized cell lines have been used extensively for vaccine production [8], but their need for surface adhesion to propagate has made scaling up the virus production in these cells difficult [9, 10]. The industry has overcome this limitation by using microcarriers such as Cytodex 1 and 3, but microcarriers are expensive and the process burdensome compared to suspension culture [11]. Successful attempts at changing anchorage-dependent cells to anchorage independent cells have been previously reported [11, 18-22].

In the present study Vero and MDCK cells which are licensed for virus propagation and vaccine production were transfected with the human siat7e gene and the effect on their viability and ability to grow as suspension cultures was evaluated. Both cell lines were successfully transfected but rate of transfection was significantly higher in Vero cells. A 4% transfection rate for MCDK cell had previously been reported using Lipofectamine 2000 [11]. Chu et al. reported that siat7e-expressing cells were at least 90% viable throughout the period of expriment, but in our study none of the transfected MDCK clones survived beyond 150 h. The reason for this discrepancy was not acertained, but could have been due to the low transfection rate and low expression level of the siat7e gene in the MDCK line we used as well as the loss of plasmid. In contrast, Vero cells showed a high rate of transfection, a high expression level of the siat7e gene and remained viable throughout the period of observation (Fig. 6). Successful conversion of anchoragedependent to anchorage-independent Vero cells using human siat1had been shown [23-24], but this is the first report of the use of siat7e gene in producing cells capable of growing in suspension. Once suspension culture using siat7e gene transfection technology is established, the increased yield and simplification of downstream processing would make vaccine production more economical.

This study successfully demonstrated the conversion of anchorage-dependent Vero cells to suspension culture through the transfection of the cell line with human siat7e gene.

#### ACKNOWLEDGEMENT

The project was supported by Pasteur Institute of Iran grant no. 606.

## **CONFLICT OF INTEREST**

The authors declare that they have no conflict of interest.

## REFERENCES

1. Bardiya N, Bae JH. Influenza vaccines: recent advances in production technologies. Appl Microbiol Biot. 2005;67(3):299-305.

2. Belsey MJ, de Lima B, Pavlou AK, Savopoulos JW. Influenza vaccines. Nature Rev Drug Discov. 2006;5(3):183-4.

3. Pau MG, Ophorst C, Koldijk MH, Schouten G, Mehtali M, Uytdehaag F. The human cell line PER.C6 provides a new manufacturing system for the production of influenza vaccines. Vaccine. 2001;19(17-19):2716-21. doi:http://dx.doi.org/10.1016/S0264-410X(00)00508-9.

4. Tree JA, Richardson C, Fooks AR, Clegg JC, Looby D. Comparison of large-scale mammalian cell culture systems with egg culture for the production of influenza virus A vaccine strains. Vaccine. 2001;19(25-26):3444-50. doi:http://dx.doi.org/10.1016/S0264-410X(01)00053-6.

5. Ozaki H, Govorkova EA, Li C, Xiong X, Webster RG, Webby RJ. Generation of high-yielding influenza A viruses in african green monkey kidney (Vero) cells by reverse genetics. J Virol. 2004;78(4):1851-7. doi:10.1128/jvi.78.4.1851-1857.2004.

6. Youil R, Su Q, Toner TJ, Szymkowiak C, Kwan WS, Rubin B *et al.* Comparative study of influenza virus replication in Vero and MDCK cell lines. J Virol Methods. 2004;120(1):23-31. doi:http://dx.doi.org/10.1016/j.jviromet.2004.03.011.

7. Doroshenko A, Halperin SA. Trivalent MDCK cell culture-derived influenza vaccine Optaflu (Novartis Vaccines). Expert Rev Vaccines. 2009;8(6):679-88.

8. Govorkova EA, Kodihalli S, Alymova IV, Fanget B, Webster RG. Growth and immunogenicity of influenza viruses cultivated in Vero or MDCK cells and in embryonated chicken eggs. Development Biol Standard J. 1999;98(73-74):39-51.

9. Frisch SM, Francis H. Disruption of epithelial cell-matrix interactions induces apoptosis. J Cell Biol. 1994;124(4):619-26. doi:10.1083/jcb.124.4.619.

10. Folkman J, Moscona A. Role of cell shape in growth control. Nature. 1978;273(5661):345-9.

11. Chu C, Lugovtsev V, Golding H, Betenbaugh M, Shiloach J. Conversion of MDCK cell line to suspension culture by transfecting with human siat7e gene and its application for influenza virus production. P Natl A Sci. 2009;106(35):14802-7.

12. Connor RJ, Kawaoka Y, Webster RG, Paulson JC. Receptor specificity in human, avian, and equine H2 and H3 influenza virus isolates. Virology. 1994;205(1):17-23.

13. Matrosovich M, Matrosovich T, Carr J, Roberts NA, Klenk HD. Overexpression of the  $\alpha$ -2,6-Sialyltransferase in MDCK cells increases

Downloaded from vacres.pasteur.ac.ir on 2024-05-03

influenza virus sensitivity to neuraminidase inhibitors. J Virol. 2003;77(15):8418-25.

14. Hatakeyama S, Sakai-Tagawa Y, Kiso M, Goto H, Kawakami C, Mitamura K et al. Enhanced expression of an alpha2,6-Linked sialic acid on MDCK cells improves isolation of human influenza viruses and evaluation of their sensitivity to a Neuraminidase inhibitor. J Clin Microbiol. 2005;43(8):4139-46.

15. Tsuchida A, Okajima T, Furukawa K, Ando T, Ishida H, Yoshida A et al. Synthesis of disialyl Lewis a (Le (a)) structure in colon cancer cell lines by a sialyltransferase, ST6GalNAc VI, responsible for the synthesis of alphaseries gangliosides. J Biol Chem. 2003;278:22787-94.

16. Jaluria P, Betenbaugh M, Konstantopoulos K, Frank B, Shiloach J. Application of microarrays to identify and characterize genes involved in attachment dependence in HeLa cells. Metab Eng. 2007;9(3):241-51.

17. Rappuoli R. Cell-Culture-Based Vaccine Production: Technological Options In: Heuer AH, editor. Engineering and Vaccine Production for an Influenza Pandemic. Washington, DC.: National Academy of Engineerin; 2006.

18. Tsao YS, Condon R, Schaefer E, Lio P, Liu Z. Development and improvement of a serum-free suspension process for the production of recombinant adenoviral vectors using HEK293 cells. Cytotechnology. 2001;37(3):189-98. doi:10.1023/a:1020555310558.

19. Daelli M, inventor Google Patents, assignee. Vero cell line adapted to grow in suspension2007.

20. Daelli MG, Forno AG, Kratje R, Etcheverrigaray M, Paillet C, inventors; Google Patents, assignee. Vero cell line which is adapted to grow in suspension, method of obtaining same and viral vaccines2012.

21. Kim H, Kim YH, Lee BY, Lee KS, Lee SJ, Park M et al., inventors; Google Patents, assignee. MDCK-derived cell lines adapted to serum-free culture and suspension culture and method for preparing vaccine virus using the cells2012.

22. Sanders BP, Edo-Matas D, Custers JHHV, Koldijk MH, Klaren V, Turk M et al. PER.C6® cells as a serum-free suspension cell platform for the production of high titer poliovirus: A potential low cost of goods option for world supply of inactivated poliovirus vaccine. Vaccine. 2013;31(5):850-6. doi:http://dx.doi.org/10.1016/j.vaccine.2012.10.070.

23. Tsuji S. Molecular cloning and functional analysis of sialyltransferases. J Biochem. 1996;120(1):1-13.

24. Li N, Qi Y, Zhang FY, Yu XH, Wu YG, Chen Y et al. Overexpression of  $\alpha$ -2,6 sialyltransferase stimulates propagation of human influenza viruses in Vero cells. Acta Virol. 2011;55(2):147-53.

25. Lewis AMJr, Alling DW, Banks SM, Soddu S, Cook JL. Evaluating virus-transformed cell tumorigenicity. J Virol Methods. 1999;79(1):41-50.